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Income, Trade and Pollution in Central Asia, Russia and China: An Econometric Analysis

Tisorn Songsermsawas
Bucknell University, ts033@bucknell.edu

Income, Trade and Pollution in Central Asia, Russia and China: An Econometric Analysis

by

Tisorn Songsermsawas

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Approved by

Professor Christopher Magee
Co-Adviser

Professor Amanda Wooden
Co-Adviser

Professor Janet Knoedler
Department Chairperson

Professor Christopher Ellis
Honors Council Representative

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Abstract

The study performs a panel estimation of the relationship between per capita income, trade, and airborne pollution in the five Central Asian nations, Russia and China between 1992 and 2008. First, this study uses an environmental Kuznets curve hypothesis (EKC) – an inverted-U relationship between the increase in income and the level of environmental degradation – to examine how income and pollution are related. Second, the study uses a gravity model to estimate the effect of a regional trade agreement (Shanghai Cooperation Organization: SCO) on incomes and carbon dioxide emissions in the region. Empirical analysis confirms the existence of the rising portion of the EKC curve in the region – a positive correlation between per capita income growth and carbon dioxide emissions- and that the volume of bilateral trade, and not the existence of a regional trade agreement, contributes to the increasing level of environmental pollution.

Chapter 1: Introduction

In recent years, the region of Central Asia has become a very important player in the international trade and energy arena. The region's abundance of natural energy resources has attracted the major powers of the world. The United States and China are trying to expand both political and economic influence in the region, while Russia is trying to retain its power in the region after the collapse of the Soviet Union.

The rich natural resources of Central Asia provide the countries in the region with enormous economic prospects. Turkmenistan and Uzbekistan sit on large reserves of oil and natural gas. However, financial limitations, technological and geographical challenges, insufficient infrastructure and political instability are the major factors that have prevented the countries from becoming the world's major energy exporters. Kazakhstan has access to the biggest recoverable oil reserves among the Caspian Sea countries. During the past few years, Kazakhstan has enjoyed a continuing increase in the volume of energy exports as well as impressive gross domestic product (GDP) growth.

The rapid growth in Central Asia's energy sector inevitably raises environmental concerns. Several of the Central Asian economies are in transition from command economy systems, inherited from the Soviet era, to market economy systems. On the other hand, Turkmenistan and Uzbekistan have not transformed into more liberalized economic systems. In both situations, the governments of these countries have tended towards short term economic expansion rather than long term sustainable development. The nations of Central Asia need to take a careful look at solutions and discover the most suitable path for creating environmentally sustainable development, in other words, maintaining their economic expansion and maximizing their valuable natural resources.

This thesis will examine the relationship between airborne pollution, trade, and income across the five Central Asian nations, Russia and China. It will discuss several aspects that play an important part in determining this relationship, including historical backgrounds, cultural similarities, geographic location, economic incentives and international political mechanisms.

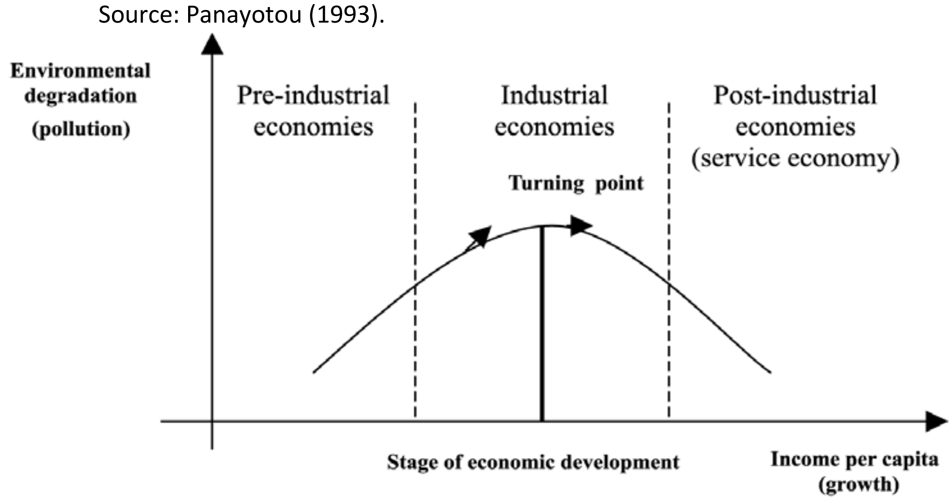
The thesis will be divided into three parts. The first part will investigate the effect of economic growth on airborne pollution in these countries by testing the Environmental Kuznets Curve hypothesis. The second part will examine the impact of the establishment of an important regional cooperation agreement, the Shanghai Cooperation Organization (SCO), on the volume of bilateral trade among the member countries. The final part will highlight the effect of international trade expansion, as a main component of economic growth, on airborne emissions in these countries. Finally, this thesis will investigate both the *direct impact* of a regional trade agreement on the volume of bilateral trade between the trading partners, as well as the *indirect impact* of GDP growth - through a regional trade agreement - on the level of airborne pollution in these countries.

Chapter 2: Literature Review

The idea of the Environmental Kuznets Curve (EKC) originated from Simon Kuznets' hypothesis on the relationship between economic growth and income inequality. Kuznets (1955) explained that as per capita income rises, income inequality also initially rises, but then after some period, starts to decline. Kuznets argued that the income distribution is likely to be more unequal at the early stages of economic growth but as economic growth progresses, the income distribution will move back towards equality.

Yandle, Vijarayaghavan and Bhattarai (2002) explain that Kuznets' hypothesis was later applied to the relationship between per capita income change and environmental quality. This application suggests that there is a positive correlation between economic growth and environmental degradation at the early stages of development. However, after reaching a certain level of income, further economic growth will instead foster environmental quality improvement. This idea is now known as the Environmental Kuznets Curve (EKC) and has become a fundamental model for hypothesizing about the environment-economy relationship

Figure 1. Environmental Kuznets Curve
Source: Panayotou (1993).



Source: Panayotou (1993)

There have been numerous studies attempting to investigate the relationship between the level of income and the level of environmental pollution or environmental degradation by using the EKC hypothesis. However, not all studies have identified the existence of the EKC relationship for all types of pollutants or environmental degradation. Moreover, the results obtained from these studies are varied across different types of airborne pollutants or environmental contamination.

Grossman and Krueger (1991) proposed an inverse U-shaped correlation, which suggested an EKC relationship, between several pollutants and GDP per capita as part of their study investigating the consequences of the North American Free Trade Agreement (NAFTA) on the environment in Mexico. Based on the hypothesis that NAFTA would cause further environmental degradation, they indicated the turning point at which an increasing level of income brings about improved air quality. During the time of the study, Mexico's per capita income fell into the zones where the air quality starts to improve.

Subsequent studies in the same manner also provided similar results. Shafik and Bandyopadhyay (1992) observed the EKC relationship between GDP per capita measured in purchasing power parity of dollars ($PPP) and 10 different variables of economic degradation as part of the World Bank's 1992 *World Development Report.* They used more varied functional forms than that of Grossman and Krueger to examine the hypothesis that when a country decreases its international trade barriers its environmental standards rise.

Selden and Song (1994) examined the EKC relationship of four pollutant emissions: SO_2, NO_x, SPM and CO. They investigate the relationship between per capita pollution emissions and per capita income over time. Panayotou (1993) further offered a very detailed pattern of an

EKC relationship between the rate of the environmental contamination from SO_2, NO_x, suspended particulate matter (SPM) and deforestation, and the level of economic development in an analysis conducted for the World Employment Program in 1992. The idea of an EKC has provided new insight in the study of environmental economics about improving and implementing sustainable development throughout the world, but should be carefully applied to decision making and public policies.

Shrestha and Timilsina (1996,1997) observe the effect of airborne emissions caused by the energy sector in several countries in Asia. They study the impact of changes in the technology-mix, fuel-mix and fuel intensity on CO_2, SO_2 and NO_x emissions during the 1980s and the 1990s. Their series of studies suggest that the volume of airborne emissions tends to be on the rise for developing countries such as Pakistan and China. On the other hand, in more advanced economies-such as Japan, Hong Kong and Malaysia-there is a gradual decline in the amount of pollution emissions.

Yaguchi, Sonobe and Otsuka (2007) investigate the contrasting hypotheses for CO_2 and SO_2 emissions and the relationship with energy consumption in China and Japan over an extended period of time. Their study suggests that neither per capita income nor previous energy consumption has an impact on the pollution emissions factor and energy consumption in Japan and China. With this outcome, the authors conclude that there is very little motivation for a country to reduce airborne emissions.

Several studies have been conducted on how international trade affects the pollution and environmental degradation of different forms. Copeland and Taylor (2004) argue that trade expansion may have effects on the environment in three aspects namely, scale effect, structural effect and technique effect (Grossman and Krueger, 1991; Kukla-Gryz, 2008). Scale effect denotes the overall scale of economic changes. Structural effect illustrates the changes in economic structure of an economy; the share of agricultural, industrial and service sectors in GDP. Technique effect portrays the effect of the mitigation of government restrictions on foreign capital investment, which would as a result contribute to the liberalization of international trade. Both Copeland and Taylor (2004) and Kukla-Gryz (2008) also note the importance of the international trade effect on environmental quality.

