Effect of Economic Growth, Trade Openness, Urbanization, and Technology on Environment of Selected Asian Countries

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Abstract

The aim of this study is to examine the impact of trade openness, urban population, technology and economic growth on environment of Asian economies i.e. Bangladesh, Hong Kong, India, Indonesia, Iran, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, and Thailand. The specific objectives of this study are tend to evaluate the effect of trade openness, technology, urbanization and economic growth on surroundings and environment (CO_2 and SO_2 emission). This study measures environmental effect through Stochastic Impact by Regression on Population, Affluence, and Technology framework in selected Asian developing countries. Data covers the time period from 1980 to 2014. This study utilize panel unit root, panel cointegration, DOLS estimator and causality tests in order to establish the association between environment and selected macro-economic variables. The results obtain from carbon dioxide emissions model show the significant impact of growth and technology on carbon emissions. While results of sulfur dioxide emissions model indicates the existence of inverted U-shaped EKC hypothesis. The study concluded that there should be research and development programs at public and private level to control pollution through new technologies.

Keywords: Trade, Population, Technology, Growth, Environment, Panel Data, Asia

JEL: C23, F62, O44, O53

1. Introduction

The relationship between public spending and national income has been an important subject of It is more often to claim that humanity can develop without causing damage to nature. Over the last few years, considerable changes occur in social and economic indicators i.e. culture, growth, free trade, technology and urban population. Human Development Report (2015) stated that people and economic growth are related towards downturn in major environmental indicators such as sulfur dioxide, carbon dioxide and manipulation of natural raw material. The economic growth, urbanization and free trade increase the pressure on natural resources (Mitra Ankita, 2015). It's fascinating to see how technology, trade openness, urbanization, economic growth, and environment are working together and against each other at the same time at any given instance. The idea of trade openness was conceived after World War II and slowly the idea became a theory, and later the theory was put to practice. By mid 1980s the practice matured and accelerated by including technological advancement that lowered the cost of transportation and communication. Since 1990, trade has increased in many Asian countries from 20 percent to 50 percent while GDP by 2.5 to 4.9 percent annually (Trade and Development Report, 2015) and Human Development Index (HDI) increased from 0.520 to 1.38 percent (Human development report, 2015). Many governments trying to protect their economies from international competitions and influence different forms of tariffs. But in 2015, according to the World Bank, the world merchandise exports exceeded from $17 trillion.

From the last three decades the connection of growth, free trade and environment has receive increased attention by many economists, environmentalists and policymakers. The critics of economic development and trade openness argued that the inadequate point of view of economic growth and trade liberation are emerging. Beside this people also see a systematic damage of earth's natural resources. Some environmentalists declared that people in a hundred years earlier would be seven times healthy and well as we are today. If a linear link between environmental degradation and economic growth is found, then environmental condition will continue to get worse with economic growth. (Akbostanci et al., 2009; Akin, 2014; Amin et al., 2009; Club of Rome, 1972; Javad et al., 2014). As trade increases, the consumption of fuels also increases which are heavily used in generation of energy and in transport (Javad et al., 2014). The low level of income per capita points toward terrible environmental degradation (Frankel and Professor, 2008).

The proponents of the free trade and economic growth argued that according to the neo-classical economic theory, trade increases the welfare of participants (Hossain, 2011; Dean, 2002). The Environment Kuznets Curve hypothesis says at the preliminary level of economic development, environmental quality starts to mitigate because of raise in greenhouse gas emissions, as the economy grows the gases begins to reduce and environmental condition become refines, making an inverted U-shaped curve (Dean, 2002; Dimitrios et al., 2003; Inam and Khalil, 2006; Grossman et al., 1995; Graciela, 1994; Kaufmann et al., 1993; Narayan et al., 2010).

As trade openness and economic growth accelerates, population is going through a phase of transformation from rural to urban areas; in 2014 the world's urban population was greater than 54 percent and projected to be 66 percent in 2050 (United Nation Population Fund, 2014). There are two stances on urbanization, technology and environment relationship, the first stance advocates that technology has a positive and significant effect on environment that slowly diminishes our humanity and human beings are getting all the technological advancement for all the wrong reasons (Mitra Ankita, 2015). A massive growth in urbanization needs vast use of energy, vehicles, and construction material which creates pollution i.e. SO_2 and CO_2 emissions, urbanization and the environmental condition is not good in short run (Shen et al., 2005; Javad et al., 2014; Kasi and Sami.2016; Li et al., 2016; Wang et al., 2016).

The second stance advocates that the technology is a way of bringing the world closer and helps to resolve problems. It is found that emissions rise with output growth but fall with on-going technological progress, it has been also found that technology in many countries have decreasing pressure on CO_2 emission (Brock and Taylor, 2010; Kang et al. ,2016). The association between environment and urbanization indicated that the environmental quality is better in advanced countries and not any harmful impacts on their natural resources (Ozturk et al., 2016; Ulla, 2010). Furthermore, a few analytical results indicated an EKC hypothesis between urbanization and environment quality which pointed out the presences of inverted U-shape curve between carbon emissions and urbanization within the STIRPAT framework (Akbostanci et al., 2009; Amin et al., 2009; Assadzadeh et al., 2014; Cole and Neumayer, 2004; Kasi and Sami, 2016, Wang et al.,2016).

This study will examine the relationship of trade openness, economic development, technology and urbanization, on environment of Asian countries (i.e. Bangladesh, Hong Kong, India, Indonesia, Iran, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, and Thailand) from 1980 to 2014. The study has the following specific objectives: to analyze the effect of openness, economic growth, technology, and urban population on CO_2 emission, to analyze the effect of economic growth, trade openness, technology, and urbanization on SO_2 emission, and to analyze the casual relationship of economic development, trade openness, urbanization and technology on environment (CO_2 and SO_2 emissions). This study examine CO_2 and SO_2 emissions, economic growth, free trade, technology and urban population through the STIRPAT within the framework of Environmental Kuznets Curve hypothesis in selected Asian developing nations. Particularly, the effect of technology on environment has come least under consideration in Pakistan and other selected Asian countries.

Augmented STIRPAT model has extended to find the impact of economic expansion, trade openness, urbanization, and technology on environment. Panel data for eleven Asian countries from 1980 to 2014 at annual frequency has been utilized. For the analysis we have selected largest Asian developing countries. Some countries are selected from the different economic communities like SAARC and ASEAN in order to see whether these countries are pollution heavens? The problem of data limitation also falls in the selection of countries. The study primarily follows Erlich and Holdren (1971) basic IPAT model and then augment it for incorporating factor urbanization and technology. The study has used panel data framework because the panel data estimates are better than cross section and time series data. Panel data framework increases the efficiency of econometric estimates by reducing collinearity among independent variables through large degree of freedom. This study has used panel cointegration and causality tests that assess the long term connection between variables (Gujarati, 2005).

