Energy Use and Corruption Mitigation: Implications for the Environmental Pollution

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Abstract. Energy consumption is a main cause of environmental pollution emissions that dampens environmental performance. Furthermore, corruption may influence emissions unswervingly by reducing the stringency of environmental regulations which could increase environmental pollution emissions. Therefore, mitigation of corruption risks is a priority to tackle the problem of energy use that dampen environment. The objective of this study is to examine the impacts of energy use on environmental pollution and whether the corruption mitigation interact the relationship between energy use and environmental pollution. The sample includes thirteen selected Asia countries (Bangladesh, Brunei, China, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam) from year 1984 to 2017. Panel regression methods are employed to investigate the impacts of energy use, foreign direct investment, economic growth, population and control of corruption risk on carbon dioxide emissions. From the results, all of the models suggest that energy consumption does dampen environmental pollution. However, when energy use interacts with corruption mitigation, harmful effects that energy consumption have on environmental quality are minimised. It is concluded that increase in energy consumption will increase the pollution but this effect could be reduced with a better control on corruption. The implications of this study suggest that anti-corruption strategies and effective environmental guidelines could limit the effects of energy use on environmental quality.

1. Introduction

Energy is one of the important tools to drive the nations and improve the development of countries. The engines of jobs and growth for the whole economies such as investments and innovations are made possible with the existence of energy [1]. However, energy consumption could pose harmful effects to the environment. Under the 2030 Agenda for Sustainable Development, one of its heart is the Sustainable Development Goal (SDG) 7, which is to ensure access to affordable, reliable, sustainable and modern energy for all. On the other hand, SDG 13 also envisions to take urgent action to combat climate change and its impacts [2-3]. Therefore, proper environmental pollution mitigation strategies should be introduced and maintained to ensure our world could promote prosperity while protecting the environment.

According to [4], since the early seventies, carbon dioxide (CO2) emissions have more than doubled and increased by approximately 40% to year 2000. The global CO2 emissions in year 2017 had reached 32.8 billion tons and risen to nearly 35 billion tons in year 2018. Asia was the main countries that emit CO2 since the early of 2000s. The emission degree in Asia doubled the degree of the Americas and...
tripled the degree of Europe which stood at 17.4 billion tons CO₂ in 2016. Specifically, China contributed greater than fifty percent of emissions in Asia and India was ranked as the second polluter with twelve percent of emissions. In year 2016, energy use was one of the highest component of emissions, contributed for forty two percent of the entire global. Energy is the most important economic resource and also an imperative tool to influence the advancement of the economy in the world [5]. Furthermore, the needs for energy has been augmented as a consequence of modernization and industrialization. Meanwhile, environmental issues and corruption are the main challenges for the world to achieve a sustainable economic. This is because the existence of corruption reduces economic and social costs of breaching the established rules, with the private advantages are placed in priority by sacrificing the social benefits [6]. It is argued that, the policymaking tools to enhance the urgency of transparency and accountability could be achieved through anti-corruption [7]. It is reasonable to explain that corruption mitigations could reduce the harmful effects of energy use on CO₂. Hence, environmental quality will be improved by integrating active anti-corruption policies to control energy use.

Generally, the energy use seem to increase over the years as depicted in Figure 1. It is obvious that the energy use in China, Malaysia, Singapore and Thailand has increased by doubled from year 1984 to 2017. All of the thirteen selected countries in Asia have proven that Asia countries are experiencing industrialization and modernization. Therefore, the demand for energy consumption increases.

In Figure 2, the carbon dioxide emissions in most of the countries in Asia is increasing except Singapore. Out of the 13 countries, Singapore is the only country that shows improvement in reducing the carbon dioxide emissions. Brunei, China, India, Malaysia, Sri Lanka, Thailand and Vietnam demonstrate that the carbon dioxide emissions have been doubled from year 1984 to 2017. Hence, it shows that the environmental problems in Asia are getting serious and the solutions to tackle this problem is necessary.

Figure 1. Energy use (kg of oil equivalent per capita) in the selected Asia countries

Figure 2. CO₂ emissions (metric tons per capita) in the selected Asia countries
The trend of corruption risk mitigation in the selected countries in Asia shows mixed result. Bangladesh, Indonesia, Pakistan, Philippines and Vietnam display improvement in corruption risk mitigation whereas Brunei, China, India, Malaysia, Myanmar, Singapore, Sri Lanka and Thailand show a deteriorating trend in the corruption risk mitigation scores. It is noticed that, Bangladesh, Indonesia, Pakistan and Philippines are among the countries that show improvement in corruption risk mitigation and therefore, their carbon dioxide emissions values are less serious compared to other countries from year 1984 to 2017.

