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Does The Steady Economic Progression Along With An Upsurge In FDI End Up Emanating More Methane Gas In The Air? A Study Of The Economic Causes Of Air Contamination From A Developing Country

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Abstract
Economic development has historically led to damage to the climate and the eco-system in the form of dangerous emissions that include carbon dioxide, methane gas and nitrous oxide among others. This study focuses on the influence of economic progression, foreign investment and crude oil price on methane emissions in the context of Pakistan. Annual figures were taken for the aforementioned variables from 1990 to 2021 and the data was analyzed through the ARDL method to find a long-run association among the time series independent variables with methane emissions. It was found that the lagged value of the first difference in oil price and foreign investment had a significant effect on methane emissions. The proxy used for measuring economic growth, i.e., GDP, was found to have no long-term impact on methane emissions, however. The Granger Causality test also suggested a positive and significant influence of oil price and foreign investment on methane emissions and an insignificant association between GDP and the dependent variable.

1. Introduction

Human activity has historically led to environmentally unfriendly outcomes particularly after the advent of the industrial revolution since the beginning of the twentieth century. This has particularly caused global warming and other climate change effects that are disastrous not only to the existing, and the future generations of, mankind but also to all types of life on the planet.

The most abundant type of greenhouse gas in the environment is Carbon Dioxide (commonly abbreviated as CO_2). According to the estimates of the U.S. Environmental Protection Agency (2023), it accounts for 79.4% of the total greenhouse gas emissions on Earth. However, empirical studies focusing on the effects of human activity on CO_2 emissions are also abundant in literature. The second most important greenhouse gas is methane (formulated as CH_4). Although much lesser in quantity than CO_2, its ability to instigate global warming per cubic meter of volume is much larger. Overall, it accounts for 11.5% of the total greenhouse emissions around the globe. This is followed by Nitrous Oxide (abbreviated as N_20), the third large-scale pollutant that is responsible for 6.2% of the total emissions.

The current study is aimed at examining the impact of oil price, economic advancement and foreign investment on methane emissions in the context of Pakistan. There are limited studies that have focused on the effect of these human-induced activities on methane emissions in Pakistani context. The rationale behind attempting to explore this relationship is that methane emissions are primarily caused, among other things, by activities initiated by humans. This includes agricultural activities, coal mining, stationery and mobile combustion, wastewater management and many industrial processes. Being an agricultural country, around 70% of Pakistan's economy is based on agriculture. Increasing agricultural production of the country would, of course, lead to growth in the economy, i.e., increase in the gross domestic product. However, this would also entail more methane being produced, the most harmful of all greenhouse gas types. Hence, economic growth also brings about more environmental pollution that is one of the biggest concerns of the day.

In the same manner, as foreign direct investment increases in a country like Pakistan where regulations that deal with environmental pollution and climate change are not very stringent, this also increases the chances of more greenhouse gases being produced with methane being no exception. In fact, multinational companies prefer to shift their pollution-creating production plants to countries that have lenient laws regarding climate protection. Hence, if Pakistan receives more of foreign investment, it is very likely that it becomes home to more harmful gases that are a byproduct of those investments.

Finally, fluctuations in crude oil price also have a bearing on the extent of greenhouse gases, in our case, methane, being produced. When the price of crude oil goes up, its usage dwindles leading to lesser methane emissions, and vice versa.

2. Literatur e Review

Owing to its importance to the healthy existence of the globe, the issue of environmental degradation has been extensively studied both in Pakistan and in other countries. The ensuing lines initially discuss some of those studies conducted in the Pakistani context:

A study conducted by Khan et al (2020) on the influence of macroeconomic and financial development on CO_2 emissions in Pakistan from 1982 to 2018 revealed that the increase in stock market index and domestic credit had a significant impact on CO2 in the short and long run. It was found that FDI only affects the outcome variable in the longer run and economic growth affects it in the shorter run only. In another study, the effect of per capita income, oil price and FDI was checked on emissions of carbon dioxide in Pakistan for the years from 1971 until 2014 checking for both the symmetric and the asymmetric effect. The study's results were in line with the EKC premise. The asymmetric results showed that oil price increase tends to reduce greenhouse emissions and vice versa (Malik et al, 2020).

Usman et al (2022) also led a study to reveal the effect of financial expansion, economic progression, trade openness and energy consumption on carbon emissions in Pakistan. It was concluded by them that the energy sources that were non-renewable and trade openness degraded environmental quality whereas renewable energy elements did not. In another study, Ahmad et al (2022) studied the impact of

Chinese FDI on economic growth in Pakistan. They found, using the ARDL method, that Chinese FDI had a constructive effect on Pakistan's economy. A positive impact of FDI, economic development and industrialization was also found on environmental quality in the Pakistani context by Munir and Ameer (2020).

