Impact of Monetary Policy Uncertainty and Fiscal Policy Uncertainty on CO2 Emissions in the Us

Khalid Anser
Xí’an University of Arts and Science South Campus: Xi’an University of Arts and Science

Qasim Syed (qasimrazasyed.economics@gmail.com)
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology - Larkana Campus
https://orcid.org/0000-0002-9328-0907

Noreen Khalid
Quaid-i-Azam University Islamabad: Quaid-i-Azam University

Jamshid Ali Turi
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology - Larkana Campus

Juned Ali Shah
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology - Larkana Campus

Research

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Abstract

Nowadays, environmental degradation is perceived as one of the serious concerns across the globe. One of the prime reasons behind environmental degradation is CO\textsubscript{2} emissions. Therefore, researchers are actively putting their efforts to explore the determinants of CO\textsubscript{2} emissions to mitigate CO\textsubscript{2} emissions. On this basis, the present study contributes to the existing literature by investigating the impact of monetary policy uncertainty (MPU) and fiscal policy uncertainty (FPU) on CO\textsubscript{2} emissions (environmental degradation). The current study employs ARDL methodology and uses annual data ranging from 1985 to 2019 for US. The results from the ARDL model report that there is an existence of long-run relationship among the variables. Moreover, MPU escalates the carbon emissions in both short-run and long-run. This implies that increase in MPU is responsible for rise in environmental degradation. On the contrary, FPU plunges the carbon emissions in both short- and long-run. This indicates that increase in FPU decreases the environmental degradation. Findings from the current study propose that policy makers should introduce reforms and launch policies to shrink MPU. Next, this study proposes that rule should be adopted as monetary policy making framework in lieu of discretion. Furthermore, the current study recommends that FPU should not be utilized as a tool to mitigate environmental degradation, because FPU has severe economic impacts.

1. Introduction

Over the past two decades, there exists a broad consensus amongst researchers, scientists, and environmentalists about the rising global warming and climate change significantly result from environmental pollution. It has shown manifestation effects on ecosystems and the overall well-being of humans in the world. The researches and statistics show that the global warming and the climate change have been employed in affecting the balance of the Earth. Since the late 19\textsuperscript{th} Century, the average Earth temperature has increased by 0.9 Celsius. This change has led to an increase in ocean water temperature from 0.4 degrees Fahrenheit since 1970. Increase in atmospheric absorption of Green House Gases (GHG) emissions like carbon dioxide (CO2), methane, nitrous oxide, water vapour, halocarbons, and ozone are essential factors behind the increase in global warming. Intergovernmental Panel on Climate Change reveals that the critical greenhouse gas is CO2, as 76\% of GHG emissions consist of CO2 gas IPCC (2014). Thus, it is essential to explore the determinants of CO2 emissions in order to decelerate the carbon emissions.

In addition, global warming and climate change are not only scientific issues but also have become important determinants of economic growth and social progress. Economic progress and issues of environmental stability and sustainability have considerably remained as predicament dilemma. After an initiation of industrial revolution in century 18\textsuperscript{th}, Growth of economic activities globally has ascended at the cost of environmental quality and public health, which seems to be a straight consequence of conventional energy sources that are being used in the process of production. Therefore, economic growth, energy, environmental quality, and public health are considered as a complex system. Belke et al.
(2011) conclude that one of the crucial components for economic growth is energy consumption that acts as a complement to labour and capital as the factors of production. On the contrary, energy consumption is one of the prime reasons behind carbon emissions. The consumption of energy, on a significant extend, relies on the utilization of fossil fuels. However, the growth in population, economic development, and technological innovation has led to an increased energy consumption demand in the time of 21st century, hence; the continuously increased utilization of fossil fuels as well as related energy technologies globally channelled the climate emergency situation (Dyson, 2005; Shahbaz et al., 2014; Rafindadi, 2016).