Further study by Antweiler, Copeland and Taylor (2001) investigates the effect of income increases and international trade liberalization on the airborne emissions of sulphur dioxide, and discovered rather unexpected results. The outcomes obtained from their study show that international trade contributes to very marginal change in the level of pollution. And according to the authors, when combining the trade-induced techniques and scale effects into account, it turns out that trade openness is surprisingly beneficial to the environment. Unfortunately, due to insufficient data on the economic structures of the Central Asian economies, we could not perform our analysis according to this study.

Ayhan Demirbas (2002) discusses concerns about the impact of wealth generation on the environment. In his case study on Turkey, the country's dramatic rapid growth in energy demand has pushed Turkey to increase its dependence on foreign energy supplies. He argues that human activity-related factors such as the increasing world population, the transition from agricultural based economy to industrial based economy in different parts of the world and the growing demand for consumption have severe impacts on the environment. The rapid economic growth in many parts of the world creates an enormous demand for energy. Energy sources such as fossil fuels and coal generate carbon dioxide and other substance emissions. The author argues that as these energy sources are still very popular and while alternative energy resources are in development, the impact on the environment is inevitably extensive. Developing efficient renewable energy resources seems to be the most appropriate approach.

The continuing increase in energy demand throughout the world brings the focus of attention to Central Asia. Arvanitopoulos (1998) points out that following the dissolution of the Soviet Union in 1991, the Commonwealth of Independent States (CIS) nations, most particularly Azerbaijan and Kazakhstan, have been using their rich oil and natural gas supplies as means to ensure their political independence and economic strength. It is estimated that the energy resources of the Central Asia - especially in the area around the Caspian Sea - might not be as abundant in quantity as that of the Middle East[1]. However, it is proved to be of excellent quality and to be an appropriate alternative energy source for the 21st century (Arvanipopoulos 1998). The prosperous energy resource of Central Asia and the Caspian Region is the major factor that attracts international trade and foreign direct investment into the region. Moreover, the cultural links between Central Asia and China along with the political history between Central Asia and Russia provide a very multi-faceted trade and economic relationships for the region.

The analysis of the trading relationship between Central Asia, China and Russian is conducted using a gravity equation. The method of using a gravity equation to analyze the volume of trade between two trading partners was first introduced by Jan Tinbergen (1962). Since its introduction, the method has been widely used to investigate bilateral trade because it usually generates a good fit and a consistent estimate (Anderson 1979, Kalirajan 1999).

[1] The World Factbook 2009, Central Intelligence Agency (CIA): Virginia.

Tinbergen's original equation illustrates the trade flow as 'masses,' which is determined by using the national income of both countries and the distance between them as the independent variables, and the total trade volume between two countries as the dependent variable. Poyhonen (1963) and Linnemann (1966) also propose that the model can be used to explain the bilateral trade flow between nations.

Tinbergen's original gravity equation has been expanded and adjusted. Frankel and Wei (1993) study the trade relationship between several countries in Asia Pacific using the gravity model by adding the GDP per capita variable to Tinbergen's basic equation. Edmonds, La Croix and Li (2008) add several dummy variables into the gravity equation to examine China's international trade. Edmonds et al.'s study corresponds with Rose (2004), with some adjustments made by Clarete, Edmonds and Wallack (2004). The dummy variables incorporated into their gravity model include land area, common boundary sharing, landlocked country, common language and colonization status. The results obtained from this expanded model suggest that these added factors contribute to the volume of trade between countries. Since this thesis focuses on the impact of a regional agreement, the SCO, we will only include the dummy variable to capture the effect of this agreement.

According to the gravity equation, the volume of trade between countries is mainly determined by the level of national income (economic size) and the distance between countries (transportation cost). However, there are several components that affect the level of trade between trading partners such as tariffs, trade quotas, export/import taxes, international exchange rates, foreign policies, or public and private sector interventions (Chen 2008). The world's main international organizations such as the Asia Pacific Economic Cooperation (APEC), the European Union (EU) or the Association of South East Asian Nations (ASEAN) establish policies and regulations that encourage trade among the members of the group rather than trade with other countries.

Chen (2008) investigates the effect of the establishment of the Shanghai Cooperation Organization (SCO) on the bilateral trade of Xinjiang, China's westernmost province, and its main trading partners by using cross-sectional trade statistics from 2004. The Chinese government's rapid development program on infrastructures in Xinjiang necessitates the need for enormous energy supplies and has successfully established strong economic ties with several countries in Asia and Europe, especially in Central Asia. However, the international trade between Xinjiang and the Middle East grows at a much slower pace. The study also indicates that the establishment of the SCO significantly contributes to the increase in the volume of bilateral trade among member nations, regardless of geographic location.

Whalley (1998) performs an empirical analysis of several regional trade agreements around the world and argues that different countries have different incentives and objectives to carefully investigate when deciding to participate in any regional trade agreement. In his study, Whalley analyzes regional trade agreements around the world including NAFTA, ASEAN, LAFTA, Andean Pact, ECOWAS, the European Union and CUSTA and points out that regional trade agreements have different main goals and objectives to pursue. For example, Canada's participation in the Canada-U.S. Free Trade Agreement (CUSTA) is mainly in order to provide greater access for its farmers to a large market like the United States. On the other hand, the establishment of the European Union (EU) as a common market is to fortify the collective bargaining and negotiation powers of member nations in the international trade venue.

The SCO was formed in part to ensure China's access to the energy resources in Central Asia. China's rapidly emerging economy requires an enormous amount of energy supply and the Chinese government considers Central Asia to be the most strategically appropriate source to supply their increasing energy demand. The year 1996, with the foundation of Shanghai Five, not only marked the start of China's close relationship with Central Asia, it also observed the official opening of the first border post between China and Kazakhstan at Dostuk-Alatau (Peyrouse 2007). This is a very important milestone in the relationship between China and Central Asia because the opening of this border post allowed goods and people to travel across the borders for the first time in several decades. Following the ideological conflict between China and the Soviet Union towards the end of the 1950's, the long border between the two countries was a closed military zone until the dissolution of the Soviet Union in 1991 (Kerr 1996). Through the establishment of the Shanghai Cooperation Organization[2], China has taken a leading role in promoting regional economic development and cultural cooperation in order to provide a solid foundation for regional political and security cooperation (Guang 2005, 2007). Chung (2004) further notes that China's active role in building strong regional cooperation with Russia and Central Asia is to balance and counter the United States' influence in Central Asia. China's main concern is that the growing American presence in Central Asia will prevent China from achieving its political and economic demands.

The close historical and economic ties that the countries in Central Asia have had with Russia since the Soviet era makes it impossible to neglect the impact of Russia's economic

[2] Shanghai Cooperation Organization (SCO) was originally created as the Shanghai Five 1996 with five founding members namely China, Kazakhstan, Kyrgyzstan, Russia and Tajikistan. After Uzbekistan joined the group in 2001, the group was renamed Shanghai Cooperation Organization.

condition and its effect on the region. The Russian Financial Crisis (also known as the Ruble Crisis) that occurred during the summer of 1998 had a significant impact not only within Russia, but also on several countries that were once part of the Soviet Union. Among the Central Asian nations, Kazakhstan - where more than 20% of the population is ethnically Russian[3] - was most heavily hit due to very strong economic ties with Russia. Kazakhstan's level of exports and foreign reserves sharply dropped. In Tajikistan and Kyrgyzstan, the ratio of debt to GDP witnessed a sharp increase in 1998 and 1999 (Pastor and Damjanovic 2003).

The growing economies and the rapidly expanding energy sectors of the Central Asian countries, Russia and China have raised concerns about the environmental quality in the region, especially airborne pollution. The lack of quantitative research that has been conducted on Central Asia has inspired the development of this thesis, with the major goal to explore the interconnected issues between income, trade and environmental pollution.

[3] Kazakhstan National Census 2009

Chapter 3: Methodology

To test the EKC hypothesis, our study uses annual time series data from the year 1992 to 2008 for Russia, China and the five Central Asian states (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) that were part of the Soviet Union and became independent in 1991, and Russia and China. Table 1 presents some basic economic and social indicators for each of these countries.

Table 1. Basic economic and social indicators, Central Asia, Russia and China, 2008

Country	Population (million)	GDP per capita (2006 US$)	Gini Coefficient[4]	SCO Membership
China	1327.66	5503.43	46.9	1996
Kazakhstan	15.55	10540.35	33.9	1996
Kyrgyzstan	5.31	2013.88	30.3	1996
Russia	142.0	14700.87	41.0	1996
Tajikistan	6.46	1864.48	32.6	1996
Turkmenistan	5.27	5306.52	40.8	-
Uzbekistan	27.19	2427.98	36.8	2001

Source: World Economic Outlook October 2009, International Monetary Fund (IMF): Washington, DC.
The World Factbook 2009, Central Intelligence Agency (CIA): Virginia.

Various studies conducted on the EKC relationship have included many different specifications for the EKC relationship model. However, the basic EKC model we investigate here includes CO_2 emissions as the dependent variable, and per capita income (or GDP) calculated based on the purchasing power parity (PPP) of each country and its squared term as the independent variables.

The decision to use carbon dioxide as a variable to represent airborne pollution is because it is the most widely recognized and consistently reported greenhouse gas. According to the estimates, carbon dioxide accounts for 9-26% of the greenhouse effect after water vapor,

[4] Most recently available figure: China – 2004, Kazakhstan – 2003, Kyrgyzstan – 2003, Russia – 2006, Tajikistan – 2003, Turkmenistan – 1998 and Uzbekistan - 2003

which accounts for approximately 36-70% (Kiehl and Trenberth 1997). Moreover, it is the type of greenhouse gas that is mostly produced from fuel combustion. Since the Central Asian countries, Russia and China are economies with rapidly growing energy sectors, carbon dioxide emissions is an appropriate measure of environmental pollution. Unfortunately, governments of these countries do not necessarily accurately report the level of carbon dioxide emissions lack of funding for data collection, attraction of foreign aid and sufficient resources. Thus, it is critical that we interpret our results with great caution.