Farooq et al (2021) aimed to inspect the existence of EKC hypothesis in the presence of financial development, FDI and urbanization in Pakistan. They observed that all those variables had a positive and significant influence on carbon emissions in the country.

Mohsin et al (2022) also investigated the influence of energy usage and economic growth on environmental sustainability. Their findings were also in line with the previous studies as they found that an increase in energy use and economic growth will tend to increase carbon emissions in Pakistan.

There have been more studies conducted outside Pakistan that have addressed the effect of various variables promoting environmental degradation. Some of these studies are outlined below:

The impact of energy consumption, FDI, and economic growth on CO_2 emissions was checked by Zubedi et al (2022) through the EKC hypothesis from the perspective of Belt and Road Initiative announced by the Government of China. The paper found that the belt and road corridors would significantly improve trade, living conditions of participating countries and foreign investment. However, it would also lead to more carbon emissions in the area that may pose health related risks to the people living nearby.

Ostic et al (2022) also explored the effect of oil and gas trading, FDI and economic growth on carbon emissions for OPEC member countries. Their study also established a positive association of these variables with CO_2 emissions.

Mujtaba and Jena (2021) analyzed the asymmetric effect of economic growth, FDI inflows, oil price and energy use on carbon emissions in India through NARDL method. They found that an escalation in economic growth leads to a decrease in carbon emissions. Moreover, a positive and negative shock in oil prices also significantly affects CO_2 emissions. In addition, inflows from FDI also support the pollution heaven hypothesis.

Mahmood et al (2022) studied the impact of economic growth, oil price and urbanization on carbon emissions in Gulf Cooperation Council (GCC) countries. They found that economic growth and urbanization leads to more carbon emissions while increase in oil prices has a negative effect on emissions in GCC countries.

Tang and Tan (2015) studied the effect of energy consumption, FDI and income on carbon emissions in Vietnam. They found that income and energy consumption have a positive effect on CO_2 emissions. However, FDI was found to have a two-way causality with carbon emissions.

Liu et al (2023), in a study on the linkage among energy consumption, urbanization, economic growth and carbon emissions in China using the ARDL methodology, found that urbanization had no impact on environmental quality both in the short and in the long run. Energy usage, however, was found to considerably harm the environment in the immediate term and over time.

Ikram et al (2021) explored the relationship among economic growth, economic complexity and ecological footprint with evidence taken from Japan. With a newly developed Quantile ARDL methodology in which they took quarterly data for the country from 1965-Q1 to 2017-Q4, they found that bidirectional causality existed between all these variables in low and high quantiles. Moreover, the existence of cointegration among the variables was also confirmed both in the short- and in the long-run.

Being a burning issue, therefore, environmental degradation has been repeatedly addressed by empirical studies in different contexts inside and outside of Pakistan.

3. Methodology

The current study involves three independent variables. These are oil price, foreign direct investment and economic growth. These are all regressed on methane emissions --- the dependent variable. The data of foreign direct investment, economic growth and methane emissions were collected from the World Bank's website. The data of oil price was taken from oilprice.com. The data for all variables were taken on annual basis from 1990 to 2021. The reason behind taking all the data from 1990, and not from any earlier year, was to develop a balanced panel since the data for all the variables taken in the study was available only from the year 1990.

Foreign direct investment was measured by net inflows of FDI (BoP) in current US dollars. Economic growth was measured by gross domestic product (GDP) in current US dollars. Oil price was calculated as the year end, or closing, price of crude oil in US dollars. Finally, methane emissions were measured by k_t of CO_2 equivalent.

In order to check for the long-run relationship of oil price, FDI and GDP (a measure of the overall economic growth) with methane emissions in the context of Pakistan, cointegration analysis was applied. Using EViews, the analysis was performed in four steps --- checking for stationarity, identifying optimal lag length, running cointegration, and, in case of existence of cointegration, applying the vector error correction model.

The following econometric model was used in the study to assess the desired relationships:

$$Methane_t = \beta_0 + \beta_1 FDI_t + \beta_2 GDP_t + \beta_3 OilPrice_t + \varepsilon_t$$

Where

$Methane_t$ = Methane emissions in Pakistan from 1990 to 2021,

FDI_t = Foreign Direct Investment in Pakistan from 1990 to 2021,

GDP_t = Gross Domestic Product of Pakistan from 1990 to 2021,

$OilPrice_t$ = Year-end Price of Crude Oil in the World from 1990 to 2021,

β_0, β_1, β_2 and β_3 are the intercept and slope coefficients, &

ε_t is the error term.