Given this background, the decline in carbon dioxide emissions is quite a crucial concern and an essential task for each country to deal with the rigorous challenges arising from climate changes and global warming. Many International organizations are putting efforts to mitigate the adverse effects of global warming through focusing on different economic and institutional policies. Despite the countless attempts to reduce the quantity of CO₂ emissions, carbon emissions are increasing globally. As mentioned in the report of 2019 issued by International Energy Agency (IEA), energy related CO₂ emissions globally has increased by 1.7% which has ultimately stems rapidly from increase in the economic growth, slower measures of energy efficiency, and reduced prices of fossil fuels.

Parallel to this, there is plethora of literature that explores the economic and non-economic determinants of carbon emissions. The key economic determinants of CO₂ emissions are: economic growth (Arouri et al., 2012; Saboori et al., 2012; Salahuddin et al., 2016; Nazir et al., 2018; Emir and Bekun, 2019), energy consumption (Zhang and Lin, 2012; Al-Mulali et al., 2013; Joo et al., 2014; Wang et al., 2016; Anser, 2019; Gu et al., 2019; Khan et al., 2019; Nathaniel and Iheonu, 2019; Wolde-Rufael and Weldemeskel, 2019), trade (Halicioglu, 2009; Shahbaz et al., 2013a; Chen et al., 2019; Haug and Ucal, 2019), financial development (Shahbaz et al., 2013b&c, Abbasi and Riaz, 2016; Dogan and Turkekul, 2016; Bekhet et al., 2017, Shoaib et al., 2020), natural resources (Bekun et al., 2019a; Danish et al., 2019; Khan et al., 2020), and FDI (Pao and Tsai, 2011; Omri et al., 2014). On the contrary, the eminent non-economic determinants of CO₂ emissions are: urbanization (Zhu et al., 2012; Sadorsky, 2014; Shahbaz et al., 2016; Ali et al., 2019), population (Dietz and Rosa, 1997; Begum et al., 2015; Dong and Kan, 2018; Hashmi and Alam, 2019), political institutions (Abid, 2016; Bhattacharya et al., 2017), and globalization (Shahbaz et al., 2017; Zaidi et al., 2019).

In addition, one strand of literature explores the relationship between economic policy uncertainty (EPU) and carbon emissions. EPU can effect carbon emissions, because there is relationship among EPU, economic growth, investment, and energy consumption. Jiang et al. (2019) employ quantile granger causality and find that there is uni-directional causality running from economic policy uncertainty (EPU) to carbon emissions in US. The study also reports that EPU escalates carbon emissions. Moreover, Pirgaip and Dinçergök (2020) investigate the causal relationship among EPU, energy consumption, and carbon emissions. The findings of the study reveal that EPU is also responsible for environmental degradation, as EPU increases carbon emissions.
Based on aforementioned studies, the present study expects that monetary policy uncertainty and fiscal policy uncertainty can also be the potential determinants of carbon emissions. There are many theoretical channels that explain the relationship between policy uncertainty and carbon emissions. For instance, monetary and fiscal policy uncertainty effect economic growth, which in turn effect carbon emissions. In addition, monetary and fiscal policy uncertainty effect investment, and investment ultimately effects carbon emissions. Similarly, monetary and fiscal policy uncertainty effect decision making of consumers and producers, which in turn affect level of consumption and production. Hence, change in consumption and production influence carbon emissions. Likewise, if there is high monetary and fiscal policy uncertainty then attention of policy makers may divert from environmental protection policies to monetary and fiscal policy uncertainty. Thus, ignorance from environmental protection policies may surge the level of carbon emissions. Additionally, monetary and fiscal policy uncertainty may discourage R&D, innovations, and clean production technologies. Ultimately, the plunge in these aforementioned factors can also effect carbon emissions.

Under the light of aforementioned discussion, it is essential to examine the impact of monetary and fiscal policy uncertainty on carbon emissions. The objective of present study is to examine whether monetary policy uncertainty (MPU) and fiscal policy uncertainty (FPU) effect carbon emissions. Moreover, this study also explores whether there is dynamic relationship among MPU, FPU, and CO2 emissions. This implies that whether MPU and FPU effect CO2 emissions in both short- and long-run.