The rest of the thesis is structured in the following way. Previous literature is discussed in section 2. Model, methodology and data are described in section 3. The empirical results are analyzed in section 4. Section 5 contains conclusion, limitations and policy recommendation.

2. Literature Review

2.1. Effect of Economic growth and Openness on Environment

Sweiter et al. (1993) examined the effect of NAFTA on the nature and atmosphere of three economies (USA, Canada, and Mexico). The study utilized panel data from 1980 to 1991 and using comparative advantage for analysis. The result indicated that, as economic growth and trade occurs, first environmental condition starts to mitigate, but as per capita income increase pollution decreases. However, high level of income give refine and better environmental conditions. Chichilnisky (1994) studied why developing countries specialize in the export and production of the product which effects the natural resources. Dividing the world in two regions North and South, the countries taken an account are USA, Germany, England, Latina American and Africa. Heckscher - Ohlin comparative advantage is well used, by making different proposition. The results indicated that South region has pollution intensive. The study that concluded through government policies and private enterprises intentions it is hope that South environmental issues will be better. Antweiler et al. (2001) examined how trade liberalization effect environment level of different economies? The panel data used for less developed countries from 1980 to 1996 and for developed countries ranged over 1971 to 1996, employed scale, composition, technique effect. The results showed that free trade has an impact on environment, it might be little or large vary from country to country. Therefore, it can be concluded that trade openness effect the environment in all countries.

Alexandrovich et al. (2003) studied impact of income on environment. Paper used panel data of EU countries (2000). The OLS estimator has been used for estimation. The results showed that countries with low per capita income have low level of environmental quality and the EU countries with high level of income have better environment conditions. It concluded that a countries with higher level of income wants clean environment. Stern (2004), explored the history of Environmental Kuznets Curve hypothesis by using ordinary least square estimator, the data of advanced and developing nations for the year 2002. Results indicated that sometimes developing countries performed better but the results were not supported Environmental Kuznets Curve hypothesis EKC. Thus by exercising modern methods of manufacturing countries should be able to get development and also protect their environment. Inam and Khalil (2006) explored the effect of trade and different variables (exports, population, FDI, GDP and land) on environment of Pakistan. Time series data covered the time span from 1972 to 2000. Augmented Dickey – Fuller and Johansen test and VAR model employed. The results indicated that variables has significant impact on environment. It is concluded that government protect the environment and as well promoting sustained economic growth.

Abdulai and Ramcke (2009) investigated effect of economic development and free trade on carbon dioxide emission. Panel data of low and high level income nations utilized period of 1980 to 2003. The study employed fixed and random effect models on low level-income and high level-income nations for estimation. Results showed that there is an Environmental Kuznets Curve hypothesis present in many countries. In many high level-income countries free trade is insignificant effect on carbon dioxide emissions but in low-level income countries free trade has significant impact on CO_2 emissions. Thus, the study concluded that low level income nations are facing more pollution then high level income economies. Akbostanci et al. (2009) explored the relationship of environment and income per capita in Turkey. Study used both panel and time series data from 1968 to 2003 covers fifty eight Turkish provinces. The unit root tests and GLS tests have been used for analysis. The findings of the study showed that pollution and income variables has long run cointegration in time series, and panel data suggested that air emissions increase as income increases. These findings given support to the view that income (GDP per capita) is the main reason of environmental degradation. Amin et al. (2009) analyzed the impact of energy use and economic growth on environment of Malaysian economy. They used time series data of Malaysia from 1999 to 2000. Leontief inverse method showed that the mix fuel strategy higher the level of CO_2, SO_2 and NO_2 emissions due to which air pollution is occurred. It is concluded that reviewing the energy strategies help to make the environment safe.

Herpel and Frankel (2009) studied is globalization worse the environmental conditions? The study used the cross-country data of developed countries of 1990 and employed OLS estimator. The results showed that cross-country data found no detrimental effects of trade and economic growth on environmental degradation in developed nations. The environmental problems could be effectively addressed if each country would not give its national sovereignty in the hands of the World Trade Organization (WTO). Lean and Smyth (2009) explored the association between economic development, carbon dioxide emissions and energy consumption from 1980 to 2006 in five ASEAN countries. The methods of panel cointegration and vector error correction model used for estimations. Results indicated that significant and positive relationship present between energy utilization and environment. A non-linear association found between emissions and output, the results supported the EKC hypothesis. The unidirectional causality exist between emissions and electricity in short-term. Further, it is advised that to get rid of pollution it is necessary to reduce the energy consumption which leads to increased carbon dioxide emissions. Narayan et al. (2010) explored that the carbon dioxide emission reduces as the income per capita grows by estimating long and short term income elasticities. The data collected from 43 countries of different regions for 1980 to 2004, employed unit root tests, and non-parametric approach. The results showed, in Middle East and East Asia the pollution is low in long run as compared to remaining three regions. However, reducing emissions in Middle and East Asian regions offers opportunity for more improvement in environmental conditions.

Ulla (2010) analyzed does the liberalization of trade effect environment in developing countries? To measure the trade and population effects on environment study used panel data through comparative advantage. The study explored, after a rapid increase in emissions, the increase of total emissions is now slowing down refer the presences of Environmental Kuznets Curve hypothesis. But to get rid of pollution additional applications are needed. Hossain (2011) investigated the relationship between different elements such as (urbanization, energy usage, economic growth and free trade) and CO_2 emissions. The paper used panel data of nine newly manufacturing nations over the period 1971 to 2007. For empirical analysis different panel tests have been performed. The results suggested the cointegration among variables and energy consumption in the sample countries increased carbon dioxide emissions. But all explanatory variables are found to be normal good in the long term, thus it is concluded that the findings of this paper can be helpful in designing the appropriate policies for environment. Pao and Tsai (2011) addressed the effect of finical development and economic growth on nature. Panel unit root, cointegration techniques have been used from 1980 to 2007. The Johansen test reported the cointegrating among variables and causality between variables. It is concluded that the main explanatory variables that are economic growth and financial development require energy for production, which create emissions.

Zhang and Gangopadhyay (2012) investigated how trade effect the environment of Yangtze River Delta in China. The paper used panel data of China's cities over the period of 2004 to 2007, by incorporated composition, scale and technique effects. The study found that increase in exports and income has a bad impact on environment. Therefore, trade is not the cause of environment degradation. Akin (2014) explored the long run connection among free trade, economic growth, energy consumption and environment. The panel data of eighty five countries for the time period 1990 to 2011 were used. Panel cointegration and causality analysis were employed. Results showed positive relationship between carbon dioxide emissions and energy consumption, also between per capita income and trade liberalization. Results also indicated the presences of cointegration between variables. The study concluded that all explanatory variables accelerates the pollution.