4. Analysis and Findings

This section involves the econometric analysis used in the study and the findings extracted from the analysis. We start with the first step necessary before running cointegration analysis which is checking for stationarity of all our variables.

4.1 Checking for Stationarity

We first ensure that all the variables are integrated at the same order. This is because cointegration can only be applied to variables that are integrated at level but become stationary at first or second difference. The augmented dickey fuller test has been employed to see whether the variables taken in the study have a unit root or not.

Table 1: Checking Stationarity for Methane Emissions

	t-Stat	Probability
ADF Test Statistic	2.678	1.000

We start with our dependent variable, i.e., methane emissions. Table 1 provides the unit root test of methane emissions at level. With an ADF test statistic of 2.678 which is highly insignificant (p-value = 1.00), the variable shows up a unit root. We now check for the unit root of methane emissions at the first difference.

Table 2: Checking Stationarity for D(Methane Emissions)

	t-Stat	Probability
ADF Test Statistic	-4.739	.001

The ADF test of methane emissions taken at first difference shows that the variable becomes stationary when at first difference. As can be seen in table 2, the ADF test statistic is highly significant at 5% level.

Table 3: Checking Stationarity for Oil Price

	t-Stat	Probability
ADF Test Statistic	-1.539	.501

The ADF test of oil price in table 3 is also insignificant when taken at level (p-value = 0.5) meaning that the variable has a unit root. Taking the variable at first difference solves the problem, however.

Table 4: Checking Stationarity for D(Oil Price)

	t-Stat	Probability
ADF Test Statistic	-5.749	.000

Table 4 presents the ADF test of oil price taken at the first difference. The test statistic is now highly significant (p-value < 0.0001) showing that the variable renders stationary when at first difference.

Table 5: Checking Stationarity for GDP

	t-Stat	Probability
ADF Test Statistic	1.614	.999

The next exogenous variable used in the study is GDP. For almost all countries, this variable normally shows a clear upward trend. In the current case also, GDP has shown a unit root as shown in table 5 (t-statistic = 1.61, p-value > .999). We will be interested in finding whether this trend component persists in the variable when taken at first difference as well or not.

Table 6: Checking Stationarity for D(GDP)

	t-Stat	Probability
ADF Test Statistic	-4.997	.000

Luckily, GDP also becomes stationary at the first difference. Table 6 gives the ADF statistic of GDP at first difference and it can be observed that the p-value is now less than .001 showing that the ADF test has achieved statistical significance.

Table 7: Checking Stationarity for FDI

	t-Stat	Probability

ADF Test Statistic	-2.586	.107

Our last variable is FDI or foreign direct investment. This variable also has a unit root when checked at level (t-statistic = -2.58, p-value = .107). The details of the ADF test for this variable are provided in table 7. Off course, like other variables, we will have to check for the stationarity of FDI at first difference as well.

Table 8: Checking Stationarity for D(FDI)

	t-Stat	Probability
ADF Test Statistic	-3.859	.006

At first difference, FDI also becomes stationary (see table 8). The ADF test statistic becomes highly significant (p-value = .006) with a value of -3.859.

We have observed that all our variables, exogenous and endogenous, show trend when at level but become stationary when at first difference. Therefore, cointegration analysis can safely be applied to check for any long-run relationship among the variables.

4.2 Optimal Lag Length

After it has been found that all variables have a unit root which is removed at first difference, the next step is to find the optimal lag length for each variable. We start with our dependent variable, i.e., methane emissions and find that almost all of the information criteria suggest only lag for the variable.

Table 9: Optimal Lag Length Selection for Methane Emissions

Lag Length Selection Criteria
Endogenous variable: Methane Emissions

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-300.6403	NA	6.99e+08	23.20310	23.25149	23.21704
1	-226.7548	136.4041*	2568800.*	17.59652*	17.69330*	17.62439*
2	-226.2692	0.859082	2674436.	17.63609	17.78126	17.67790
3	-226.2603	0.015079	2890433.	17.71233	17.90588	17.76807
4	-226.2351	0.040745	3122944.	17.78731	18.02926	17.85698

Table 9 presents the optimal lag length for methane emissions as prescribed by LR, FPE, AIC, SC, and HQ criteria. As has been discussed, all these criteria suggest that there should be one lag only for the dependent variable.