To investigate the impact of MPU and FPU on CO2 emission, we select the United States of America (US) for our analysis. The motivation behind selecting US for investigation is the fact that US is largest economy of the world. Moreover, US is also second highest carbon emitter in entire world. Next, prior studies on monetary and fiscal policy uncertainty employ GARCH models on variables of monetary policy and fiscal policy in order to generate the variables for monetary and fiscal policy uncertainty. However, Baker et al. (2016) develop economic policy uncertainty indices (e.g., monetary, fiscal, and trade policy uncertainty index). The index is developed on the basis of newspaper articles related to policy uncertainty. The data on monetary policy uncertainty index and fiscal policy uncertainty index is available for limited countries including US therefore this study investigates the impact of MPU and FPU on CO2 emissions for US.

The present study contributes to the existing literature in many ways. First, to the best of our knowledge, this is first study that examines the impact of MPU on CO2 emissions. Second, to the best of our knowledge, there is no study that examines the effect of FPU on CO2 emissions. This study fills this gap by probing the impact of FPU on CO2 emissions. Last, prior studies on the relationship between policy uncertainty and CO2 emissions do not investigate the dynamic relationship between the policy uncertainty (e.g., economic policy uncertainty, monetary, fiscal, and trade policy uncertainty etc.) and CO2 emissions. Therefore, the present study employs ARDL model to discern whether there is dynamic relationship among the MPU, FPU, and CO2 emissions. ARDL approach proposed by Pesaran et al. (2001) explains the short- and long-run relationship among variables simultaneously. The reason behind employing the ARDL is that the previous tests such as Engle-Granger test (1987), Johansen test (1991) of
co-integration had some limitations. For instance, variables must follow same order of. In case of ARDL, it is not necessary that all variables have to be stationary at same level. Therefore, ARDL model is superior to other aforementioned models.

The remainder of the study is structured as follows. Section 2 reviews the literature related to CO2 emissions, MPU, and FPU. Methodology is discussed in section 3. Section 4 reports the data. Section 5 presents the results. Section 6 describes the implication and concludes the study.