2.2. Effect of Urbanization and Technology on Environment

Panayiotou's (2000) studied the effect of growing population on natural resources. The panel data of OECD countries were used from 1970 to 1990 by using OLS estimation technique to measure the IPAT model. The results indicated the mixed relationship between carbon dioxide emission and population. It is concluded that governments should introduce new technologies which help to decrease the pressure on natural resources and clean environment which is important for growing population. Cole and Neumayer (2004) analyzed air pollution and urbanization factors. The study utilized 86 countries from 1977 to 1990 for CO_2 emission and SO_2 cover 54 countries from 1971 to 1990. The study employed the OLS method. In the case of CO_2 model, the elasticity of carbon emissions with respect to population is equal to unity and in SO_2 model the population-emissions elasticity is rise rapidly as population increases. Thus it is concluded that carbon dioxide emissions has great impact on environment as compared to sulfur emissions. Dietz et al. (2006) examined the effect of population, urban population, modernization, and wealth on CO_2 emissions in European Union countries. The study used the panel data over the time period 1975 to 1999, by using STIRPAT model through OLS estimator. Results indicated that population growth, energy sector has a significant impact on CO_2 emission. Therefore, the study concluded that to deal with these driving forces of pollution countries require drastic reforms in these sectors to bring pollution down.

Feng and Lantz (2006) analyzed the different factors which create CO_2 emissions in Canada. The study used provincial level panel data of five Canadian regions, over the period 1970 to 2000. The study employed GLS econometric method, Durbin-Watson test and fixed effect for estimations. The results indicated, population positively contributed to fossil fuel consumption which directed to increase in the CO_2 emissions. And technology also changed its pattern from negative to positive. Hence, the findings of this paper suggested that main reason of carbon dioxide emissions in Canada is the fuel utilization. Richard and He (2009) tested the EKC hypothesis for per capita income and CO_2 emissions in Canada. Time series data cover period from 1948 to 2004 and non-linear parametric model were used. The empirical results suggested that the share of industrial production negatively affect environment but there is no clear evidence of EKC hypotheses, because of oil shock in 1970s the less polluting production methods were ignored. It is concluded that new production methods increase the profit of individuals which provides the base for good environmental conditions. Taylor and Brock (2010) tested the environmental analysis with the help of Solow growth model. The study used OPEC members by using OLS estimator. Results indicated that emissions increase with growth but reduce with technological progress. Yet it is concluded that the induction of new technologies are useful for environment.

Mason (2011) explored the relationship of population size and carbon emissions. Panel data set of OECD economies from 1990 to 2007 and fixed effect method were used. The results suggested that there are environmental advantages for countries projected to decrease in population size, such as Germany. The results also indicated that in place of increasing fertility rates, it is far better for environment friendly countries to meet pollution challenges by increasing the retirement age, raising productivity and training the long-term unemployed. The study concluded that government should revisited their policies. Menz and Kuhling (2011) studied the relationship between population aging and SO_2 emission. Panel data of 25 OECD countries collected from 1970 to 2000.The fixed effect model was used. Results indicated that the association between sulfur dioxide emissions and population is positive. It is concluded that as aging factor increased, air pollution also increased. Abdullah et al. (2013) investigated the power consumption effect on environment. Through GMM estimator the panel data of twenty three economies evaluated, from 2000 to 2011. The results showed the unidirectional casual association between GDP and power usage and energy consumption has significant effect on environment. Conclusion can be drawn from results that energy use is not environment friendly.

Chandran and Tang (2013) analyzed the effect of transportation sectors, FDI, and energy consumption on CO_2 emission for five ASEAN countries. The empirical period covered from 1971 to 2008.For the estimation this study used panel cointegration and causality test. Results found that energy and FDI expansion hypotheses are valid in Indonesia, Malaysia, Singapore and Thailand. They concluded that countries environment gets better with the passage of time. Javad et al. (2014) explored the effect of economic development, urbanization and energy usage on carbon dioxide emissions. The paper covered the time period from 1980 to 2012. The study employed GMM method. The result showed a long run link between urban population, income per capita, and gasoline use on CO_2 emissions. Carbon dioxide emissions create harmful effect in the form of global warming and risks of climate change. Chen et al. (2015) examined the effect of modern technological changes and economic expansion on the nature of China. Panel data of China's provinces used and applied GLS estimator to test the EKC hypothesis. Study indicated the presence of EKC hypothesis between CO_2 emission and income. Moreover, energy efficiency, energy structure, and industrial structure have a significant effect on CO_2 emissions. It is concluded that energy sector is the main source of environmental degradation.

Dogan and Turkekul (2016) analyzed the link between carbon dioxide emissions, finical development, energy consumption, trade, real output, and urban population. Time series data of USA employed from 1960 to 2010. The study used unit root, ARDL, and ECM for estimations. Study showed that there are enough evidence of unidirectional causal link between GDP and energy usage and casual link also moving from financial development to output. Furthermore, energy policies contributes to reduce CO_2 emissions without damaging sustainable growth. Javid and Fatima (2016) studied the relationship between power consumption, banking development, free trade and pollution. Study used the data of Pakistan from 1971 to 2013 Pakistan. The study used the methodology of ARDL and causality. The energy structure and finical development are increased at the cost of environment degradation, but free trade has insignificant impact on environment. Kang et al. (2016) explored the impact of urbanization on the environment of China. Panel data of thirty five provinces of China used from 1997 to 2012. The methodology of Random and Fixed effect estimation technique were used. Results of study showed that energy structure, income per capita, and urbanization are positive significant effects on CO_2 emissions, while trade openness has negative effect on CO_2 emissions. Moreover, results concluded that decrease in carbon dioxide emissions is related to control urbanization, income per capita and energy use.

Kasi and Sami (2016) investigated the impact of economic growth, energy use, urban population and trade on carbon dioxide emission. The study covered panel data of 58 economies over the period of 1990 to 2012. The study used Generalized Method of Moments estimator. Trade and urban population have the negative effect on environment. Moreover, outcome of estimations also indicated the existence of an inverted U-shaped curve between carbon dioxide emissions and GDP per capita. The study concluded that as economic growth accelerates the environmental conditions start improving. Li et al. (2016) studied the EKC hypothesis not only for CO_2 emissions, but also for waste water emissions and solid waste emissions. A panel data of China's

28 provinces over the period of 1996 to 2012. The study employed the GMM approach, auto-regressive distributed lag, Mean Group estimator, Dynamic Fixed Effects estimator and the Pooled Mean Group estimator for estimations. The study explored trade openness and urbanization effect the environment in long run. They concluded that government should control the urbanization rate.