Table 10: Optimal Lag Length Selection for GDP

Lag Length Selection Criteria
Endogenous variable: GDP

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-803.2854	NA	1.13e+22	53.61903	53.66573	53.63397
1	-747.7199	103.7224*	2.98e+20*	49.98132*	50.07474*	50.01121*

2	-747.1745	0.981590	3.07e+20	50.01164	50.15176	50.05646

Table 10 gives the optimal lag length for GDP. As can be seen, a lag length of "1" has been suggested by all the information criteria for GDP as well.

Table 11: Optimal Lag Length Selection for FDI

Lag Length Selection Criteria						
Endogenous variable: FDI						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-628.7820	NA	2.01e+18	44.98443	45.03201	44.99898
1	-614.0792	27.30518	7.57e+17	44.00566	44.10082	44.03475
2	-611.0026	5.494093*	6.53e+17*	43.85733*	44.00006*	43.90096*
3	-610.9008	0.174438	6.97e+17	43.92149	44.11180	43.97967
4	-610.9001	0.001125	7.50e+17	43.99287	44.23076	44.06559

The optimal lag length for the next exogenous variable, i.e., FDI, has been provided in table 11. All the information criteria hold that there should be two lags for FDI. All the criteria report minimum values for the second lag.

Table 12: Optimal Lag Length Selection for Oil Price

Lag Length Selection Criteria						
Endogenous variable: Oil Price						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-132.3643	NA	802.8556	9.526022	9.573600	9.540567
1	-115.2511	31.78174*	254.0274*	8.375075*	8.470233*	8.404166*
2	-115.1867	0.114852	271.7435	8.441910	8.584646	8.485546
3	-114.9549	0.397411	287.3987	8.496780	8.687095	8.554961
4	-114.8783	0.125891	307.5778	8.562735	8.800628	8.635461

For Oil Price, the optimal lag length as suggested by LR, FPE, AIC, SC, and HQ is again one (see table 12). Overall, the information criteria have suggested only one lag for three out of four variables including the dependent variable. However, for FDI, two lags have been suggested. We can therefore safely assume to take one lag while running the cointegration analysis.

4.3 Cointegration Test

After identifying the optimal lag length for our variables, we proceed to run cointegration analysis to find how many cointegrating equations are there in our variables. Table 13 provides cointegration analysis using the trace test and the maximum eigenvalue approach.

Table 13: Cointegration Test

Cointegration Test (Trace)				
No. of CE(s)	Eigenvalue	Trace	0.05 Crit. Val.	Prob.**

None *	.661	64.842	47.856	.001
At the max 1 *	.481	34.516	29.797	.013
At the max 2 *	.342	16.171	15.495	.039
At the max 3 *	.148	4.468	3.841	.034
Trace test indicates 4 cointegrating equations at the 0.05 level				
Cointegration Test (Maximum Eigenvalue)				
No. of CE(s)	Eigenvalue	Max-Eigen	0.05 Crit. Val.	Prob.**
None *	.661	30.325	27.584	.022
At the max 1	.480	18.346	21.132	.117
At the max 2	.342	11.702	14.265	.122
At the max 3 *	.147	4.468	3.841	.035
Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level				

As per the trace test, all the four hypothesized CE(s) have a trace statistic value higher than their respective critical value. Therefore, probability values of all the four hypothesis are less than .05 (representing statistical significance). This suggests that there are four cointegrating equations among our variables.

If we, however, look into the maximum eigenvalue test results, only one hypothesis that assumes “none” or “no cointegrating equation” has a Max-Eigen statistic (30.33) higher than the critical value (27.58) resulting in rejection of the hypothesis. Therefore, it may be inferred that there is at the very least one cointegrating equation at the .05 level.

The two cointegration tests suggest different number of cointegrating equations. However, since researchers give more importance to the maximum eigenvalue approach, therefore it may be inferred that there exists, at the very least, one cointegrating equation among our variables. Which of the two variables are co-integrated in the long run will be found out soon as we proceed towards step 4, i.e., the Vector Error Correction Model.

4.4 Vector Error Correction Estimates

The last step in search for a long-run relationship among our proposed variables is the vector error correction model. This model is run only if, in the previous step, it is found that there exists at least one cointegrating equation between the variables. Since the maximum eigenvalue approach declares the existence of one cointegrating equation, we perform VECM. Table 14 presents results of the VECM estimates.