To test the relationship between per capita income and carbon dioxide pollution, our basic model can be expressed as follows:

$$CO_2emit_{it} = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 year_t + \varepsilon \qquad (1.1)$$

where: CO_2emit represents the amount of CO_2 emissions for each country; GDP represents the per capita GDP; β is the regression parameter; year is the time effect; ε is a deviation term; and *i* refers to the *i* th area and *t* refers to the *t* th time period.

Based on this model, if the relationship between CO_2 emissions in Central Asia and the per capita income is the inverted U-shape, as in the EKC hypothesis, then $\beta_1$would be positive and $\beta_2$would be negative. Given that the current economic condition of Central Asia is still in the developing stage, it is possible that the economies of Central Asia are on the rising portion of the EKC curve, provided that the EKC relationship exists in Central Asia.

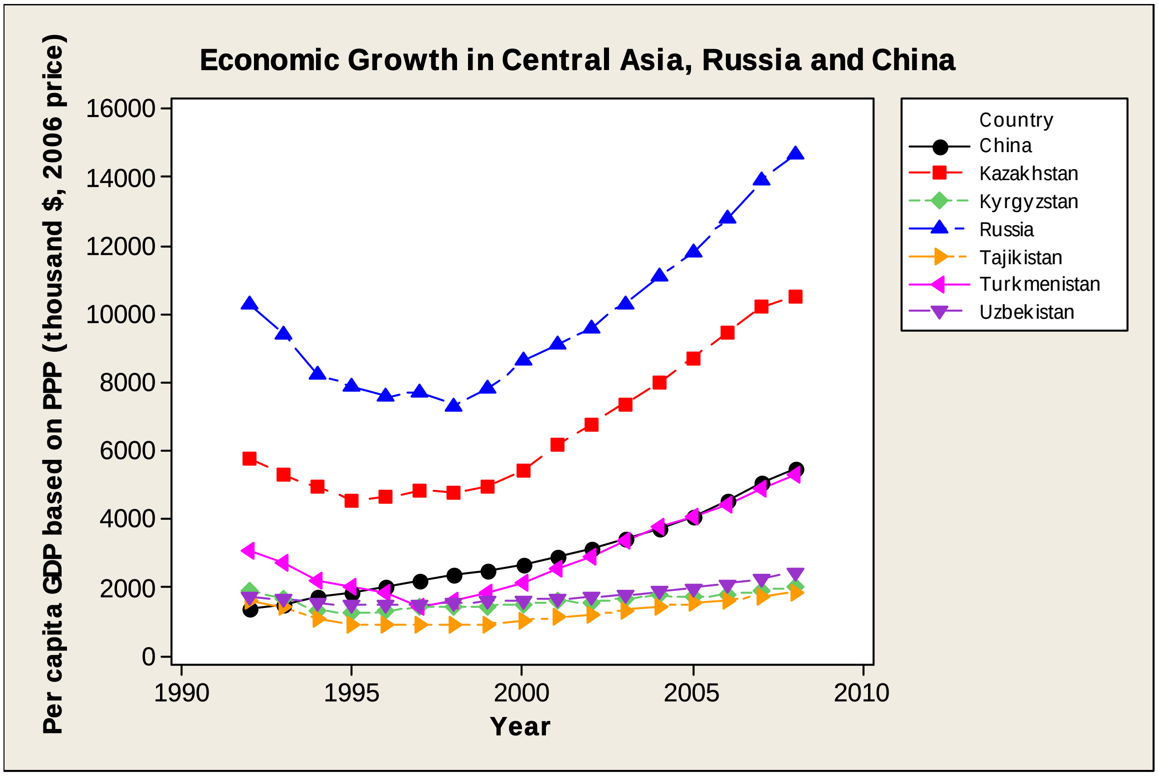


Figure 2. Source: World Economic Outlook October 2009, International Monetary Fund (IMF): Washington, DC.

In order to test the EKC hypothesis in Central Asia, it is necessary to observe the economic growth performance of Russia, China and the Central Asian economies since independence. Figure 2 above shows that after the dissolution of the Soviet Union, all Central Asian nations saw a sharp decline in per capita GDP and this drop was sustained until the second half of the 1990s. The termination of the commanded distribution of goods and services within the Soviet Union caused a severe impact on the living standard of the Central Asian population (Pomfret 2006). It is interesting to observe that these Central Asian states became independent from the Soviet Union with similar economic systems. However, only about two decades later, the economic performances of each country have developed their own unique characteristics. While Kazakhstan, Kyrgyzstan and Tajikistan have been successful in gradually transforming from the centrally-planned command economic system to the market economic system, Turkmenistan and Uzbekistan have not engaged as much in such a transformation to open economic systems.

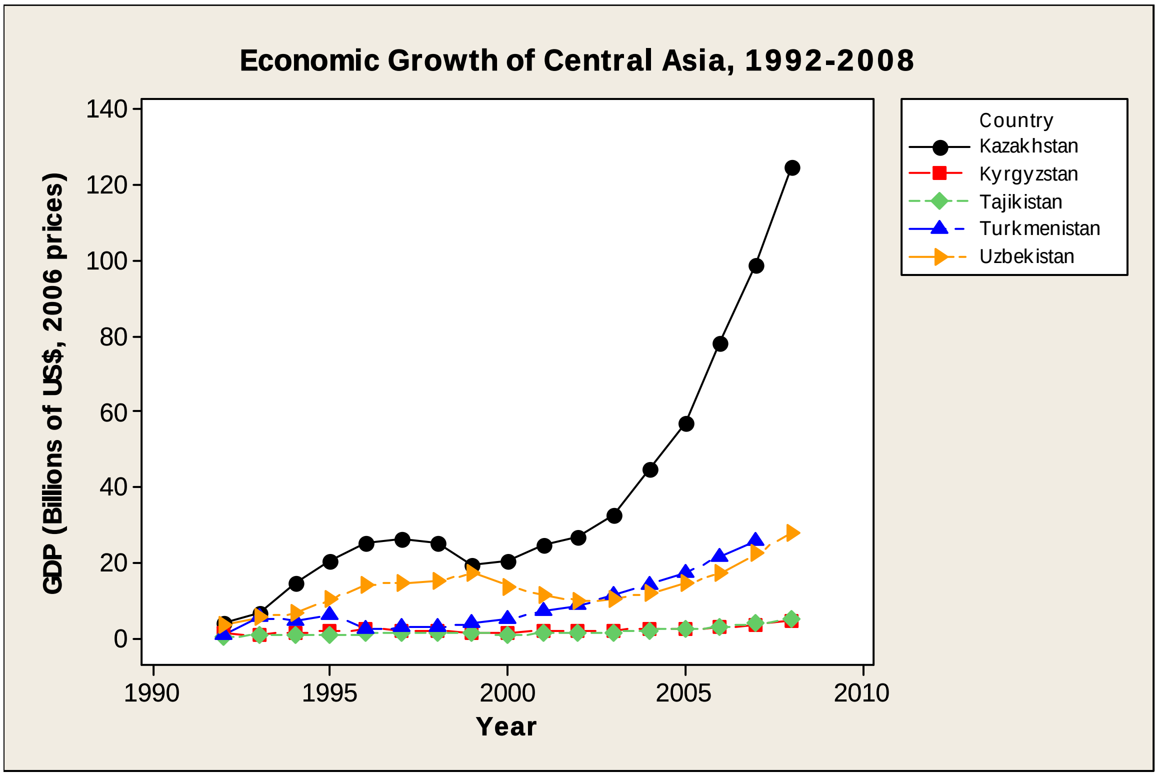


Figure 3. Source: World Economic Outlook October 2009, International Monetary Fund (IMF): Washington, DC.

From the illustrations in Figure 2 and Figure 3, it is evident that Kazakhstan and Turkmenistan have enjoyed the best economic growth performance among the Central Asian nations. This is mainly due to their petroleum and natural gas reserves. Based on the estimates released in 2008 by the Energy Information Administration (EIA) of the U.S. Department of Energy, Kazakhstan currently produces more than one billion barrels of petroleum a day, making the nation the world's 14th largest oil producer. Between 1999 and 2003, Kazakhstan's petroleum industry expanded by approximately 14% annually; this roughly doubled the nation's total oil production since its independence (Najman et al. 2008). According to the data in Figure 3, Kazakhstan's GDP level almost tripled between 2004 and 2008. This huge leap of GDP level is mainly due to the aggressive expansion of the energy sector and the surge in prices of petroleum and natural gas. Turkmenistan's political and economic development, on the other hand, relies heavily on the country's rich natural gas supplies (Pomfret 2006). The unchecked power of the dictatorship was key to the country's aggressive move to maximize its economic growth via energy sector revenue. Russia also witnessed economic growth patterns similar to Kazakhstan and Turkmenistan. The dissolution of the Soviet Union resulted in a sharp decline in the level of output and income in Russia.