2. Literature Review

This section briefly reviews the literature related to the determinants of carbon emissions. As climate change and global warming are becoming common concerns throughout the world, a substantial number of researches have analyzed it along with different influential factors impelling carbon emissions (Richmond and Kaufmann, 2006; Katircioğlu and Taşpinar, 2017; Mutascu, 2018; Jiang et al., 2019b). In addition, Zhang and Cheng (2009) conclude that there exists granger causality among economic growth, energy consumption, and carbon emissions. Next, Acaravci and Ozturk (2010) examine the casual relationship between carbon emission, GDP growth, and energy consumption employing ARDL approach. The results for the Granger casualty test specify bi-directional relationship between the variables. Additionally, Saboori et al. (2014) note the bi-directional relationship between carbon emissions and economic growth for OECD countries. Furthermore, Bano et al. (2018) investigate the impact of human capital on carbon emissions. The findings from this study report that human capital mitigates the carbon emissions without effecting economic growth. Parallel to this, there are many studies that investigate the validity of environmental Kuznets curve (EKC). EKC depicts the inverted U-shaped association between the carbon emissions and economic growth. The EKC states that in initial phases of economic growth, the pollution in the environment will rise. However, it will eventually improve at a later stage in the future. One strand of literature concludes that EKC does exist. For instance, Dogan and Seker (2016) examine the validity of EKC for European Union. The findings highlight that EKC does exist. Moreover, trade and renewable energy are responsible for mitigating carbon emissions. In addition, one-way causality is running from economic growth to carbon emissions. Next, Jamel and Maktouf (2017) confirm the existence of EKC for 40 European countries. Similarly, Heidari et al. (2015) employ panel smooth transition regression to examine the occurrence of EKC in ASEAN countries. The study reports that EKC holds for ASEAN economies. Additionally, Pata (2018) also reports that EKC holds for Turkey. Moreover, the study finds that financial development and urbanization escalates CO2 emissions. On the contrary, there exists rich body of literature that notes that EKC does not hold. For instance, Al-Mulali et al. (2015) conclude that EKC is not valid for Vietnam. Sirag et al. (2018) employ dynamic panel threshold model to investigate the existence of EKC. The authors conclude that inverted-U shaped relationship between economic growth and carbon emissions does not hold. Furthermore, FDI also contributes to economic growth at the cost of environmental degradation. To investigate this hypothesis, Essandoh et al. (2020) employ PMG-ARDL approach. The results from PMG-ARDL report that FDI increases carbon emissions in developed countries. However, the study also notes that a negative long-run relationship between trade
openness and CO\textsubscript{2} emissions exits exclusively for developed countries. Long et al. (2015) examine the relationship among economic growth, energy consumption and carbon dioxide emissions in China. The results report that energy consumption has more effect on carbon dioxide emissions as compare to economic growth. Moreover, GDP has bi-directional relationship with carbon dioxide emissions (CO\textsubscript{2}). Additionally, Nguyen and Kakinaka (2019) analyze that how relationship between energy consumption and carbon dioxide emissions are linked with development phase through implementation of panel co-integration for 107 countries. The findings from the study show that in high-income countries renewable energy consumption is negatively linked with carbon emissions. However, in low income countries, renewable energy consumption is positively linked with carbon emissions. Furthermore, Apergis and Payne (2015) conduct a study on long run relationship and dynamics among renewable energy consumption per capita, carbon dioxide emission per capita, and GDP per capita employing panel co-integration techniques for 11 South American countries. The results describe that there is long-run and positive relationship among aforementioned variables. Similarly, Lau et al (2014) probe the relationship among economic growth, FDI, trade openness, and carbon dioxide emissions for Malaysia. Findings from ARDL bounds test and granger causality conclude that inverted U-shaped relationship exist between carbon dioxide emissions and economic growth in both short-and long-run for Malaysia. Additionally, Lee (2013) investigates the impact of foreign direct investment (FDI), energy use, and economic growth on carbon emissions. Results from fixed effects model for selected G20 countries conclude that FDI, energy use, and economic growth effect carbon emissions. Furthermore, Garrone and Grilli (2010) investigate the impact of R&D on carbon emissions for 13 highly developed economies employing dynamic panel models. The results show that government R&D expenditure is not enough to enhance energy innovation progress. Moreover, public energy R&D has no effect on carbon emissions. Parallel to this, Zhang and Zhang (2018) probe the impact of GDP, trade structure, exchange rate and foreign direct investment inflows on China’s carbon emissions over the time period of 1982 to 2016. The findings from ARDL and granger causality reveal that EKC hypothesis is valid for China. Moreover, services trade and exchange rate have negative impact on carbon emissions. On the contrary, the study highlights that FDI escalates carbon emissions.

3. Model And Methodology

To investigate the impact of MPU and FPU on CO\textsubscript{2} emissions, this study develops the following model.

\[ CO_2 = f(MPU, FPU, GDP) \] (1)

Where, MPU and FPU are the potential determinants of carbon emissions. The economic intuition (theoretical linkage) behind MPU and FPU is already discussed in introduction section. On the contrary, to overcome the problem of omitted variable bias, this study also use GDP per capita as control variable. The economic intuition behind employing GDP is the fact that income of an economy effects consumption, investment, energy consumption, and production, which ultimately influence carbon
emissions. There are many studies that employ GDP as prime determinant of carbon emissions (Bekun et al., 2019a; Ummalla and Goyari, 2020; Nathaniel et al., 2020; Coskuner et al., 2020).