Table 14: Vector Error Correction Estimates

Cointegrating Equation	Cointegrating Equation 1
Methane Emissions(-1)	1.000
Oil Price(-1)	128.251 [1.862]
GDP(-1)	-2.13E-07 [-9.333]

FDI(-1)	-4.06E-06 [-3.623]			
C	-79823.87			
Error Correction:	D(Methane Emissions)	D(Oil Price)	D(GDP)	D(FDI)
CointEq1	0.090 [2.955]	-0.0002 [-0.529]	796881.9 [3.044]	21260.68 [1.071]
D(Methane Emissions(-1))	-0.351 [-1.973]	-0.0009 [-0.406]	-3495460. [-2.294]	28482.14 [0.246]
D(Oil Price(-1))	37.100 [2.039]	-0.098 [-0.425]	-4.58E+08 [-2.939]	-24714305 [-2.092]
D(GDP(-1))	2.52E-08 [1.042]	5.78E-11 [0.188]	0.348 [1.686]	-0.014 [-0.890]
D(FDI(-1))	8.52E-07 [2.623]	2.44E-10 [0.059]	9.274 [3.338]	0.561 [2.663]
C	3830.519 [6.768]	3.521 [0.489]	1.67E+10 [3.439]	1.48E+08 [0.402]

As can be seen, the aforementioned table has two portions. The first portion of the table gives the cointegration equation. We need to reverse the signs of the coefficients in this portion before interpreting the results. Here, after reversal of the coefficients' signs, we hold that GDP and FDI appear to have a positive and significant relationship with methane emissions. However, oil price has a negative albeit insignificant association with methane emissions.

The second portion of table 14 provides the error correction estimates. It contains the error correction of the cointegrating equation and the lagged values of the independent variables. It shows the speed with which our variables move back to the equilibrium after some shock. The sign of the cointegrating equation should technically be negative and it should be significant. This is because a negative sign shows movement towards the equilibrium whereas a positive sign represents movement away from the equilibrium. In our case, it is significant but positive. The coefficient of the error correction term is +0.09. This indicates that the deviation from long-run relationship is corrected at a rate of -9% in the present period. This is not a good result as we want this deviation to be negative and more than, or somewhere close to, 20%. In the current analysis, it is 9% positive, not a much desired value.

We move further down the table and check for the error correction of our independent variables. We find that the lagged value of the first difference in Oil Price has a coefficient of 37.1 with a t-statistic of 2.04 making it statistically significant. The lagged value of the first difference in FDI also has a significant t-statistic of 2.62 though the coefficient is very small. The t-statistic of the lagged value of GDP, however, is insignificant (1.04). Hence, the relationship of oil price and FDI with methane emissions is positively and significantly corrected after an exogenous shock while the relationship of GDP with methane emissions is not. It must be mentioned that as the respective beta coefficients signify, oil price has a much more visible relationship with methane emissions in the long-run than the FDI.

The error correction equation is:

D(Methane Emissions) = 0.09(ECT$_{t-1}$) – 0.35D(Methane Emissions$_{t-1}$) + 37.1D(Oil Price$_{t-1}$) + 2.52E-08D(GDP$_{t-1}$) + 8.52E-07D(FDI$_{t-1}$) + 3830

4.5 Short-run Causality

After exploring the existence of a long-run relationship between/among our variables, we proceed to check for short-term relationship. One way to do this is through VEC Granger Causality/Block Exogeneity Wald Test. The test is provided below:

Table 15: Short-run Causality Test

Granger Causality Test
Dependent variable: D(Methane Emissions)

Excluded	Chi-sq	Df	Prob.
D(Oil Price)	4.157531	1	0.0414
D(GDP)	1.085370	1	0.2975
D(FDI)	6.882051	1	0.0087
All	19.93315	3	0.0002

As per results of the Granger Causality test given in table 15, oil price (Chi-sq = 4.16, p-value = .04) and FDI (Chi-sq = 6.88, p-value = .01) have a significant positive relationship with methane emissions whereas GDP (Chi-sq = 1.09, p-value = .30) does not have any association with the dependent variable.

Another way to check for the short-term relationship among variables is through Pairwise Granger Causality tests. Table 16 provides results of the Pairwise Granger Causality Tests.