The other three Central Asian nations have mixed economic growth experiences. The outbreak of civil war in Tajikistan resulted in a dramatic output decline starting in 1992 and lasted until the end of the 1990s (Pomfret 1995, 2006), but today is the most politically stabled country in Central Asia. In Kyrgyzstan, the administration's decision to adopt rapid economic reform policy unfortunately did not help foster considerable economic growth (Gleason 2003). However, it is important to highlight that Kyrgyzstan is the nation with the greatest political liberalization and civil right protections (Wooden and Stefes 2009). Uzbekistan's economic growth, on the other hand, has been the most stable of all Central Asian nations. The output decline following the breakup of the Soviet Union in 1991 was the least among the five nations. The price of cotton, Uzbekistan's main exporting good, soared in the 1990s, and this played an important role in fostering Uzbekistan's economic growth (Gleason 2003, Pomfret 2006). Entering the 21st century, it is very interesting to closely follow the economic performance of

Russia and the Central Asian states with their growing energy sectors as the main driving factor for growth.

While Russia, along with the other former Soviet republics, had experienced economic decline after the collapse of the Soviet Union in 1991, China has been enjoying tremendous economic growth since the implementation of the Reform and Open-up Policy in 1978. Beginning in 1991, the Chinese government has fostered a very aggressive economic development policy. In Xinjiang, the westernmost province of China neighboring Central Asia, the Chinese government decided to invest in building an integrated infrastructure in the region and relocated a large number of ethnic Hans into the province, where the majority of the population is Muslim Uyghur. Due to the scarcity of energy resources in Xinjiang, the Chinese government sees the neighboring Central Asian region as the target for foreign investment and has been actively investing in Central Asia during the past decade. China's rapid and aggressive economic expansion policy is the major contribution to the success of economic growth the nation is enjoying today.

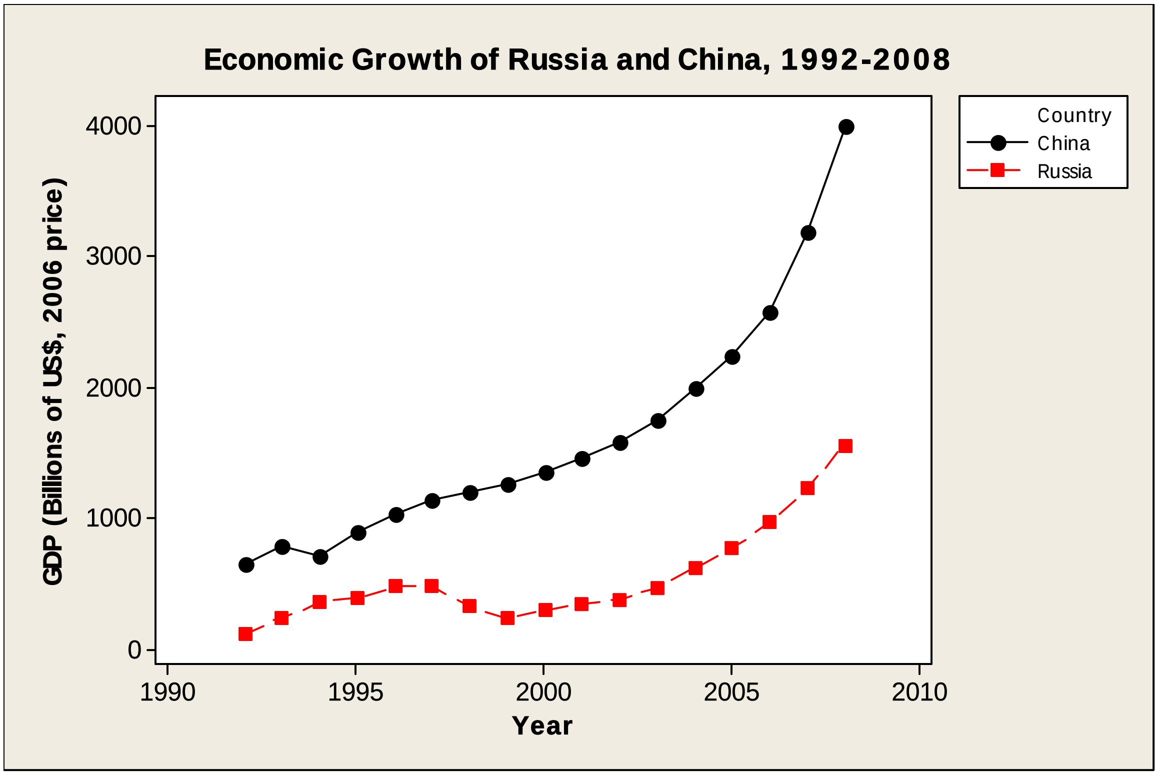


Figure 4. Source: World Economic Outlook October 2009, International Monetary Fund (IMF): Washington, DC.

The graphs in Figure 4 show that China's economic growth has been much faster than that of Russia over the past 20 years. This is mainly due to the fact that China began at a much lower level of per capita income; however, China still lags behind Russia and Kazakhstan in per capita income, as Figure 2 showed. Therefore, when estimating the EKC hypothesis for China, we expect China's per capita GDP level to still fall on the increasing portion of the inverted-U curve behind Russia and Kazakhstan.

Given the large dependency of the Central Asian economies on the energy sector, the expanding economy of Russia, and China's financial boom, we expect a strong correlation between their economic growth performance and their CO_2 emissions. In order to better understand the CO_2 emissions situation in Central Asia, it is helpful to investigate the illustrations below.

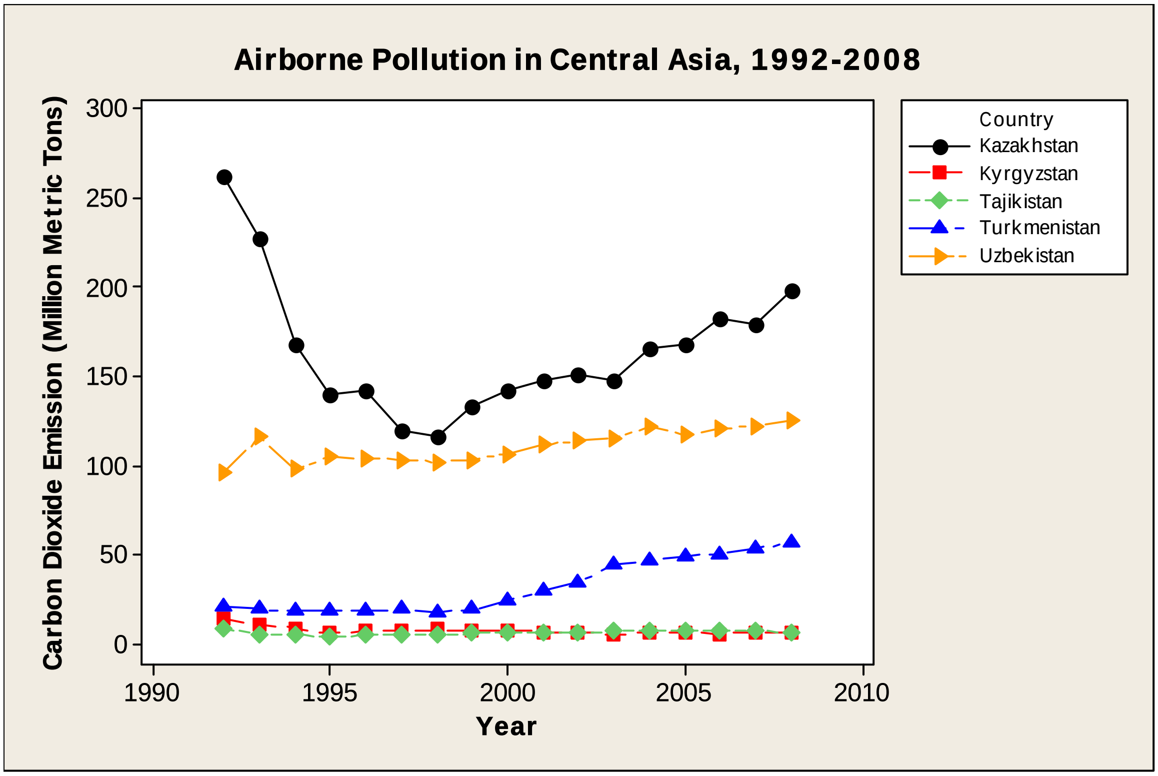


Figure 5. Source: Energy Information Administration (EIA), U.S. Department of Energy.