Moreover, Co-integration reports whether the variables are jointly related in long-run. There are many conventional methodologies to test the long-run relationship amongst the variables such as Engle-Granger test (1987), Fully Modified Ordinary Least Squares (FMOLS) method, and Johansen test (1991). However, these tests have some limitations. For instance, the variables must be stationary and/or their order of integration should be at the same level. To overcome these limitations, Pesaran et al. (2001) develop ARDL bounds test to examine the co-integration among variables. ARDL methodology is applicable even variables are integrated at I (0) and/or I (1). It also allows the series to have different optimal lags. Based on these advantages, this study employs ARDL bounds test. In case of our study, variable of MPU is stationary at I (0) whereas all other variables (FPU, GDP and CO₂ emissions) are stationary at I (1). Finally, the estimation of short-run and long-run effects of independent variables on dependent variable are evaluated at the same time which helps researchers to accurately distinguish between two as of utmost importance in economic analysis and decision making

Furthermore, a single reduced form equation is applied through ARDL approach. In the context of this study, the ARDL model is illustrated below:

\[
\Delta CO_2 = \alpha + \sum_{i=1}^{p} \beta_i \Delta CO_2_{t-i} + \sum_{i=1}^{q} \gamma_i \Delta MPU_{t-i} + \sum_{i=1}^{q} \omega_i \Delta FPU_{t-i} + \\
\sum_{i=1}^{q} \delta_i \Delta GDP_{t-i} + \pi_1 CO_2_{t-1} + \pi_2 MPU_{t-1} + \pi_3 FPU_{t-1} + \pi_4 GDP_{t-1} + \varepsilon_t
\]

(2)

Where, CO₂, MPU, FPU and GDP indicate carbon emissions, monetary policy uncertainty, fiscal policy uncertainty and gross domestic product respectively. Moreover, i and t are indices of lags and time respectively. Next, \( \varepsilon \) is error term.

### 4. Data Analysis

In this study, annual data for US is used to analyze the impact of monetary policy uncertainty (MPU) and fiscal policy uncertainty (FPU) on the environmental degradation. The sample size is consists of 35 observations from January 1985 to December 2019. The dependent variable of the study is the carbon dioxide (CO₂) emissions which specifically believed to contribute about 76% of the total U.S anthropogenic greenhouse gas emissions (GHG). The data on CO₂ emissions (metric ton per capita) is obtained from EIA (Energy Information Administration) U.S. The key independent variables of the study are monetary policy uncertainty (MPU) and fiscal policy uncertainty (FPU). Additionally, Baker et al. (2016) construct a new index of economic policy uncertainty (EPU) which is based on newspaper articles and coverage. Moreover, apart from EPU, Baker et al. (2016) also develop the sub-groups (categorical policy uncertainty indices) e.g., MPU and FPU. Therefore, data on these two policy uncertainties are
obtained from www.policyuncertainty.com. Moreover, this study uses the real gross domestic product (GDP) per capita as control variables to lessen the hitch of omitted variable bias. The data on GDP is obtained from Federal Reserve economic data (FRED).

Afterwards, all variables are transformed into a logarithm form. Then descriptive statistics are reported in table 1. Descriptive statistics renders some features/characteristics of the data e.g. what is the maximum, minimum, and average value in the data. Next, unit root test is employed that investigates whether the data have constant mean, variance, and autocorrelation over the time. Moreover, ADF unit root test is also applied to examine the order of integration of all variables.

As can be seen in table 1, on average GDP per capita has highest value (4.11) whereas highest standard deviation is observed in MPU (0.15). Moreover, all variables are negatively skewed. Next, Jarque-bera tests highlights that all variables are normally distributed.

Next, this study applies ADF unit root test to examine the order of integration. ARDL model is only applicable if the variables are integrated at I (0) and/or I (1). If any of the variables is integrated at I (2), ARDL model may give pseudo results.

Table 2 represents the ADF test statistics for all the variables. The results show that the CO$_2$, FPU and GDP are non-stationary at level, and stationary at 1$^{st}$ difference. Whereas, MPU is stationary at level I (0). Thus, the present study may employ ARDL methodology. Moreover, we employ granger causality test to discern the direction of the relationship.

5. Results

This section illustrates the results from ARDL model. The optimal lags are chosen on the basis of AIC. However, we restrict maximum lags up to 2. Table 3 reports the results from bounds test. However, table 4 shows the short-run as well as long-run results from ARDL model.

Table 3 shows that calculated values of both t-statistic and F-statistic at 5% significance level are greater than upper bound values which indicate that the null hypothesis of no co-integration can be rejected. Therefore, we conclude that there is existence of co-integration amongst the variables.