Table 16: Granger Causality Test

Pairwise Test of Granger Causality The Null:	Obs	F-Statistic	p-value
Oil Price does not Granger Cause Methane Emissions	28	5.785	.009
Methane Emissions does not Granger Cause Oil Price		.284	.755
GDP does not Granger Cause Methane Emissions	28	.148	.863
Methane Emissions does not Granger Cause GDP		7.393	.003
FDI does not Granger Cause Methane Emissions	28	6.776	.005
Methane Emissions does not Granger Cause FDI		1.196	.321
GDP does not Granger Cause Oil Price	30	.170	.844
Oil Price does not Granger Cause GDP		2.438	.108
FDI does not Granger Cause Oil Price	30	.668	.522
Oil Price does not Granger Cause FDI		2.558	.098
FDI does not Granger Cause GDP	30	.239	.789
GDP does not Granger Cause FDI		.384	.685

Results of the Pairwise Granger Causality Tests are also similar to the ones given by VEC Granger Causality Tests / Block Exogeneity Wald Tests. With an F Statistic of 5.78 and a p-value of 0.009, the Null Hypothesis presuming that Oil Price does not Granger Cause Methane Emissions has been rejected. Hence, it can be concluded that Oil Price does Granger Cause Methane Emissions. In the same manner, FDI also Granger Causes Methane Emissions (F-Statistic = 6.78, p-value = .005). As long as our third variable, i.e., GDP, is concerned, the variable does not Granger Cause Methane Emissions. However, the relationship between them seems to be in the reverse order. In fact, Methane Emissions seem to Granger Cause changes in GDP. Altogether, we find that in line with results of the VEC Granger Causality test and Vector Error Correction Estimates, only Oil Price and FDI significantly affect methane emissions while GDP does not.

4.6 Some Diagnostic Tests

We now conduct some diagnostic tests to see whether the major assumptions of cointegration are met or not. Table 17 provides the autocorrelation test for our variables using the VEC Residual Serial Correlation LM Tests. The p-values for both lags is more than 0.05 indicating that there is no serial correlation in the data.

Table 17: Serial Correlation Test

Serial Correlation LM Tests Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	13.74146	16	0.6180	0.851088	(16, 46.5)	0.6246
2	12.61408	16	0.7007	0.772734	(16, 46.5)	0.7064

Next, we check for the normality of residuals for our variables, specifically the dependent variable. Table 18 presents a check for the skewness of our variables.

Table 18: Residual Normality --- Checking for Skewness

Component	Skewness	Chi-sq	Df	Prob.*
1	.112	.058	1	.809
2	-.910	3.869	1	.049
3	-.716	2.395	1	.122
4	.142	.095	1	.758
Joint		6.417	4	.170

The four components in the aforementioned table represent the four variables. The p-value column shows that the skewness of the second component is statistically significant (less than 5%). Looking at the VAR specification, we find that the second component corresponds to the Oil Price. Hence, we may conclude that the residuals of oil price are not normally distributed. Off course, oil price does not need to be normal as it is based on many external factors. However, Table 19 provides the Jarque-Bera statistic for all variables (it is widely considered as a good statistic for assessing normality). The Jarque-Bera values are insignificant for all components individually and for the overall model jointly. This represents that the data is overall normally distributed and there is not much deviation from the normality. The table providing the JB values for each variable follows. The joint Jarque-Bera value is also given in the table along with its probability.

Table 19: Residual Normality --- The Jarque-Bera Test

Residual Normality Tests			
Component	Jarque-Bera	Df	Prob.
1	.133	2	.935
2	5.472	2	.065
3	2.880	2	.237
4	1.788	2	.409
Joint	10.274	8	0.246

We continue with our diagnostic tests and check for the heteroscedasticity as well. The VEC Residual Heteroscedasticity tests given in table 20 show that the Chi-square statistic is 104.33 with a p-value of 0.36. As the p-value of the Chi-square statistic is greater than 0.05, we cannot reject the null hypothesis that the residuals are homoscedastic. Hence, the residuals are not heteroskedastic either and we are safe with this assumption.

Table 20: Heteroskedasticity Test

VEC Residual Heteroskedasticity Test		
Joint test:		
Chi-sq	df	Prob.
104.335	100	.364

4.7 Variance Decomposition

We finally check for variance decomposition of our dependent variable. The results are presented in table 21. As can be observed, for the first component, 100% of the variance in methane emissions in the first period is explained by its own lag with no variance coming from other variables. Then in the second period, 76.83% of variance in methane emissions is coming from its own lag, 20.63% from oil price, 0.33% from GDP, and 2.22% from FDI. This again testifies that the major contributor of methane emissions in our study is oil price followed by FDI. The variable GDP plays very little to no role in affecting emissions of the greenhouse gas.

Table 21: Variance Decomposition of Methane Emissions

Period	S.E.	Methane Emissions	Oil Price	GDP	FDI
1	1248.864	100.0000	0.000000	0.000000	0.000000
2	2014.223	76.82914	20.62727	0.326685	2.216907
3	2461.683	78.87082	17.45078	1.590860	2.087536
4	2987.164	79.23066	17.19541	2.021606	1.552333
5	3532.059	76.71800	19.12110	1.622361	2.538534

As a last step, we also observe the impulse response of our variables, particularly the dependent variable, in order to understand the effect of a one-unit shock to any of our variables on the entire system of variables over time. The following figure gives a separate impulse response for each variable taken in the study. It can be seen how the shock effects propagate through the system over the time horizon of the study.