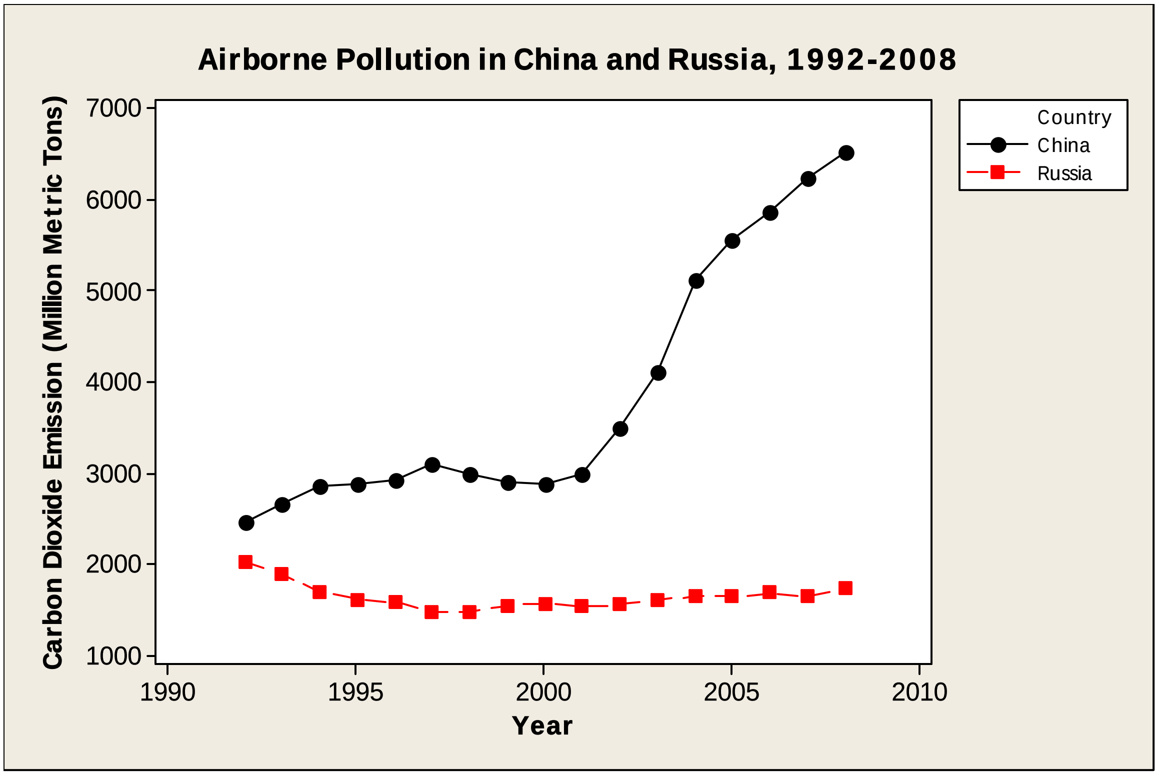


Figure 6. Source: Energy Information Administration (EIA), U.S. Department of Energy.

The scatter plot of the level of CO_2 emissions in the five Central Asian nations, and in Russia and in China over time suggests that there is a relationship between economic growth and the amount of CO_2 emissions. Assuming that the EKC hypothesis is correct, the economies of Central Asia, Russia and China are all still in the developing stages. Therefore, we expect to find a positive relationship between per capita GDP growth and the amount of CO_2 emissions; that is, Central Asia is on the rising portion of the EKC curve. By testing the EKC hypothesis, we can see that the amount of CO_2 emissions in each country will vary according to their economic growth performances. For Kazakhstan, economic growth has gone through significant changes over the years since its independence. Therefore, we can see that there is a much larger variation in the amount of CO_2 emissions than that of Uzbekistan, where its economic growth has been rather stable over the years since independence. It is also necessary to highlight the similar patterns in per capita income growth and carbon dioxide emissions in Kazakhstan. Following the dissolution of the Soviet Union, Kazakhstan's per capita income constantly dropped until the Russian Financial Crisis occurred in 1998 and has been steadily increasing from 1999 onwards. The level of carbon dioxide emissions in Kazakhstan has also witnessed similar patterns in which emissions level decreased through most of the 1990's and started to recover around the end of that decade.

The dataset used in the present analysis - of per capita income and CO_2 emissions - is a panel dataset obtained from several sources and it covers the time period from 1992 to 2008. The data on economic growth were obtained from the World Economic Outlook report, published by the International Monetary Fund (IMF). We use real per capita GDP based on the purchasing power parity in constant 2006 U.S. dollars so as to account for the effect of inflation. With this selection, our GDP per capita data will truly reflect the economic growth of each Central Asian nation. The CO_2 emissions data were taken from the Energy Information Administration (EIA) of the U.S. Department of Energy. This variable is calculated based on the total consumption of fossil fuels of each country.[5]

In order to fully capture the effect of the regional trade agreement between Central Asia, Russia and China on the level of bilateral trade, it is important that we divide our time period into two different stages. The first time period is from the years 1992-1996, which covers the period from the dissolution of the Soviet Union towards the end of 1991 until after the Shanghai Five was created in 1996. The other period covers the period from the year 1997

[5] See Table 3. in Appendix B for variable definitions, their sources.

onwards. The Shanghai Five group was further strengthened in 2001 when Uzbekistan joined and it was subsequently renamed the Shanghai Cooperation Organization (SCO).

One of the main incentives for the establishment of the Shanghai Five, which subsequently became SCO, is to enhance and promote economic relationships among the member nations. Several studies have discussed the implications of the bilateral trade relationship between trading partners using the gravity model and it appears to be an accurate description of this relationship.

According to the basic gravity model proposed by Tinbergen (1962), the volume of bilateral trade between two countries is determined to be directly proportional to the level of output income of both countries (GDP) and inversely proportional to the distance between the two countries. However, this gravity model is usually expressed in the natural logarithm form, as Deardorff (1998) illustrates. Therefore, our basic gravity model can be derived as follows:

$$lntrade_{ij} = \beta_0 + \beta_1 \, ln\left(GDP_i * GDP_j\right) + \beta_2 \, ln \, distance_{ij} \qquad (2.1)$$

where: ln*trade* represents the natural log of the amount of international trade (the sum of exports and imports) between two countries; GDP represents the total output (GDP); ln*distance* is the natural logarithm of the distance between two countries; β is the regression parameter; ε is the deviation term.

This basic gravity model illustrates that trade is directly determined by demand, which is represented by the GDP of the trading partners. This model also expresses that trade volume depends on the distance between countries. Due to the fact that distance is an indication of transportation costs, the further two countries are from each other, the lower the trade volume between two countries is going to be (Batra 2004). Chen (2008) further notes that distance also reflects other determinants relevant to international trade including trade policies and cultural backgrounds. Therefore, according to this model, we expect the coefficient β_1 to be positive and β_2 to be negative.

The transformation of the 'Shanghai Five,' which was launched in 1996, into the Shanghai Cooperation Organization (SCO) in 2001 has helped promote bilateral trade among member countries. The current six members (China, Kazakhstan, Kyrgyzstan, Tajikistan, Russia and Uzbekistan) have been very active in enhancing cooperation in areas including trade, security and cultural issues. To further investigate whether SCO has a positive effect on the members' bilateral trade with its trading partners under the SCO agreement, we adjust our basic gravity model by adding the dummy variable for SCO as follows:

$$lntrade_{ij} = \beta_0 + \beta_1 \ln\left(GDP_i * GDP_j\right) + \beta_2 \ln distance_{ij} \quad (2.3)$$

$$+\beta_3 year_t + \beta_4 SCO_t + \varepsilon$$

where: all variables in this model remain the same as they are in the basic gravity model; and *year* is the time effect. The variable *SCO* is a dummy variable indicating that a country is a member of the regional trade agreement (1997 onwards). The *SCO* variable takes the value 1 if both trading partners are part of the SCO in that particular year and takes value 0 otherwise.

It is important to highlight the significance of a trade relationship among the Central Asian countries, Russia and China. Based on the statistics of the IMF in 2007, the total trade volume between Russia and China increased by more than 40% from 2006 to 2007, with the total trading amount exceeding $40 billion dollars. This is also partly due to the surge in oil price during the summer of 2008. For Kazakhstan, the revenue generated from its oil and natural gas sector accounts for approximately 25% of the country's GDP and represents more than 60% of its overall exports (CIA World Factbook 2009). These figures illustrate the importance of international trade as a main factor contributing to economic growth of the Central Asian countries, Russia and China.

The data used to test whether the establishment of a regional trade agreement helps foster bilateral trade among the Central Asian countries, Russia and China is a panel dataset of all pairs of Asian countries from the year 1992 to 2008. According to the definition given by the United Nations, Asia consists of 47 countries. However, some countries in Asia were omitted from the dataset due to insufficient data.[6] The data on economic growth (GDP) were obtained from the World Economic Outlook report, published by the International Monetary Fund (IMF). This variable has been adjusted and recalculated to capture the effect of inflation by using 2006 dollar prices. The distance variable in the models studied was obtained from the CEPII Database released by the Research Center in International Economics. This variable is given by the distance (measured in kilometers) between the two most financially significant cities of each country[7].

Finally, after testing the effect of income on airborne pollution, and the effect of the SCO on bilateral trade, we will investigate whether there is a direct relationship between the volume of international trade and the level of income, and an indirect relationship between the volume of international trade and the level of carbon dioxide emissions. From these two relationships, if there is a direct correlation between international trade and level of income,

[6] Countries and territories excluded from the dataset were: Afghanistan, Brunei, Burma, Bhutan, Cambodia, Iraq, Laos, Maldives, Nepal, North Korea, Taiwan

[7] For example, although the capital city of Kazakhstan is Astana, its financial capital is Almaty. Therefore, Almaty is used to measure the distance between Kazakhstan and other countries.

we can conclude that there is also a correlation between international trade increase due to the effect of a regional trade agreement and the level of airborne pollution.

To observe this implied relationship, we will use the EKC hypothesis by substituting the per capita GDP variable by the bilateral trade volume. Therefore, we can transform the adjusted EKC model and rewrite it as follows:

$$lnCO_2emit_{it} = \beta_0 + \beta_1 tottrade_{ij} + \beta_2 tottrade_{ij}^2 + \beta_3 year_t + \beta_4 country_i + \varepsilon \quad (3.1)$$

where: $lnCO_2emit$ represents the natural log of CO_2 emissions for the Central Asian countries; Russia and China; the variable *tottrade* represents the sum of exports and imports between countries *i* and *j* in each year *t* between 1992 and 2008; β is the regression parameter; year is the time effect; country is the dummy variable for each country and ε is a deviation term.