Ozturk et al. (2016) examined the Environment Kuznets Curve hypothesis. The panel data of OCED countries covered the time period of 1990 to 2012 by using panel unit root test, co-integration, Granger causality, and VECM approaches. Result showed urbanization, GDP, and energy consumption increased the CO_2 emission. More trade and use of renewable energy are good to fight against global warming in these countries. The study concluded that main emphasis should be on an extensive use of renewable energy in order to reduce the possibilities of pollution. Wang et al. (2016) investigated the Environment Kuznets Curve hypothesis for SO_2 emissions, urbanization rate and economic expansion. The study used a panel data of Chain provinces from 1990 to 2012, by using panel fixed effect models. The results suggested that SO_2 emissions increase in an initial stage of economic expansion and after a certain point sulfur dioxide emissions began to decrease as country become wealthy. The study concluded the existence of EKC hypotheses among sulfur dioxide emissions, economic growth and urbanization.

Although a rich and wise literature is available on environment but mostly the studies are conducted to measure the impact of economic growth, urbanization and trade liberalization on environment. Few studies analyzed the effect of technology on environment especially for Asian countries. Therefore, it is an important to discover all these factors which effect the environment of the Asian countries.

3. Model, Methodology and Data

3.1 Model

Erlich and Holdren (1971) proposed a conceptual framework to analyze the different factors which effect the environment through the IPAT equation.

$$\mathbf{I = f\,(P, A, T)} \qquad \mathbf{(1)}$$

Where, I is environmental impact, P is population, A is affluence, and T is technology

The IPAT equation shows how different factors effect the environment. However, in the early 1990's the world focuses was shifted towards the climate change (Rutlan, 1993).In the new world's environment scenario the IPAT framework has influenced by the impact of urban population, age compositions and other demographic factors on gas emissions (Pebley, 1998).

Dietz and Rosa (1994) derived a stochastic version of the IPAT equation and variables are: affluence (A), industry as a proxy of the technology (T), and population size (P). For econometric and statistical analysis they introduce STIRPAT model. It check the role of population size, age composition and urbanization rate (demographic) variables on carbon dioxide emission the first specification is present by the following equation:

$$\mathbf{I_i = a\, P_i^{b}\, Ai^{c}\, Ti^{d}\, e_i} \qquad \mathbf{(2)}$$

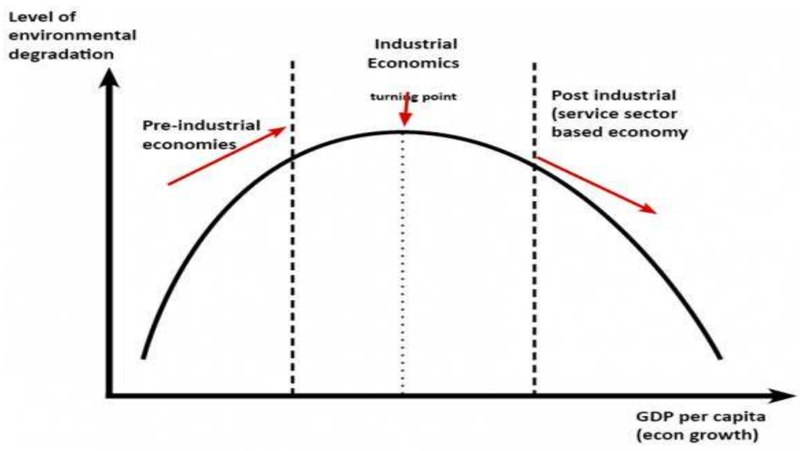
Where, I is the environmental impact, P is population, A is affluence, T is technology, and E is error term.

York et al. (2003) included a quadratic version of affluence to test the Environmental Kuznets Curve (EKC), which assumed to show the inverted u shaped relationship between the economic growth, income, and environment. They in cooperated a new variable in quadratic term that is urbanization (modernization) that effect the environment in many ways i.e. the use of fossil fuels in the form of energy consumption and in vehicles.

3.1.1. Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) is frequently used to explain the association between environment and economic growth. The curve can be expressed as follow: as GDP per capita grows, so does environment deteriorate. However, after attain a certain level, increase in GDP per capita leads to decrease environmental degradation. Particularly:

- At low level of income pollution decline is unwanted as individuals are comfortable using their restricted income to encounter their basic consumption necessities.
- When a particular level of income is obtained, people start feeling the trade – off between consumption and environmental quality.
- The individuals prefer to upgrades environmental condition over more consumption, and environmental quality starts to improve parallel with economic growth. All these three conditions can well defined through following figure.



The progress pattern of any economy is represented by the changing forms of economic activity. Firstly, society put resources in the primary sector i.e. agriculture and extraction. Secondly, resources are shifted to the secondary sector i.e. industry and manufacturing, as essential needs are fulfilled and more consumption is concentrated on consumption goods. Lastly, population moves from the secondary to the tertiary category i.e. services sector which characterized by lower level of pollution.

3.2. Methodology

3.2.1. Econometric Model

3.2.1.1. Basic Econometric Model

Cole and Neumayer (2004), examined the impact of demographic factors on air pollution (SO_2) by using IPAT and STIRPAT models. They expressed equation 2 in logarithmic form as:

$$\ln I_{it} = \alpha_i + b(\ln P_{it}) + c(\ln A_{it}) + d(\ln T_{it}) + \varepsilon_{it} \quad (3)$$

Where, I measures carbon or sulfur dioxide emission, T measures energy intensity (proxied by total energy use per unit of GDP) or manufacturing share, P measures population size, age composition and urbanization rate, and **ε** is error term.

Wang et al. (2016) purposed two types of the STIRPAT model to test the inverse U- shaped relationship between urbanization, economic growth, and sulfur dioxide emission. In their models, except urbanization all other explanatory variables are in logarithmic form, for direct interpretation in elasticites. Within the Environmental Kuznets Curve (EKC) hypothesis the two models are estimated as follow:

$$lnSE_{it} = \alpha_i+\beta_1 lnP_{it}+\beta_2 lnA_{it}+\beta_4 lnEI_{it}+\beta_5 UR_{it}+\beta_6 UR^2_{it}+T_t+\varepsilon_{it} \quad (4)$$

$$lnSE_{it} = \alpha_i+\beta_1 lnP_{it}+\beta_2 lnA_{it}+\beta_3 (lnAit)^2+\beta_4 lnEI_{it}+\beta_5 UR_{it}+T_t+\varepsilon_{it} \quad (5)$$

Where, SE_{it} is the amount of sulfur dioxide emission, P is population, A is GDP per capita, UR is urbanization level, EI is energy intensity, T is time varying omitted variables and stochastic shocks that are common in all countries, and **ε** is the error term.