Table 4 reports the short- and long-run coefficients from ARDL model, and results of diagnostic tests. Short-run results show that the coefficients of MPU, FPU and GDP are statistically significant at 1% level. Particularly, coefficients of MPU and GDP are positive whereas FPU is negative. This implies that MPU and GDP escalate carbon emissions. Thus, we conclude that MPU and GDP increase environmental degradation. However, FPU plunges carbon emissions in the short-run. The table shows that the coefficient of MPU is 0.037 which means 1% increase in MPU leads to 0.037% increase in CO$_2$ emissions. The coefficient of GDP is 1.140, which means that 1% increase in GDP leads to 1.1402% increase in CO$_2$ emissions. Next, the coefficient of FPU implies that 1% increase in FPU decreases carbon emissions by 0.035%.
Furthermore, long-run results from ARDL model show that the coefficient of MPU is positive and statistically significant. This explains that 0.106% CO₂ emissions are fostered by a 1% increase in MPU. Next, the coefficient of FPU is negative and statistically significant. The coefficient of FPU implies that a 1% increase in FPU decreases carbon emissions by 0.073%. Additionally, GDP also negatively affects the carbon emissions in long-run as the coefficient of GDP is negative and statistically significant. The coefficient of GDP explains that a 1% increase in GDP declines carbon emissions by 0.029% in long-run.

The possible reasons behind these results are: first, MPU increases the carbon emissions because higher monetary policy uncertainty discourages research and development (R&D), innovations, new technology and pollution-free means of production, which increases carbon emissions. Next, if monetary policy is uncertain then producers will be unaware of the upcoming policy. Thus, producers move toward traditional cost effective ways of production, and environmental friendly means would not be discovered. Hence, level of carbon emissions may increase. Additionally, if monetary policy is uncertain then investors would not prefer to invest much in environment friendly means of production which leads to an increase in carbon emissions. On the contrary, FPU plunges economic growth, which in turn mitigates carbon emissions. Similarly, focused on the notion of Environmental Kuznets Curve (EKC), which explains that there is an inverted U-shaped relationship between economic growth and environmental degradation, and it is time-varying and differs from short-run to long-run. In short-run economic growth contributes to the environmental degradation as production increases carbon emissions also increase. However, in long-run, high level of income prompts people to demand pollution free environment. Therefore, environment friendly means of productions are utilized, which in turn impedes carbon emissions.

Moreover, the findings from the current study are in line with the conclusion of Jiang et al. (2019) and Pirgaip and Dinçergök (2020), which report that economic policy uncertainty effects carbon emissions.

Next, the table 4 also reports the results of all diagnostic tests namely; Ramsey RESET test, LM serial correlation test, CUSUM test, CUSUM² test, Jarque-bera normality test, ARCH test and Adj. R², and ECT (error correction term). Adj. R² describes the goodness to fit of model. The value of Adj. R² is 0.79 which means independent variables are explaining 79% variations in dependent variable. Ramsey RESET test is applied to check the misspecification in the model. The probability value of Ramsey RESET test is 0.57, which implies that there is no misspecification in the model. Next, LM serial correlation test at 10 lags is applied to check the non-zero correlation between errors (serial correlation problem). The value of LM test is 0.21, which indicates that the problem of serial correlation is not present. Further, CUSUM and CUSUM² tests are applied to check the stability of model. According to results (figure 1 and figure 2), both plots lie within the critical bounds, which conclude that the model is structurally stable. The probability value of Jarque-bera normality test is 0.27, which indicates that there is normal distribution of error term. Moreover, ARCH test concludes that variance of error term is constant over the time. Furthermore, the value of ECT is -0.70, which indicates that any deviation from long-run equilibrium is corrected by 70% each year.
6. Conclusion

This study investigates whether MPU and FPU effect carbon emissions in US. The study uses time series annual data from 1985 to 2019, and the US economy is taken for analysis. Furthermore, this paper employs the ARDL model to analyze the effect of MPU and FPU on carbon dioxide emissions. The results from the ARDL model reveal that there is co-integration amongst the variables i.e. the existence of long run relationship among variables. Moreover, findings from ARDL model also conclude that in the short run MPU and GDP has positive relationship with CO2 emissions whereas FPU has negative relationship with carbon emissions. These results indicate that MPU and GDP escalate carbon emissions. Thus, MPU and GDP contribute to pollution and environmental degradation. On the contrary, FPU impedes carbon emissions. This implies that FPU raises the environmental quality by mitigating carbon emissions.