The purpose of this transformed EKC model is to investigate whether the volume of bilateral trade would be an appropriate explanatory variable for the Central Asian countries, Russia and China. According to this model, if there is a relationship between bilateral trade and airborne pollution, we can establish a connection between international trade and airborne pollution since international trade is an important contributing factor to a country's income level.

Chapter 4: Analysis

We start our estimation of the relationship between per capita income level in Central Asian nations, Russia and China and their carbon dioxide emissions level by using the EKC hypothesis from our basic model.

$$CO_2emit_{it} = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 year_t + \varepsilon \quad (1.1)$$

Statistical diagnostic tests indicate a few problems that require model adjustment. The Breusch-Pagan Test suggests that there is evidence of heteroskedasticity for this model. We address this by transforming the response variable, CO_2 emissions, by taking the natural logarithm. Furthermore, the Prais-Winston test for autocorrelation detects that there is significant evidence of autocorrelation. This evidence points out that a significant variable contributing to CO_2 emissions is not included in this basic model. Therefore, we add a lag of CO_2 emissions as another explanatory variable in our model. This would account for that fact that CO_2 emission is persistent over time and there is a strong correlation between the amount of CO_2 emissions of one particular period and subsequent periods.[8] After these additions, we can rewrite our basic model as,

$$lnCO_2emit_{it} = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 year_t + \beta_4 lnCO_2emit_{it-1} + \varepsilon \quad (1.2)$$

where: $ln\mathrm{CO_2emit_{it-1}}$ represents the amount of CO_2 emissions from the previous time period.

With the adjusted model, we can estimate the EKC relationship for the Central Asia countries, Russia and China as in the following table.

[8] A correlation test indicates no multicollinearity among explanatory variables.

Table 2. Estimation results of Environmental Kuznets Curve in Central Asia, Russia and China

Variable	Basic Model (1.1)	Adjusted Model (1.2)
Intercept	-38940.66	167.626*
Per Capita GDP#	383.278*	0.304*
(Per Capita GDP)$^{2\#}$	-22.844*	-0.012
Year	19.436	-0.084
ln(Lagged-CO_2 emissions)	-	0.729*
R^2	0.312	0.902
F-statistic	4.418	124.014
No. of observations	112	96

Note: # based on purchasing power parity (PPP).
*Statistically significant at the 5% level.

Table 2 represents our regression results for the EKC for all Central Asian countries, Russia and China inclusively using the basic model (1.1) and the adjusted model (1.2). In both models, the coefficients estimates β_1 and β_2 on per capita GDP and its squared term are positive and negative, respectively. The coefficient of the time variable in model (1.2), although is negative, indicating that airborne pollution is estimated to slightly decrease over time. The economic recessions in 1998 and in 2008 might also affect this coefficient to be negative. This result indicates that there is evidence of an inverted U-shaped EKC curve between per capita GDP and CO_2 emissions in the Central Asian countries, Russia and China.

In model (1.2), which is already adjusted for autocorrelation and heteroskedasticity, we obtain a more robust test of the hypothesized EKC relationship. The per capita GDP term is statically significant at the 5% level, while its squared term is not statistically significant. This positive coefficient of the per capita GDP term suggests that pollution is expected to increase as per capita income rises. However, its negative squared term indicates that rate of increase in pollution is decreasing. However, since the economies of the Central Asian nations, Russia and

China are still currently in the developing stages, they are still in the rising portion of the hypothesized EKC relationship, should this relationship exist. Therefore, the squared term, which tests whether or not there will be an inflection point for the CO_2 emissions to decline in the future, is not statistically significant in this model.

Extensions of the basic models (1.1) and (1.2) can also be made in order to capture the carbon dioxide emissions behavior of each specific country. A dummy variable for each country is assigned according to observations of each country, and the new models can be expressed as:

$$CO_2emit_{it} = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 year_t + \beta_4 country_i + \varepsilon \quad (1.3)$$

and similarly, with the lag term of the carbon dioxide emissions of the year prior,

$$lnCO_2emit_{it} = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 year_t + \beta_4 country_i + \beta_5 lnCO_2emit_{it-1} + \varepsilon \quad (1.4)$$

where: all variables remain the same as models (1.1), (1.2) and (1.3) and country is a dummy variable for each of the five Central Asian countries, Russia and China[9].

[9] Dummy variable for Russia is omitted throughout the regression analysis.

Table 3. Estimation results of Environmental Kuznets Curve in Central Asia, Russia and China (continued)

Variable	Extended Basic Model (1.3)	Extended Adjusted Model (1.4)
Intercept	12222.90	28.770*
Per Capita GDP#	617.242*	0.418*
(Per Capita GDP)$^{2\#}$	-29.547*	-0.019*
Year	-6.832*	-0.012*
Country Dummy for China	3769.98*	1.935*
Country Dummy for Kazakhstan	-171.325*	-1.982*
Country Dummy for Kyrgyzstan	-538.341*	-3.878*
Country Dummy for Russia	-	-
Country Dummy for Tajikistan	-719.161*	-3.906*
Country Dummy for Turkmenistan	-334.368*	-2.882*
Country Dummy for Uzbekistan	-112.198*	-1.174*
ln(Lagged-CO_2 emissions)	-	0.006
R^2	0.956	0.997
F-statistic	129.772	2000.693
No. of observations	112	96

Note: # based on purchasing power parity (PPP).
*Statistically significant at the 5% level.

Our regression results EKC analysis of the Central Asian countries, Russia and China from Table 3 reflect the relationship between economic growth and CO_2 emissions when the country dummy variables are included. Similar to our regression results in Table 1, in both models, we obtained positive and negative coefficient estimates β_1 and β_2 for the CO_2 emissions response variable, respectively. In model (1.3), our results show that our coefficient estimates β_1 and β_2 for per capita GDP and its squared term are statistically significant at the 5% significant level. With this model, we might conclude that the per capita GDP growth would affect the amount of CO_2 emissions in each of the Central Asian nations, Russia and China.

Again, in light of autocorrelation and heteroskedasticity we transform our basic and adjusted models into extended models (1.3) and (1.4) respectively. In model (1.4), the coefficients estimates for per capita GDP β_1 and β_2 are both also statistically significant. This result shows that there is enough evidence to support our hypothesis that there may be an EKC relationship between per capita GDP and the amount of CO_2 in the Central Asian countries, Russia and China. Moreover, the R^2 value we obtained from the regression of model (1.4) is also very high. This also indicates the "good fit" overall of this model in representing the relationship between per capita GDP and the emissions of CO_2 very efficiently.

Based on the results obtained from the adjusted model (1.2), we can estimate the inflection point of the EKC curve to predict the level of per capita income that marks the point at which the falling portion of the EKC curve is located, if the EKC relationship actually exists. Using this model, we forecast the turning point on the EKC curve to occur at per capita GDP level of $12,667. And according to the extended adjusted model (1.4), the turning point on the EKC curve is estimated to occur at the per capita GDP level of $11,000. Although this projected turning point is still far above the current per capita income level of all five Central Asian countries and China, the per capita income level of Russia in 2008 (as shown in Table 1) has already exceeded this estimated figure[10]. However, that Russia's income level falls relatively close to the inflection point makes increases in Russia's per capita income level still have very marginal effect on its pollution level. Moreover, the carbon dioxide emissions level of Russia (as shown in Figure 6) does not appear to have a declining pattern yet. This observation might also lead us to the question of whether the EKC relationship would eventually exist for these heavily energy sector trade-driven economies since in this study we only test the increasing portion of the EKC.

[10] According to the 2008 estimates by the World Bank, countries with GNI per capita below $11,905 are considered to be developing countries. With this criterion, all Central Asian countries, Russia and China are classified as developing countries.

The coefficient estimates for our country dummy variables provide results accurate with our dataset. That is, larger countries like China and Russia emit more carbon dioxide than smaller countries. Considering model (1.4), large industrial-oriented countries such as Russia and China yield larger coefficients for the country dummy variables than those of the five Central Asian countries. This is because Russia and China are much bigger economies than the Central Asian countries. Therefore, they have much higher pollution level than the Central Asian countries. According to the Chinese National Bureau of Statistics, China is the world's fastest expanding economy and has been growing continuously at an average of more than 10% each year since 1980. The abundance in oil, natural gas and precious minerals is the major contributing factor to Russia's economic growth. Although the dissolution of the Soviet Union in 1991 and the Russian Financial Crisis in 1998 resulted in a significant decline in the output level of Russia and its neighboring countries, Russia's economy is still expanding rapidly with great future growth potential. Growing energy powers in Central Asia such as Uzbekistan, Kazakhstan, and Turkmenistan also yield significant negative coefficients on each country's dummy variable because these are much smaller economies when compared to China and Russia, and thus emit much less pollution than those two countries. Kazakhstan is a very important oil exporting nation, Turkmenistan is among the world's largest natural gas exporter and Uzbekistan's economy relies heavily on its cotton and gold production. The smaller and less-industrialized nations namely Kyrgyzstan and Tajikistan, based on the regression results, do not emit as much CO_2 as the others. This is mainly due to the lack of industrialization in these two countries. However, their mountainous geographical characteristic provides Kyrgyzstan and Tajikistan enormous potential for the production of hydroelectric power.

The results from our econometric analysis of the relationship between per capita income and carbon dioxide emissions level using the EKC hypothesis suggested that there is a strong correlation between the two variables. It is important to consider that the economies of Central Asian countries, Russia and China are driven by international trade. More importantly, these countries, with the exception of Turkmenistan, have established regional cooperation and formal economic agreements on a wide range of issues including trade, the Shanghai Cooperation Organization (SCO).