3.2.1.2. Econometric Model for Carbon Dioxide Emissions

The present study pursues with the model of Cole and Neumary (2004) for CO_2 emissions and includes trade openness as an explanatory variable as:

$$lnI_{it} = \alpha_{it}+\beta_1 lnP_{it}+\beta_2 lnA_{it}+\beta_3 lnT_{it}+\beta_4 lnTO_{it}+\varepsilon_{it} \quad (6)$$

Where, I_{it} is carbon dioxide emission, P_{it} is urbanization rate, A_{it} GDP per capita, T_{it} is energy use, TO_{it} is trade openness, and **ε** is error term.

3.2.1.3. Econometric Model for Sulfur Dioxide Emissions

Sulfur dioxide emission, utilize Wang et al. (2016) STIRPAT model within the Environmental Kuznets Curve (EKC) hypothesis framework model as:

$$lnSE_{it} = \alpha_i+\beta_1 lnP_{it}+\beta_2 lnA_{it}+\beta_3 (lnA_{it})^2+\beta_4 lnT_{it}+\beta_5 lnTO_{it}+\varepsilon_{it} \quad (7)$$

Where, SE_{it} is sulfur dioxide emission, P_{it} is urbanization rate, A_{it} is GDP per capita growth, A_{it}^2 is square of economic growth, T_{it} is energy use, TO_{it} is trade openness, and **ε** is error term.

3.2.2. Panel Data Framework

This study employs panel data because it provides an immense number of data points (N, T), decreases the collinearity between independent variables and enhancing the degrees of freedom which further enhance the capability of econometric estimations. More importantly, longitudinal data eligible to analyze a number of integral economic queries that cannot be addressed using cross-sectional or time-series data. Panel data allow a means of resolving the econometric complications that often arises in empirical studies, which raise because of excluded variables that are associated with explanatory variables (Gujarati, 2005).

3.2.2.1. Panel Unit Root Test

In panel cointegration, the first step is to examine whether the variables contain a panel unit root. Variables which contains unit root is further investigated by the panel cointegration. There are several forms of unit root test:

- Levin, Lin & Chu
- Im, Peasaran and Shin
- ADF – Fisher

Levin and Lin (1992), presented a unit-root test which based on pooled cross-section data. This test is better choice for researcher as compared to separate unit-root tests for each variable, it can give substantial development in statistical function. The LLC test consider when number of countries (N) lies between 10 and 25 and time period lies between 5 and 250. Im, Pesaran and Shin (2003) introduced the test statistic in which the variables under consideration for countries N over the time period T are normally categorized with zero mean and finite heterogeneous variance. Test is based on pooled regressions and IPS test is a generalized form of the LLC tests. The Fisher (2003) test is an exact (explicit) test. The validity of the test depends on the T which going to infinity. ADF test assume that the error terms are uncorrelated. But when the error term is correlated ADF presented an augmented unit root in which they amplified their previous unit root test by adding the lags of the dependent variable on the right hand side.

3.2.2.2. Panel Cointegration

Same order of integration show the validity of panel cointegration. For several important hypothesis various cointegration methods have been adapted.

3.2.2.3. Panel Co- integration Tests

There are two types of panel cointegration tests:

- Residual based tests
- Maximum likelihood based test

There are different forms of residual based tests:

- Pedroni (1999,2004)
- Kao (1999)

3.2.2.4. Pedroni Test

Pedroni (1995) purposed the panel cointegration test to enhance the procedure in the case of multiple variables. There are four within-dimension-based statistics (i.e. panel-*v*, panel-*ρ,* semi-parametric panel-*t* and parametric panel-*t)* statistics. And three between-dimension-based statistics (i.e. group-*ρ,* semi-parametric group-*t* and parametric group-*t*) statistics. The regression is estimated by the OLS technique. The Pedroni is based on Engle-Granger (1987) two-steps cointegration test. The results of Pedroni test are interpreting through the p- values of v- statistics and ρ group-statistics etc.

3.2.2.5. Kao Test

The Kao test mostly follows the basic approach of Pedroni test, but indicates cross-section specific intercepts and homogeneous coefficients on the first-stage regressors. Kao proposed DOLS estimator of Saikkonen (1991) and the fully-modified OLS (FMOLS) estimator of Phillips and Hansen (1990) for estimations.

3.2.2.7. Johansen Cointegration Test

The properties of Johansen test are asymptotic such as large samples. If sample size is too small, then outcome would not be dependable. In this test all the variables are considered as endogenous. Johansen cointegration methodology is employed to check long-run relationship within vector error-correction model.

3.3.2.8. Vector Error-Correction Model (VECM)

If variables have presences of long-run association, then causality test will perform within the framework of VECM by differentiating the short and long run causality. Long-run causal association is measured by significance of t tests of lagged ECT, which contains long-term information which is derived from long-run cointegration association.

3.2.2.9. Causality Analysis

When the presence of cointegration among the variables is confirmed but it does not explain that which variable cause the other. Causality indicated the relationship among variables in at least one direction. However, to analyze the short run relationship among the variables the causality test has been applied using a Wald test.

3.3. Data

This study uses data of eleven Asian countries i.e. Pakistan, India, Bangladesh, Indonesia, Thailand, Malaysia, Philippines, Sri Lanka, Iran, Singapore, and Hong Kong from 1980 to 2014. Due to the unavailability of data for all Asian developing countries the study focuses on only eleven countries. The main sources of data are "World Development Indicators", published by the World Bank, International Energy Agency, and Pakistan Economic Survey. Detailed description of variables and their sources are given in Appendix A.

4. Results

4.12. Panel Unit Root Test

In the panel data testing for the degree of integration is must because regression results may be ambiguous if the variables are not stationary. This study used Levin, Lin and Chu (LLC, 2002), Im, Peasaran and Shin (IPS, 2003) and ADF Fisher (2003), unit root test to examine the order of integration. The lag is selected through Schwarz criteria. The results of unit root test results are showed in table 4.1.