Note: The scores ranging from 0 to 6, a score of 6 points equates to high corruption risk mitigation (very low corruption risk) and a score of 0 points to low corruption risk mitigation (very high corruption risk)

![Corruption Risk Mitigation](image)

**Figure 3.** Corruption Risk Mitigation in the selected Asia countries

As a background overview from Figure 1 to Figure 3, it is apparent that the energy use in Asia is increasing over the years, but the carbon dioxide emissions may be subjected to the corruption risk mitigation strategies. This is because, when the corruption risk mitigation strategies are higher, the imposition of the tax laws are more stringent. Therefore, the polluters will make an effort to reduce their emissions in order to reduce the cost of penalty. In the past, although the control of corruption risk have improved in some of the countries in Asia, the Asian CO2 emissions are still increasing and posed a major concern to the regulators. Hence, examining the impacts of energy use on carbon emissions, could be performed to assist the Asia organization to enact climate change strategies. Therefore, the objective of this study is to examine the impacts of energy use on environmental pollution and whether the corruption mitigation interact the relationship between energy use and environmental pollution.

The contribution of this study highlights the effects of energy use and other important macroeconomics variables (namely for direct investment, economic growth and population) on carbon dioxide emissions in Asia countries. Particularly, it highlights the role of mitigation in corruption risk in interacting energy use on effect of carbon dioxide emissions. Past literatures that explore the issues of corruption and environmental pollution in Asia countries are limited despite Asia was the main source of emissions in the world. The literature that focus on the issues of corruption and environmental pollution are [6, 8-9] where they place emphasis on OECD countries, randomly selected countries and Gulf countries respectively.

2. Literature Review

More recent attention has focused on the issue of energy use and its potential ecological and environmental impacts [10]. Corruption poses a major risk in Central Asia [5]. This empirical study shows that the proportion of corruption cases is pretty high, and the energy industry turns out the most corrupt. Energy industry is monopolized by few firms and with their considerable monopoly power, the incentives for illicit gain are common. However, the hesitation caused by corruption does not exceed the attraction of energy, which explains why so many foreign companies regularly bid and compete for rights to the energy sectors of Central Asia despite the corruption situation. In other words, the influential energy firms have practically assumed corruption as an alternative ways of controlling local
regulators or gaining political support. In a study conducted by [11], it was highlighted that climate change has emerged as one of the defining issues of the early 21st century. The degree of climate change is influenced by several factors including the pace of greenhouse gas emissions, the response of ecosystems to the changing climate and deforestation rates. Alarmingly, global emissions of greenhouse gases have amplified by 45% since 1990 and were anticipated to generate significant risks to societies and ecosystems. Hence, what is the impact of energy use on carbon dioxide emissions is an urgent question.

In the recent studies by [12–14], they criticized that majority of the studies [15-16] related to environment pollution were focusing on Environmental Kuznets Curve hypothesis (EKC) that heavily analysing the effect of economic growth on pollution. The study would have been more interesting if it had included other relevant variables such as foreign direct investment (FDI), trade and energy use. [16] deliberates that the nexus between FDI and emissions is aimed at corroborating the presence of pollution haven hypothesis. Pollution haven hypothesis is generally understood to mean that foreign firms in dirty sectors are more probable to transfer pollution undertakings from developed countries to weakly regulated developing countries to escape from domestic environmental control costs, which directly dampens the environment of the recipient countries. As a result, the influx of FDI would lead to a rise in green house gases (GHG) emissions. On the other hand, pollution halo hypothesis explains that FDI inflows have positive spillover effects such as up-to-date technologies, advanced management practices and employment expansion that are conducive curb pollutant emissions [17].

In addition to FDI, trade may be another factor of environmental pollution [13]. Kasman [18] revealed that international trade grounds the movement of final and intermediary goods from one country to another for further production process or consumption that will lead to pollution. Next, enormous energy use at household and industrial levels gave birth to phenomenon of pollutant emissions [19]. Industrialization process dependent on fossil fuel-based energy industry that will lead to tremendous energy consumption [20]. As a consequence of gigantic energy use, an upsurge of pollutant emissions is observed. The studies presented thus far provide evidence FDI, trade and energy use are the important factors to explain GHG emissions. Therefore, this study includes FDI, population and economic growth in the relationship between energy use and the environment in Asia countries to fill in the literature gap.