To estimate the effect of a regional trade agreement on the bilateral trade volume of a country and its trading partners, we will use a gravity model. According to the basic gravity model (2.1) introduced in the previous chapter, we can expect the coefficient of the natural logarithmic combined GDP term to be positive under the hypothesis that, as countries become richer, there will be more bilateral between them. The natural logarithmic distance term is expected to be negative because country pairs which are far apart will be less likely to have a large volume of bilateral trade between them.

We will then also add another time variable into model (2.1) in order to capture the trend over time in bilateral trade flows. This addition will help us determine whether the volume of bilateral is likely to increase over time. Therefore, our model can be rewritten as:

$$lntrade_{ij} = \beta_0 + \beta_1 \, ln\left(GDP_i * GDP_j\right) + \beta_2 \, ln \, distance_{ij} + \beta_3 year_t + \varepsilon \qquad (2.2)$$

where *year* represents the years *t* between 1992 and 2008.

Table 4. Gravity Model

Variable	Basic Model (2.1)	Adjusted Model (2.2)
Intercept	10.796*	40.402*
ln (GDP_{export}*GDP_{import})	1.464*	1.475*
ln distance	-1.899*	-1.913*
Year	-	-0.015
R^2	0.716	0.717
F-statistic	2255.55	1505.963
No. of observations	4284	4284

Note: *Statistically significant at the 5% level

The results in Table 4 illustrate the relationship between the level of GDP and the volume of bilateral trade between the Central Asian nations, Russia and China, and their Asian trading partners. From the coefficients in the regression model (2.1), we can see that both the natural log of the combined GDP term and the natural log of the distance variable are statistically significant. We can also ensure that this model corresponds with our prior expectation and also with previous studies by Batra (2004) and Chen (2008) among others. The coefficient on the combined GDP term is positive, which means trading partners trade more goods and services as their income level increases. The negative coefficient on the distance variable confirms that countries which are far from each other have lower amounts of bilateral trade. In model (2.2) the year variable which was introduced in order to capture the time trend has a negative coefficient. This result might suggest that as time passes there is an insignificant decrease in bilateral trade volume between the Central Asian countries, Russia and China and their 30 Asian trading partners represented in the dataset.

After testing the validity of the gravity model, we then extend our gravity equation in order to capture the effect of the establishment of the Shanghai Cooperation Organization (SCO) on the bilateral trade between the member countries. In order to test this, we need to introduce a dummy variable for SCO. Our model for this test can be adjusted as previously denoted in model (2.3).

Over the past few years, there have been several major developments within the countries that are members of the SCO regional agreement that would help strengthen the economic relationships among the members. Some of the major attractions include China's proposal in 2009 at the SCO Leaders' Summit in Yekaterinburg, Russia to sponsor a US$10 billion loan for other SCO members to recover economically following the global economic downturn that began in the summer of 2008. To investigate this recent impact of SCO during the last few years, we will once again readjust our model as follows:

$$lntrade_{ij} = \beta_0 + \beta_1\, ln\left(GDP_i * GDP_j\right) + \beta_2\, ln\, distance_{ij} \qquad (2.4)$$

$$+\beta_3 year + \beta_4 SCO_t + \beta_5 (year06 - 08) * SCO_t + \varepsilon$$

where: the variable $(year06 - 08) * SCO_t$ serves as the interaction term to determine the impact of the SCO regional agreement on the level of bilateral trade among the member countries during last few years in the dataset (2006-2008).

Table 5. Gravity Model (continued)

Variable	Extended Basic Model (2.3)	Extended Adjusted Model (2.4)
Intercept	56.583*	58.036*
ln (GDP_{export}*GDP_{import})	1.421*	1.421*
ln distance	-1.689*	-1.688*
Year	-0.024*	-0.024*
SCO	1.544*	1.496*
SCO in 2006-08	-	0.194
R^2	0.726	0.726
F-statistic	1191.094	952.842
No. of observations	4284	4284

Note: *Statistically significant at the 5% level

The results obtained in table 5 show the effect of the SCO regional agreement on the level of bilateral trade among the members of the countries under the agreement. In model (2.3) the coefficient of the SCO variable is positive and statistically significant. This result suggests that the establishment of SCO helps to substantially increase the amount of trade between countries under the agreement. From this model (2.3), it is estimated that the foundation of SCO helped to increase the bilateral trade between the member nations by 368.33%. The same figure when obtained from model (2.4) would estimate the increase in bilateral between the member nations to be 441.95%.

In model (2.4), the results from the regression show that during the final three years of the available dataset (2006-2008), the impact of the SCO agreement on the level of bilateral trade of the member nations during this period of time is not significantly different than it was for the time period from 1996 to 2005. The most reasonable explanation for such a result is that the volume of bilateral between SCO members and non-SCO members is also increasing significantly as well as the volume of bilateral trade among SCO members during these years. The statistical insignificance of the interaction term shows that the effect of the SCO on the level of bilateral trade among the member countries is the same in the earlier period as in the past few years.

From our two previous basic models and their derivatives, we have observed the relationship between per capita income and airborne pollution, and between national income level and bilateral trade. We can now combine the two relationships together and identify the link between the effects of the SCO regional trade agreement on the level of airborne pollution. This link can be investigated by substituting the per capita income variable and its squared term in the EKC hypothesis with the new total bilateral trade variable and its squared term in a particular year *t* from 1992 to 2008.

With this adjustment, we can transform our model (1.3) into a new model as follows:

$$lnCO_2emit_{it} = \beta_0 + \beta_1 tottrade + \beta_2 tottrade^2 + \beta_3 year_t + \beta_4 country_i + \varepsilon \qquad (3.1)$$

where: the variable *tottrade* represents the total amount of bilateral trade among the Central Asian countries; Russia and China in each year *t*; and the remaining variables same as previously defined. And similarly, we introduce a lag of CO_2 emissions as another explanatory variable in this adjusted model.

$$lnCO_2emit_{it} = \beta_0 + \beta_1 tottrade + \beta_2 tottrade^2 + \beta_3 year_t + \beta_4 country_i + \beta_5 lnCO_2emit_{it-1} + \varepsilon \qquad (3.2)$$

where: $lnCO_2emit_{it-1}$ represents the amount of CO_2 emissions from the previous time period.

Table 6. Estimation results of adjusted Environmental Kuznets Curve in Central Asia, Russia and China

Variable	Basic Model (3.1)	Adjusted Model (3.2)
Intercept	261.760*	29.493
Total Bilateral Trade	0.332*	0.084*
(Total Bilateral Trade)^2	-0.004*	-0.001*
Year	-0.129*	-0.014
ln(Lagged-CO_2 emissions)	-	0.781*
R^2	0.796	0.944
F-statistic	66.094	87.573
No. of observations	112	96

Note: *Statistically significant at the 5% level.

The regression result shows a similar outcome to the previous regression using the EKC hypothesis with the per capita income and its squared term as the explanatory variables. The important finding is that all of the explanatory variables in both models (3.1) and (3.2) yield statistically significant results. The positive coefficient of the total bilateral trade among the Central Asian countries, Russia and China confirms the claim that the increase in international trade contributes to the rise in the level of carbon dioxide emissions. The squared term of the total bilateral trade variable has a negative coefficient and is statistically significant. This negative term suggests that it is likely that the inverted-U relationship between bilateral trade and the level of carbon dioxide emissions exists. However, the Russian Financial Crisis in 1998 and the Economic Downturn in 2008 might also contribute to this negative coefficient. In addition, it is also interesting to notice that the total bilateral trade variables as shown in the table above explain carbon dioxide emission better than the per capita income variables as previously tested by models (1.1) and (1.2) since they result in higher R^2 values.

Table 7. Estimates of the Effect of SCO establishment on the trade volume and pollution level in Central Asian countries (except Turkmenistan), Russia and China, 2008