Table 4.1: Results of Panel Unit Root Test

	LLC		**IPS**		**ADF Fisher test**		**Order of Integration**		
	Level	**1st difference**	**Level**	**1st difference**	**Level**	**1st difference**	**LLC**	**IPS**	**ADF**
Ln CO_2	-3.6994***	-	0.3790	-13.6276***	40.436**	-	I(0)	I(1)	I(0)
Ln P	-1.7482**	-	4.2578	-3.130**	33.788**	-	I(0)	I(1)	I(0)
Ln A	4.7533	-9.4856***	6.8264	-8.6518***	5.2011	118.425**	I(1)	I(1)	I(1)
Ln FIXED	-4.5600***	-	-0.4841*	-	36.101***	-	I(0)	I(1)	I(0)
Ln T	1.3386	-14.3498***	4.4245	-13.5925***	11.0264	191.65***	I(1)	I(1)	I(1)
Ln TO	0.2485	-13.8999***	1.0682	-14.7910***	38.4446**	-	I(1)	I(1)	I(0)
Ln SO_2	-3.3394	-	0.0668	-16.8530***	27.3630	232.32***	I(0)	I(1)	I(1)
$(Ln A)^2$	5.3372	-9.4576***	7.4371	-8.6251***	4.0795	117.90***	I(1)	I(1)	I(1)

*Note: ***,**,and * shows significance at 1%, 5%, and 10% level respectively*

Results of Levin, Lin & Chu, and ADF test results are mixed, some variables are stationary at level and some are at first difference. But the results of Im, Peasaran and Shin test, found all variables are integrated of order one (I(1)), therefore the cointegration tests are applied to examine whether there exist a long run relationship between the variables.

4.2. Results for CO_2 Emissions

The panel cointegration between CO_2 emissions and explanatory variables is tested by utilizing Pedroni (1999), Kao (1999), and Fisher Johansen (2000) tests. The Pedroni's cointegration results of carbon dioxide emissions are presented in table 4.2.

Table 4.2: Results of Pedroni Cointegration Test

Intercept			**Intercept and Trend**		
Within-dimension			**Within-dimension**		
	Test Stats	**Prob.**		**Test Stats**	**Prob.**
Panel v-Statistic	0.9131	0.1806	**Panel v-Statistic**	0.3273	0.3717
Panel rho-Statistic	0.0347	0.5139	**Panel rho-Statistic**	-0.3785	0.3525
Panel PP-Statistic	-1.5910	0.0558	**Panel PP-Statistic**	-4.7109	0.0000
Panel ADF-Statistic	-2.0233	0.0215	**Panel ADF-Statistic**	-5.412710	0.0000
Between-dimension			**Between-dimension**		
	Test Stats	**Prob.**		**Test Stats**	**Prob.**
Group rho-Statistic	1.1140	0.8674	**Group rho-Statistic**	1.2694	0.8979
Group PP-Statistic	-1.6617	0.0483	**Group PP-Statistic**	-4.8844	0.0000
Group ADF-Statistic	-3.2340	0.0006	**Group ADF-Statistic**	-5.6846	0.0000

Table 4.2 indicates the long run relationship exist between the variables. The panel v, panel rho and group rho are insignificant. Panel ADF, panel PP are significant at 1 percent and group PP and group ADF are also significant at 1 percent level of significance These four test statistics support the cointegration relationship between urbanization, GDP, technology, free trade and

CO_2 emissions. Table 4.3 shows the result of Kao panel cointegration test, which indicates there is no long run link among the variables.

Table 4.3: Result of Kao Cointegration Test

	t – Statistic	Prob.
ADF	-1.1995	0.1152

Table 4.4: Results of Fisher – Johansen Cointegration

No. of CE(s)	Trace test	Prob.	Max-Eigen	Prob.
None	197.1	0.0000	139.8	0.0000
At most 1	79.88	0.0000	56.95	0.0000
At most 2	37.10	0.0051	24.62	0.1358
At most 3	25.76	0.1053	20.02	0.3316
At most 4	27.87	0.0641	27.87	0.041

In addition, the results of Fisher - Johansen cointegration test are given in table 4.4. The results show the existence of cointegration between carbon dioxide emissions, economic growth, trade openness, urbanization, and technology.

Majority of the cointegration test indicates the presence of cointegration among variables, therefore the study estimate the long run coefficients with Ordinary Least Square (OLS) estimator (Stock, 1987), Panel Dynamic Ordinary Least Squares (DOLS) estimator (Stock, 1987; Saikkonen, 1991), and Fully Modified Ordinary Least Square technique (Phillips and Hansen, 1990). The study preferred panel DOLS method for the estimation of long run coefficient which is less bias and has more appropriate properties than the OLS and FMOLS estimators (Akin, 2014). The variables are expressed in logarithmic form, presents the elasticities of CO_2 emissions with respect to urbanization, economic growth, technology, and trade liberalization.

From the estimated results in table 4.5, DOLS method explores that the urbanization has positive and insignificant impact on CO_2 emission in the long run. The result of positive and insignificant relationship between carbon dioxide emissions and urbanization is also found by Cole and Neumayer (2004). Economic growth has significant and positive impact on CO_2 emissions and its elasticity is 0.2058. The results indicate, economic growth (GDP per capita) increase the CO_2 emissions , better economic conditions increase the demand of goods and services, that leads the production of pollution intensive industries. Akbostanci et al.(2009), Akin (2014), Amin et al.

(2009), Club of Rome (1972), Javad et al. (2014), Nigal and Baron (1992) also found the same result.

Table 4.5: Long Run Dynamics

Dependent variables: CO_2 (I)			
Variables	**OLS**	**DOLS**	**FMOLS**
LN P	0.2076*** (0.0304)	0.0977 (0.1571)	0.2486 (0.1566)
LN A	0.8047*** (0.0579)	0.2058** (0.0849)	0.8749*** (0.1624)
LN T	0.1124*** (0.0739)	0.9909*** (0.1045)	0.0149 (0.0217)
LN TO	-0.2671*** (0.0739)	-0.0727 (0.0692)	0.1741 (0.1542)
R-square	0.8219	0.9984	0.9861

*Note: ***,**,and * shows significance at 1%, 5%, and 10% level respectively.*
Standard errors are in parenthesis

Technology has also positively significant effect on carbon dioxide emissions with 0.9909 elasticity, which is higher than other variables elasticities. The technology is measured through energy consumption, made by utilizing fossil oils. In Asian developing nations the consumption of energy by industrial sector has been increased to 53% which is harmful for environment. The positive association between energy consumption and CO_2 emissions have also been found by Dietz et al.(2006), Feng and Lantz (2006), Javed et al (2014), Kang et al. (2016), Ozturk and Mulali (2016).Trade openness has no impact on CO_2 emissions in long run. The negative and insignificant association between trade openness and carbon dioxide emission is also found by Runge (1994), and Helpman (1998). After investigated the cointegration, table 4.6 presents long run causality. The long-run causality measures the speed of adjustment back to the long-run equilibrium value.

In table 4.6 analyze the results of error correction term of CO_2 emissions is significant and negative that there is long-run causal link running from urbanization, economic growth, technology, and trade openness to CO_2 emissions it is similar to the findings of Akin (2014). The ECT term of urban population is positive and insignificant which indicates that when any disturbance in the long run, urbanization does not make any adjustments to reestablish the long run cointegration (Mashi and Mashi, 1996). The error correction term of economic growth is significant and positive indicates there is no long run relationship exist. The ECT term of technology is insignificant and positive there is no evidence about long run relationship. The error correction term of trade openness is negative and significant showed that there is long run causality moving from carbon dioxide emissions, urbanization, economic growth and technology to trade openness. Afterwards, in order to improve the statistical specification of the model, applied Wald tests for the short-run causality.