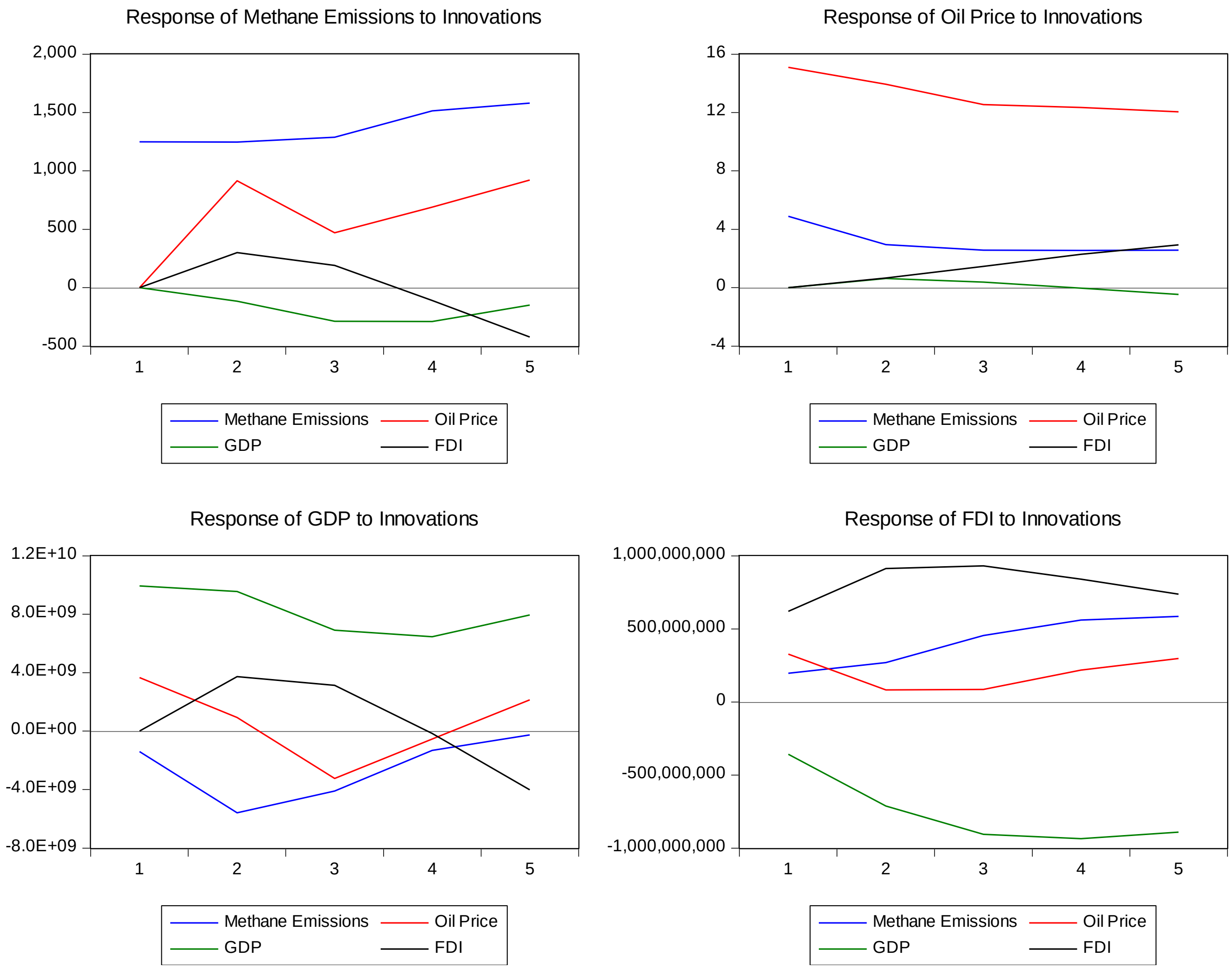

Figure 1: Impulse Response of Cholesky One S.D. Innovations

Conclusion

The study was undertaken to measure the impact of oil price, FDI and economic growth (measured by GDP) on methane emissions in Pakistan. To understand their interrelationship, cointegration analysis was employed. Since cointegration requires that all the variables are integrated when at level and become stationary when taken at the first, or second or even at the third, difference, a unit root test was employed which revealed that all the variables were initially integrated but became stationary at the first difference. In the next stage, we searched for the optimal lag length and found that it was "1" for all the variables. We then proceeded with the cointegration test. The Maximum Eigenvalue approach indicated at least one cointegrating equation among our variables. As a last step, we measured the Vector Error Correction Estimates. It was found that the lagged value of the first difference in both Oil Price and FDI had a significant impact on methane emissions. The third variable, i.e., GDP, had no long-term impact on methane emissions, however.