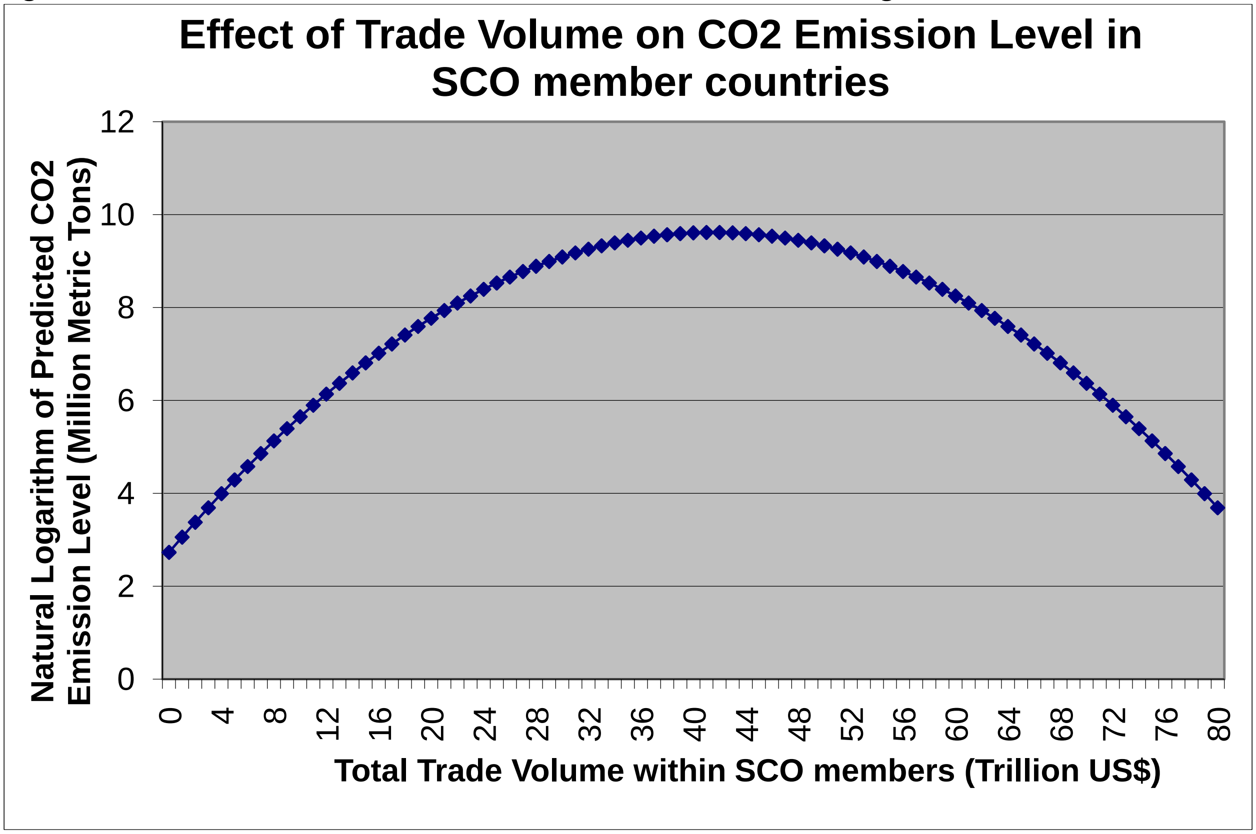
Country	Actual Trade w/ SCO	Predicted Trade w/o SCO	Actual CO_2 Emissions w/ SCO	Predicted CO_2 Emissions w/o SCO
China	71.567	13.205	6533.554	9881.071
Kazakhstan	32.851	6.061	198.896	1.765
Kyrgyzstan	2.911	0.537	5.781	2.716
Russia	67.466	12.448	1729.381	873.886
Tajikistan	1.855	0.342	6.432	3.944
Uzbekistan	5.563	1.026	125.491	31.360

Source: own calculations based on model (2.4)

The figures in Table 7 illustrate the amount of total bilateral trade among the SCO member nations that occurred in 2008. The actual trade amount represents the total bilateral trade that each SCO member country had with other SCO members in 2008. From these figures, we can use the estimates we obtained in model (2.4) to approximate the predicted trade between each SCO member and their SCO trading partners without the effect of the SCO agreement. From the table, we can observe exponential increases in trade volume across all SCO members. Subsequently, we can use model (3.1) to predict the level of CO_2 emissions of SCO member countries without the effect of the SCO agreement.

Considering the predicted level of carbon dioxide emissions of SCO members when excluding the effect of SCO agreement, there are some very interesting observations to note. While the predicted CO_2 emission level for Kyrgyzstan, Russia, Tajikistan and Uzbekistan are considerably lower than their actual emission level, the predicted emission level for Kazakhstan is extremely smaller than the actual emission level. On the contrary, the predicted emission level for China turns out to be higher than the actual emission level.

Figure 7. Predictions of CO_2 in SCO member countries after removing the effect of SCO



The illustration in Figure 7 shows this prediction of the carbon dioxide emission levels in SCO member countries after removing the effect of SCO. Although these predicted values might appear implausible, they still help to explain the carbon dioxide emitting behavior of each SCO member. For China, we observe a higher predicted emission level than the actual level. The explanation for this outcome is that there are other important factors that drive China's airborne pollution emission apart from bilateral trade with its trading partners. On the other hand, Kazakhstan's actual emission level turns out to be astronomically greater than the predicted emission level after eliminating the effect of SCO. This is because when considering the actual and predicted per capita income levels for Kazakhstan (32.851 and 6.061

respectively), these two numbers fall on the steeply rising portion of the curve in Figure 7. Thus, the difference between the actual and predicted levels is enormous.

The outcomes from models (3.1) and (3.2) confirm that income level (here measured by the total trade volume) is an appropriate explanatory variable for the level of airborne emission and suggest evidence of an EKC relationship. This result is consistent with previous studies conducted on the EKC relationship by Grossman and Krueger (1991), Selden and Song (1994) and Shrestha and Timilisna (1996, 1997) among others. However, this result is contradictory to surprising result in the study by Antweiler, Copeland and Taylor (2001) which found that overall freer trade reduces pollution.

Chapter 5: Conclusion

The analyses conducted in this thesis help us to understand the relationship between economic growth, international trade and environmental quality, as we are witnessing an increasing concern about the impact of economic growth, trade and regional trade agreements on pollution. Throughout the analyses, we sought to determine the relationship between income, trade and airborne pollution in the Central Asian countries, Russia and China. The first relationship we test is between per capita income and the level of carbon dioxide emissions under the EKC hypothesis. The empirical results suggest that there might be such a relationship in the Central Asian countries, Russia and China. However, since the per capita income levels of these countries are still on the rising portion of the EKC curve, it is difficult to determine the long-run pattern of this relationship.

The other connection we have analyzed is the effect of regional cooperation – Shanghai Cooperation Organization (SCO) - on the level of bilateral trade between the member countries using the gravity model. The results suggest that the establishment of the SCO contributes to a substantial increase in trade among the members according to the organization's aim to promote economic cooperation in the region.

Finally, we have observed the effect of the growth in bilateral trade among the Central Asian countries, Russia and China, and its impact on the level of carbon dioxide emissions in these countries. This result helps highlight the direct impact of a regional trade agreement on the volume of bilateral trade between the trading partners, and the indirect impact of output income growth on the level of airborne pollution in these countries

The results obtained in this thesis have highlighted the impact of the growing international trade on the environmental quality. The analysis conducted in this thesis has shown that for dominantly trade-driven countries like Russia, China and the Central Asian countries, whose economies are highly dependent on trade, trade level (as a measure of economic growth) captures the relationship between income level and environmental pollution.

This thesis hopes to address the growing concern on the level of airborne pollution in rapidly growing economies, especially those heavily driven by their large industrial and energy sectors such as Russia and China. Statistical data have pointed out that the emphasis on economic success has overshadowed the awareness of the surrounding environment. The economies of the Central Asian nations, particularly Kazakhstan, Kyrgyzstan and Tajikistan, are in the transitioning process from the centrally-planned economic system inherited from the Soviet era to the free market economy system. Due to this transition, the governments of these countries tend to focus more on creating short-term economic impacts rather than building an integrated sustainable development system for the long run (Pomfret 2006; Najman et al. 2008). Therefore, it is crucial for the governments of the Central Asian countries, Russia and China to orchestrate the most suitable path to create a sustainable development environment while maintaining their economic expansion and maximizing their valuable natural resources.

There are several possibilities for the development and future studies for this thesis. Given the different levels of the economic and social openness of the Central Asian nations, it is interesting to investigate the effect of economic system and government regime on the level of pollution of these countries. It is also worth exploring how trading partners which share similar economic structures and have close trading relationships with Central Asia, Russia and China such as Azerbaijan, Iran, Ukraine and Turkey affect the pollution level of these countries. Moreover, bilateral trade variable used to test EKC might be substituted with share of exports in GDP or ratio between exports and GDP.

This thesis has performed another quantitative study on the trade relationship in the Central Asian region using a gravity model. While Chen (2008) uses a cross-sectional dataset, the dataset used in this thesis is a panel dataset from 1992 to 2008. This thesis examines the EKC relationship in Central Asia, which has never been previously conducted. It also finds that for energy and trade driven economies like the Central Asian countries, Russia and China, trade is a better explanatory variable to describe airborne emission behavior than their per capita income level. And most importantly, it highlights the fact that the establishment of a regional agreement, in this case the SCO, has contributed to the increase in airborne pollution in the region. Therefore, countries forming a regional agreement might need to consider including environmental commitments into their agendas as well.

Appendix A

Figure 8. Map of Central Asia

Source: Najman, B. et al. (2008). *The Economics and Politics of Oil in the Caspian Basin*

Appendix B

Table 8. Variable Definitions and Sources

Variable	Definiton	Source
Per capita GDP	GDP per capita, constant 2006 prices Based on PPP (US dollars)	www.imf.org
Per capita GDP^2	GDP per capita, constant 2006 prices Based on PPP squared (US dollars)	www.imf.org
GDP	GDP, constant 2006 prices (billions of US dollars)	www.imf.org
GDP^2	GDP, constant 2006 prices (billions of US dollars)	www.imf.org
Bilateral Trade	Total bilateral trade among SCO members (trillion of US dollars)	www.imf.org
Bilateral $Trade^2$	Total bilateral trade among SCO members (trillion of US dollars)	www.imf.org
Distance	Estimated distance between two countries (kilometers)	www.cepii.fr
CO2emit	CO2 Emission calculated based on fuel consumption (million metric tons)	www.iea.org
Year	Time effect	
CHN	dummy variable: China	
KAZ	dummy variable: Kazakhstan	
KGZ	dummy variable: Kyrgyzstan	
RUS	dummy variable: Russia	
TJK	dummy variable: Tajikistan	
TKM	dummy variable: Turkmenistan	
UZB	dummy variable: Uzbekistan	

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