Table 4.6: Long Run Causality

Variables	ECT
Ln CO_2	-0.0239 (-2.1875)
Ln P	0.0005 (0.0347)
Ln A	0.0116 (3.1651)
Ln T	0.0972 (0.6753)
Ln TO	-0.0221 (-2.2290)

Note:. t-values are in parenthesis

The short-run causality results are reported in Table 4.7. Findings indicate that there is short-run unidirectional causality from economic growth to carbon dioxide emissions and trade openness. Also there is causality from technology to urbanization.

Table 4.7 Short Run Causality

Short run causality (Chi-square)					
Indep vars→ Dep vars↓	**ΔLn CO_2**	**ΔLn P**	**ΔLn A**	**ΔLn T**	**ΔLn TO**
ΔLnCO_2	-	0.3065 (0.5798)	7.1488*** (0.0075)	2.4565 (0.1170)	2.0045 (0.1568)
ΔLn P	0.1239 (0.7248)	-	0.1105 (0.7395)	0.0013** (0.0137)	0.5443 (0.4606)
ΔLn A	0.0862 (0.7690)	1.1517 (0.2832)	-	7.9488*** (0.0048)	0.24747 (0.6189)
ΔLn T	1.0793 (0.6189)	0.0238 (0.8772)	0.5384 (0.4631)	-	0.3805 (0.5373)
ΔLn TO	0.6211 (0.4306)	0.0388 (0.8437)	3.3874* (0.0657)	3.7986** (0.0513)	-

Note: ***, **and * indicates 1%, 5% and 10% level of significance respectively.
The p values are in parentheses. Δ denotes the first difference.

4.3. Results for SO_2 Emissions

According to panel unit root test, reported in table 4.1 all variables are stationary at I (1) in Im, Peasaran and Shin test. Hence, the cointegration tests are used to check if there exist a long run relationship between the variables. The cointegration between sulfur dioxide emissions and explanatory variables are examined by exercising, cointegration tests of Pedroni (1999), Kao (1999), and Fisher Johansen (2000). The outcome of Pedroni test are illustrated in table 4.8.

Table 4.8: Results of Pedroni Cointegration Test

Intercept			**Intercept and Trend**		
Within-dimension			**Within-dimension**		
	Test Stats	**Prob.**		**Test Stats**	**Prob.**
Panel v-Statistic	-3.0252	0.9988	**Panel v-Statistic**	-1.5916	0.9443
Panel rho-Statistic	2.6250	0.9957	**Panel rho-Statistic**	1.6281	0.9483
Panel PP-Statistic	-8.4379	0.0000	**Panel PP-Statistic**	-7.6235	0.0000
Panel ADF-Statistic	-7.1752	0.0000	**Panel ADF-Statistic**	-6.2160	0.0000
Between-dimension			**Between-dimension**		
	Test Stats	**Prob.**		**Test Stats**	**Prob.**
Group rho-Statistic	2..0993	0.9821	**Group rho-Statistic**	1.4472	0.9261
Group PP-Statistic	-7.2133	0.0000	**Group PP-Statistic**	-5.3660	0.0000
Group ADF-Statistic	-7.1655	0.0000	**Group ADF-Statistic**	-5.2016	0.0000

Table 4.8 exhibits the long term relationship between the variables. The panel PP and ADF, group PP and ADF are significant at 1%, results suggests cointegration between variables. Table 4.8 presents the outcome of Kao test, which refer there is no cointegration among SO_2, urbanization, economic growth, square of economic growth, technology, and trade openness. The results of Fisher – Johansen cointegration are demonstrates in table 4.10 show the existence of five cointegrating vectors at 1% level of significance. Overall, there is strong statistical evidence of cointegration among variables.

Table 4.9: Result of Kao Cointegration Test

	t – Statistic	Prob.
ADF	-0.6321	0.2636

Table 4.10: Results of Fisher – Johansen Cointegration

No. of CE(s)	Trace test	Prob.	Max-Eigen	Prob.
None	323.1	0.0000	180.1	0.0000
At most 1	167.2	0.0000	80.17	0.0000
At most 2	99.91	0.0000	44.27	0.0005
At most 3	68.55	0.0000	37.44	0.0046
At most 4	48.71	0.0001	34.84	0.0021
At most 5	36.83	0.0055	36.83	0.0055

Evidence of cointegration among variables rule out the chance of the calculated relationship's being ambiguous, as a result study consider OLS estimator, DOLS estimator, and FMOLS estimator methods to measure the long run coefficients. The DOLS estimator is preferred here, but for the robustness the study also perform alternative estimation procedures.

Table 4.11: Long Run Dynamics

Dependent variables: CO_2 (I)			
Variables	**OLS**	**DOLS**	**FMOLS**
LN P	0.2238*** (0.0185)	-0.8398*** (0.2564)	-0.3581*** (0.0947)
LN A	-0.9065*** (0.1656)	1.8516*** (0.7504)	2.3186*** (0.4399)
LN A^2	0.0582*** (0.0099)	-0.0990** (0.0448)	-0.1011 (0.0292)
LN T	-0.0182 (0.0120)	0.4806*** (0.1418)	0.0074 (0.0130)
LN TO	0.1347*** (0.0451)	0.0656*** (0.1275)	-0.2835*** (0.0092)
R-square	0.5555	0.9878	0.8528

*Note: ***,**,and * shows significance at 1%, 5%, and 10% level respectively.*
Standard errors are in parenthesis

According to the DOLS estimator, urban population has negative and significant effect on SO_2 emissions in the long run. The urbanization has significant impact which is also found by Ulla (2010), Li et al. (2016), Nayran et al. (2013), Richard and He (2009), Shahbaz (2012), Hossain (2011) and Solarin et al. (2015). While the coefficients of GDP per capita and its square value both are significant but GDP per capita has a positive and its square term shows negative impact on SO_2 emissions. This indicates the existence of Kuznets inverted-U shape hypothesis means sulfur dioxide emissions first increases and after certain threshold its starts decreasing. This inverted-U hypothesis is also found by Dean (2002), Dimitrios et al. (2003), Inam and Khalil (2006), Grossman et al. (1995), Graciela (1994), Kaufmann et al. (1993), Narayan et al. (2010), Peridy (2006), Zeng and Eastin (2007), Zhang and Gangopadhyay (2012). Technology has positive and significant effect on SO_2 emission in the sample countries the use of oil consumption per capita increase, it's consume in transport, generation of electricity and industries which create air pollution. Abdullah et al. (2013), Akin (2014), Amin et al. (2009), Dietz et al. (2006), Feng and Lantz (2006), Ozturk and Mulali (2016) also found the similar result. Trade openness has also significant effect on sulfur dioxide emissions, in developing nations imports of pollution intensive vehicles, machinery are increased because developed countries exchange their pollution creating machineries and vehicles to less developing nations and adopt environment friendly goods. The results of Antweiler et al. (2001), Li et al. (2016) supported the results of this study.