The study by [6] examines how corruption and energy innovations affect carbon emissions. This study uses a panel data model of 16 selected OECD countries, covering the period of year 1995 to 2016. It uses the hypothesis of the environmental Kuznets curve (EKC) that investigates nexus between the economic growth and carbon emissions. The empirical results demonstrate that when economic systems interact with corruption, positive effects that energy innovations have on environmental quality are reduced. Moreover, the amount of economic growth needed to limit environmental pollution levels is also distorted. In the long term, corruption appears to be maleficient for the environment because it restricts the phase at which decontamination occurs; i.e., corruption reduces the positive effect generated by measures focused on energy innovation in terms of reducing environmental pollution. Hence, identifying the interaction role of corruption on a certain variable to the environmental emissions, this study explores the interaction effect of control of corruption on energy use to carbon dioxide emissions in Asia countries.

3. Data and Methodology
This study was an attempt to investigate the impact of energy use and corruption risk mitigation on carbon dioxide emissions in the selected 13 Asia countries. These countries are Bangladesh, Brunei, China, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. These countries were being selected due to their energy use and CO2 emissions were relatively high compared to the rest of the Asian countries. The sample period of this study was from 1984 to 2017. The period begins with 1984 as to in line with the availability of institutional quality data that offers the corruption risk mitigation data which is provided by [21] and up to the latest macroeconomic variables data that is supplied by The World Bank. The dependent variable is carbon dioxide emissions (CO2), the independent variables are energy use (ENE), foreign direct investment (FDI), economic growth which is proxied by growth of domestics products per capita (GDPCG),
population (POP) and corruption risk mitigation (CRM). The interaction effect of CRM on ENE is displayed as CRM*ENE.

According to [21], corruption is a threat to foreign investment as it distorts the economic and financial environment. Such corruption can make it difficult to conduct business effectively. The greatest risk in such corruption is that at some time it will become so overweening rendering the country ungovernable. The scores are ranging from 0 to 6. A score of 6 points equates to high corruption risk mitigation (very low corruption risk) and a score of 0 points to low corruption risk mitigation (very high corruption risk)

Following the models by [6, 22], the panel regression models in this research is examined through three models namely, pooled ordinary linear regression model (pooled OLS), random effect model (REM) and fixed effect model (FEM).

The pooled OLS model is expressed as:

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \varepsilon_{it}
\]  

(1)

The REM model is expressed as:

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \lambda_i + u_{it},
\]

where \(\text{Cov}(\lambda_i, X_{it}) = 0\)

(2)

The FEM model is expressed as:

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \lambda_i + u_{it},
\]

where \(\text{Cov}(\lambda_i, X_{it}) \neq 0\)

(3)

When interaction effect of CRM*ENE is included in the model, model 1 to 3 will become model 4 to 6 respectively.

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \beta_6 CRM_{it} * ENE_{it} + \varepsilon_{it}
\]

(4)

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \beta_6 CRM_{it} * ENE_{it} + \lambda_i + u_{it}, \text{ where Cov}(\lambda_i, X_{it}) = 0
\]

(5)

\[
CO2_{it} = \beta_0 + \beta_1 ENE_{it} + \beta_2 FDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \beta_5 CRM_{it} + \beta_6 CRM_{it} * ENE_{it} + \lambda_i + u_{it}, \text{ where Cov}(\lambda_i, X_{it}) \neq 0
\]

(6)

Firstly, to disregard the panel structure of the data, pooled OLS is employed. This means that the model disregard the panel nature of the data. Since the advantage of POLS is to treat \(\varepsilon_i\) as identically and independently distributed disturbances that are uncorrelated with explanatory variables. Thus, the data can be pooled and OLS can be utilised to evaluate the model. However, pooled OLS has its disadvantage. It may cause heterogeneity bias, which explains that the countries are all different from one another in fundamental unmeasured ways that vary across countries. Hence, REM or FEM will be employed because \(\varepsilon_i\) is decomposed into two independent components error term as \(\varepsilon_{it} = \lambda_i + u_{it}\). \(\lambda_i\) is time invariant that captures the country-specific effect. The advantages of REM are to handle the constants for each section as random parameters by assuming \(\lambda_i\) as a random variable and it is drawn independently from some probability distribution. On the other hand, the advantage of FEM is that the constant is treated as group specific which means the model allows for different constants for each country. The \(\lambda_i\) in FEM is assumed to be constant and it may be correlated with some of the explanatory variables in the model. The selection between pooled OLS and REM is based on Breusch-Pagan Lagrangian Multiplier (BPLM) test where the null hypothesis refers to \(\sigma^2_\pi = 0\) (Pooled OLS is preferred).
versus the alternative hypothesis refers to $\sigma_i^2 > 0$ (REM is preferred). The choice between REM and FEM is based on Hausman Test where the null hypothesis refers to $Cov(\lambda_i, X_i) = 0$ (REM is preferred than FEM), versus the alternative hypothesis refers to $Cov(\lambda_i, X_i) \neq 0$ (FEM is preferred than REM) [23–25]. The explanations of the variables are presented in Table 1.