However, in long run, findings also reveal that GDP and FPU have negative relationship with CO2 emissions. This indicates that FPU and GDP mitigate carbon emissions, and escalate the environmental quality. However, in long-run, MPU increases the CO$_2$ emissions, which implies that MPU increases the pollution and environmental degradation.

Given these findings, this study deducts many policy implications. For instance, the study suggests that policy makers should minimize the distortions (uncertainty) in monetary policy, as MPU has adverse environmental impacts. Moreover, central bank should inform other economic agents (i.e., producers, investors, and consumers) about the upcoming monetary policy in order to halt the environmental effects of MPU. Moreover, in debate of rule versus discretion, policy makers should adopt rule as monetary policy making framework. On the contrary, environmental quality could be improved at the cost of FPU therefore policy makers should not use FPU as a tool to mitigate CO2 emissions, as FPU itself has adverse economic impacts.

For future research trends, the impact of different policy uncertainties on carbon emissions can be explored. Furthermore, the relationship amongst the variables of MPU, FPU on CO2 emission can also be investigated in other economies. Moreover, there are few limitations in this study. First, this study uses small data set (34 observations). Second, due to small data set, the present study employs just one control variable, which may cause omitted variable bias.

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8. Tables

Table 1: Descriptive statistics
### Table 2: Unit root test

| Variables | I(0)   | I(1)   |
|-----------|--------|--------|
| CO₂       | 0.9370 | 0.0005*** |
| MPU       | 0.0114** | -      |
| FPU       | 0.0509 | 0.0000*** |
| GDP       | 0.5886 | 0.0144**  |

*Note: *, ** and *** shows level of significance at 10%, 5% and 1% respectively. Null Hypothesis: Variable has a unit root.*

### Table 3: Co-integration results

| Bounds test | Value | I(0) | I(1) |
|-------------|-------|------|------|
| t-statistic | -6.030147 | -2.86 | -3.78 |
| F-statistic | 9.248282 | 3.23  | 4.35  |
Null Hypothesis: No co-integration

Table 4: Short- and long-run results from ARDL model

| Variable   | Coefficient | Probability Value |
|------------|-------------|-------------------|
| **Short-run coefficients**                  |             |                   |
| Constant  | 0.585384    | 0.0000***         |
| $\Delta MPU_t$ | 0.036962    | 0.0002***         |
| $\Delta MPU_{t-1}$ | -           | -                 |
| $\Delta FPU_t$ | -0.035282   | 0.0001***         |
| $\Delta FPU_{t-1}$ | -           | -                 |
| $\Delta GDP_t$ | 1.140289    | 0.0000***         |
| **Long-run coefficients**                  |             |                   |
| Constant  | 0.585384    | 0.0001***         |
| $CO2_{t-1}$ | -0.452709   | 0.0000***         |
| $MPU_{t-1}$ | 0.105765    | 0.0000***         |
| $FPU_{t-1}$ | -0.073178   | 0.0000***         |
| $GDP_{t-1}$ | -0.029433   | 0.0356**          |
| **Diagnostic tests**                       |             |                   |
| Adj. $R^2$ | 0.79        |                   |
| Ramsey RESET test | (0.57)   |                   |
| LM serial correlation test | (0.21) |                   |
| CUSUM test                   | Stable      |                   |
| CUSUM$^2$ test               | Stable      |                   |
| Jarque-Bera normality test   | (0.27)      |                   |
| ARCH test                    | (0.79)      |                   |
| ECT                          | -0.70***    |                   |
Note: *, ** and *** shows level of significance at 10%, 5% and 1% respectively. (.) indicates probability value.