Table 4.12: Long Run Causality

Variables	ECT
Ln SO_2	0.00008 (0.2646)
Ln P	0.0002 (0.8170)
Ln A	-00002 (-2.7335)
Ln A^2	-0.0053 (-4.1750)
Ln T	0.0004 (0.1486)
Ln TO	-0.00008 (-0.4484)

Note: t-statistics are in parenthesis

The table 4.12 presents the results of long run causality. The ECT term of sulfur dioxide emissions is insignificant and negative implies long-run non-causality, and thus that explanatory variables are weakly exogenous (Engle and Granger, 1987). The error correction term of urbanization is also positive and insignificant there is no prove of long run. The ECT of economic growth is negative and significant indicates that there is causality running from sulfur dioxide emissions, urbanization, square of economic growth, technology, trade openness to economic growth. The error correction term of square of economic growth is also significant and negative there is long term causal link moving from sulfur dioxide emissions, urbanization, and economic growth, technology, and trade openness to square of economic growth. Technology ECT is positive and insignificant suggests there is no long run causality (Hossain, 2011). Trade openness ECT is negative and insignificant refers when a divergence from the long run relationship take place, trade openness does not make any efforts to fix the long run equilibrium (Chandran and Tang, 2003).

Table 4.13 Short Run Causality

Short run causality (Chi-square)						
Indep vars → Dep vars↓	**ΔLn SO_2**	**ΔLn P**	**ΔLn A**	**ΔLn A^2**	**ΔLn T**	**ΔLn TO**
Δ$LnSO_2$	-	11.8467*** (0.0006)	0.9381 (0.3328)	0.5742 (0.4486)	0.0067 (0.9344)	0.31600 (0.5740)
ΔLn P	2.7958 (0.0945)	-	0.0761 (0.7826)	0.0442 (0.8334)	0.0005 (0.9812)	0.4369 (0.5086)
ΔLn A	0.0095* (0.9224)	0.6468 (0.4212)	-	9.7809*** (0.0018)	0.1695 (0.6806)	0.6990 (0.4031)
ΔLn A^2	0.0068 (0.9342)	0.4037 (0.5252)	10.542*** (0.0012)	-	0.5029 (0.4782)	0.4338 (0.5101)
ΔLn T	0.0409 (0.8397)	0.0002 (0.9887)	0.1947 (0.6590)	0.13861 (0.7097)	-	0.3712 (0.5423)
ΔLn TO	0.0620 (0.8033)	0.1713 (0.6789)	2.44801 (0.1177)	1.8489 (0.1739)	0.0299 (0.8626)	-

Note: ***, **and * indicates 1%, 5% and 10% level of significance respectively.
The p values are in parentheses. Δ denotes the first difference.

Table 4.13 shows short term causality results, unidirectional causal link moving from urbanization towards SO_2 emissions. A bidirectional causal association exists between economic growth and square of economic growth.

5. Conclusion

The goal of this study is to determine the effect of economic growth, trade liberation, urban population and technology on carbon and sulfur dioxide emissions. The data cover the time period over 1980 to 2014 at an annual frequency. The study has used augmented STIRPAT model to accomplish the objectives of thesis by incorporating trade openness, economic growth, technology and urban population factors as they are assumed to be important determinants of environment. The study has used panel data framework because the panel data estimates are better than cross section and time series data.

In Bangladesh, Hong Kong, India, Indonesia, Iran, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, and Thailand environmental determinants are economic growth (GDP per capita), trade liberalization, urbanization and technology in both emissions models. While the carbon emission was measured in metric tons indicated hard form emissions, and sulfur dioxide emissions estimated in CO_2 emissions from electricity and heat production, total (% of total fuel combustion) showed air pollution. It's hard to find that which variable effect environment. For improving the environmental conditions countries should have clear idea that which variable cause more pollution. In environmental analysis the impact of some variables are not clear like urbanization.

In carbon dioxide emissions model the results of Pedroni and Fisher-Johansen co-integration indicating co-integration between variables. The findings of this work also showed a significantly positive signs for the coefficients of economic growth and technology proposing that these two explanatory variables have happened at the cost of environmental quality. In long run the free trade has no impact on CO_2 emission. This thesis also examined causal relationships among the variables using error correction model. A long run causality test established the causal association among the variables which are CO_2 emissions and free trade. In the short run, unidirectional causality has been found between variables.

Moreover, the sulfur dioxide emissions model outcome also established the cointegration among the variables through Pedroni and Johansen tests. The findings of DOLS estimator indicated the presence of EKC between economic growth and SO_2 pollution. Technology and trade openness have significant and positive influence on SO_2 emissions, while urbanization has significant and negative impact on pollution. The results of short run causality is obtained through Wald test which indicates bidirectional causality and there is also long run causal link exists between variables.

The limitation of study is the scarcity of data on air pollution and the data of all Asian developing nations are not available in order to get a comprehensive effect of urbanization, technology, economic development, and free trade on SO_2 and CO_2 emissions. It's concluded that technology has play a vital role in increases of harmful emissions but it is an essential part of the modern services and industry sectors, which help to attain the economic development.

Moreover, these findings are similar with Abdullah et al. (2013), Akin (2014) and Javed and Fatima (2016).

5.1. Policy Recommendation

According to the findings of this study following policy recommendations are suggested:

- There should be research and development programs at government and private levels to control pollution through new technologies, these activities are also important to get sustainable development in selected countries which are still unreachable.
- In the selected group of Asian countries it would be a wise choice to use disposed off wastes as a source of energy which results in lower dependency on fossil fuels that leads to reduce emissions.

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Appendix A

Variable	Description	Source
I	Carbon dioxide emission in metric per tons.	World Development Indicator (WDI) and International Energy Agency (IEA)
P	Urban population percentage of total population.	World Development Indicator (WDI)
A	GDP per capita (proxy for economic growth) measured in US$ at constant price.	World Development Indicator (WDI)
TO	Trade openness expressed in percentage	World Development Indicator (WDI)
T	Energy use kg of oil equivalent per capita (proxy for technology)	World Development Indicator (WDI)
SE	CO_2 emissions from electricity and heat production, total (percentage of total fuel combustion) (proxy for SO_2 emission).	World Development Indicator (WDI) and International Energy Agency (IEA).