4. Results and Discussions

Table 1 displays the descriptive statistics of the variables. It is observed that the variation of ENE between the countries are large which infers that the energy used in these 13 countries are varied among each other. The risk control mitigation scores shows the mean value as 2.585 is considered as high risk (range 0 to 6), suggest that the risk control mitigation in these countries still require much more improvements. The carbon dioxide emissions is at an average of 3.56, far below the maximum value of 25.24. The highest CO2 emissions country is Brunei and this explains that it is the most polluted countries compared to other Asian countries.

**Table 1.** Descriptive statistics of the variables

| Variable                          | Mean  | Std.Dev | Min    | Max    | Observations |
|-----------------------------------|-------|---------|--------|--------|--------------|
| Carbon dioxide, CO2               | 3.5653 | 5.2950  | 0.1005 | 25.2375| 403          |
| (metric tons per capita)          |       |         |        |        |              |
| overall                           | 3.5633 | 5.2950  | 0.1006 | 25.2375| 403          |
| between                          | 5.1839 | 1.8067  | 0.1936 | 17.3689| 403          |
| within                           | 1.7807 | -5.0172 | 11.4319|        |              |
| Energy use, ENE                   | 1517.32| 2134.46 | 103.71 | 9829.33| 402          |
| (kg of oil per capita)            |       |         |        |        |              |
| overall                           | 1517.31| 2134.47 | 103.71 | 9829.33| 402          |
| between                          | 2152.53| 148.73  | 7449.14|        |              |
| within                           | 510.63 | -692.91 | 4222.26|        |              |
| Foreign direct investment, FDI    | 3.1955 | 4.4231  | -2.7574| 26.5212| 408          |
| (% of GDP)                        |       |         |        |        |              |
| overall                           | 3.1955 | 4.4231  | -2.7574| 26.5212| 408          |
| between                          | 3.7914 | 0.5219  | 14.9761|        |              |
| within                           | 2.2779 | -7.5542 | 14.7406|        |              |
| Gross domestic per capita growth, | 3.7525 | 3.8434  | -14.346| 13.6383| 441          |
| GDPCG (annual %)                  |       |         |        |        |              |
| overall                           | 3.7525 | 3.8434  | -14.346| 13.6383| 441          |
| between                          | 2.2792 | -1.0563 | 8.7786 |        |              |
| within                           | 3.1556 | -1.0563 | 8.7786 |        |              |
| Population, POP                   | 239    | 401     | 218.22 | 1.40   | 442          |
| (total unit)                      |       |         |        |        |              |
| overall                           | 239    | 401     | 218.22 | 1.40   | 442          |
| between                          | 412    | 0.32    | 1.2    |        |              |
| within                           | 58.2   | 57.5    | 483    |        |              |
| Corruption risk mitigation, CRM   | 2.5853 | 1.1027  | 0      | 6      | 441          |
| (score)                           |       |         |        |        |              |
| overall                           | 2.5853 | 1.1027  | 0      | 6      | 441          |
| between                          | 0.8153 | 1.5541  | 4.512  |        |              |
| within                           | 0.7743 | 0.3912  | 4.4574 |        |              |

The panel regression results is shown in Table 2. Model 1 to Model 3 are the models without interaction effect between energy use and corruption risk mitigation and Model 4 to Model 6 are models with interaction effect corruption risk mitigation. It is obvious that ENE exerts positive and significant impact on CO2 emissions throughout Model 1 to Model 6. This is consistent with the findings by [6], [20, 26], suggests that most of the countries in Asia are developing countries, they require energy
proceed with essential services and expand more new industries to support the economic growth. Thus, energy consumption is a major source of environmental pollution emissions and suggest that implementation of environmental regulation is an effective measure to prevent environmental degradation. For an illustration, one of the effective regulation is the India’s Green Rating Project. In order to minimize the pollution emissions of companies, the heavy polluters will be punished and their reputations will be affected. This is because, this project discloses the information about the companies’ environmental performance. The investors will discontinue their cooperation or support with these polluters that will lead to disruption in operations in these polluters. However, improvement in economic growth itself will not affect CO2 emissions as the coefficients of GDPCG are not significant from Model 1 to Model 6. FDI shows negative and significant effect on CO2 emissions. Hence, the results support pollution halo hypothesis which explains that FDI inflows have positive spillover effects such as up-to-date technologies that help Asia countries to curb pollutant emissions [17]. Population is generally increasing the CO2 emissions because communities require energy to support their daily activities. From Model 4 to Model 6, the coefficients for ENE*CRM are negative and significant towards CO2 emissions. These results suggest that with proper corruption risk mitigation, it could actually assist in the appropriate policies implementation to consume energy that eventually reduces the CO2 emissions. These results collaborate with [27] that better institutional quality such as control of corruption is a means of improving energy efficiency to curb emissions.

Table 2. Panel regression results of energy use, corruption risk mitigation and other variables on CO2

| Model | (1)-POLSS | (2)-RE | (3)-FE | (4)-POLSS | (5)-RE | (6)-FE |
|-------|-----------|-------|--------|-----------|--------|--------|
| ENE   | 0.002***  | 0.0024*** | 0.0016*** | 0.00273*** | 0.00341*** | 0.0054*** |
|       | (5.18e-05) | (6.25e-05) | (0.0001) | (0.0002) | (0.0002) | (0.0003) |
| FDI   | -0.087*** | -0.128*** | -0.234*** | -0.0473 | -0.0794** | -0.138*** |
|       | (0.025) | (0.0277) | (0.0325) | (0.0326) | (0.0331) | (0.0261) |
| GDPCG | 0.030    | 0.0253  | 0.0340  | 0.0242  | 0.0170  | 0.0296  |
|       | (0.023) | (0.0241) | (0.0240) | (0.0232) | (0.0238) | (0.0187) |
| POP   | 4.18e-10** | 4.30e-10 | 4.63e-09*** | 3.78e-10* | 2.22e-10 | 2.22e-10** |
|       | (2.05e-10) | (2.92e-10) | (1.23e-09) | (2.05e-10) | (3.70e-10) | (9.68e-10) |
| CRM   | 0.301*** | 0.265*** | -0.0575  | 0.405*** | 0.549*** | 0.878*** |
|       | (0.083) | (0.0877) | (0.0970) | (0.100) | (0.111) | (0.0977) |
| ENE*CRM | -0.0001* | -0.0004*** | -0.0014*** | -0.0001* | -0.0004*** | -0.0014*** |
|       | (6.20e-05) | (8.03e-05) | (9.04e-05) | (6.20e-05) | (8.03e-05) | (9.04e-05) |
| Constant | -0.794*** | -0.533** | 0.603    | -1.082*** | -1.100*** | -0.955** |
|       | (0.216) | (0.262) | (0.461) | (0.266) | (0.341) | (0.373) |
| Observations | 368 | 368 | 368 | 368 | 368 | 368 |
| R-squared | 0.900 | 0.898 | 0.338 | 0.901 | 0.879 | 0.600 |
| Countries | 13 | 13 | 13 | 13 | 13 | 13 |

Overall, the results indicate that energy use and population could increase CO2 emissions. FDI welcomes foreign investment that could assist the local industry to adopt high advanced technology such as renewable energy that may reduce the CO2 emissions. An appropriate control of corruption could change the harmful effect of energy use on carbon dioxide emissions to improving the environmental issue. Hence, control on corruption have important effect on energy and environmental policy. After controlling for corruption, the illicit funds would be reduced. Thus, these funds could be allocated by the government more efficiently.

5. Conclusion

Energy plays an important character in economics, politics, and people’s living. Hence, sustainable energy development is the main condition of economic growth and social stability. This study shows that corruption risk control could protect and share the usage of energy in Asia countries. Hence, it is essential to guarantee the comprehensive commitment of all stakeholders in establishing integrity and combatting with corruption. Therefore, firms should formulate a risk management plan that is including...
corruption prevention, as well as, the governments play the major decision to implement specific procedures and regulations for private business in order to provide good conditions for corruption risk.

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