We then also checked for short run causality among the variables using the VEC Granger Causality/Block Exogeneity Test. This test also suggested a positive and significant relationship of Oil Price and FDI with methane emissions and an insignificant association between GDP and the dependent variable. In fact, the Pairwise Granger Causality test also suggests the same --- that Oil Price and FDI Granger Cause methane emissions. For our third variable, GDP, the test concludes that the relationship between GDP and methane emissions is in the opposite direction, i.e., that methane emissions Granger Cause changes in the GDP.

On the basis of the above empirical findings, we conclude, therefore, that methane emissions --- one of the deadliest ingredients of greenhouse gas emissions --- is largely influenced by oil price and then by FDI. These results are in line with the literature as well. In fact, as the price of the crude oil products increases, its usage starts getting shrinked leading to lesser methane emissions. Similarly, more foreign direct investment may bring more prosperity to the country but is also the cause of more emissions that have an adverse effect on the climate of the country. Although an increased economic growth in a country has also been historically associated with more climate change effects and global warming, this study could not find any statistically significant association between GDP (a proxy used to indicate economic growth) and methane emissions, however.

References

Ikram, M., Xia, W., Fareed, Z., Shahzad, U., & Rafique, M. Z. (2021). Exploring the nexus between economic complexity, economic growth and ecological footprint: Contextual evidences from Japan. Sustainable Energy Technologies and Assessments, 47, 101460.

Farooq, A., Anwar, A., Ahad, M., Shabbir, G., & Imran, Z. A. (2021). A validity of environmental Kuznets curve under the role of urbanization, financial development index and foreign direct investment in Pakistan. Journal of Economic and Administrative Sciences.

Liu, H., Wong, W. K., Cong, P. T., Nassani, A. A., Haffar, M., & Abu-Rumman, A. (2023). Linkage among Urbanization, energy Consumption, economic growth and carbon Emissions. Panel data analysis for China using ARDL model. Fuel, 332, 126122.

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. Energy, 79, 447-454.

Mahmood, H., Asadov, A., Tanveer, M., Furqan, M., & Yu, Z. (2022). Impact of oil price, economic growth and urbanization on CO2 emissions in GCC countries: asymmetry analysis. Sustainability, 14(8), 4562.

Mohsin, M., Naseem, S., Sarfraz, M., Rehman, M., & Baig, S. A. (2022). Does energy use and economic growth allow for environmental sustainability? An empirical analysis of Pakistan. Environmental Science and Pollution Research, 29(35), 52873-52884.

Khan, M. I., Teng, J. Z., & Khan, M. K. (2020). The impact of macroeconomic and financial development on carbon dioxide emissions in Pakistan: evidence with a novel dynamic simulated ARDL approach. Environmental Science and Pollution Research, 27, 39560-39571.

Malik, M. Y., Latif, K., Khan, Z., Butt, H. D., Hussain, M., & Nadeem, M. A. (2020). Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. Science of the Total Environment, 726, 138421.

Usman, M., Kousar, R., Makhdum, M. S. A., Yaseen, M. R., & Nadeem, A. M. (2022). Do financial development, economic growth, energy consumption, and trade openness contribute to increase carbon emission in Pakistan? An insight based on ARDL bound testing approach. Environment, Development and Sustainability, 1-30.

Ahmad, M. S., Szczepankiewicz, E. I., Yonghong, D., Ullah, F., Ullah, I., & Loopesco, W. E. (2022). Does Chinese foreign direct investment (FDI) stimulate economic growth in Pakistan? An application of the autoregressive distributed lag (ARDL bounds) testing approach. Energies, 15(6), 2050.

Munir, K., & Ameer, A. (2020). Nonlinear effect of FDI, economic growth, and industrialization on environmental quality: evidence from Pakistan. Management of Environmental Quality: An International Journal, 31(1), 223-234.

Zubedi, A., Jianqiu, Z., Ali, Q., Memon, I., & Zubedi, E. (2022). Impact of energy consumption, economic growth, and FDI through environmental Kuznets Curve: perspective from Belt and Road initiative and Pakistan. Mathematical Problems in Engineering, 2022.

Ostic, D., Twum, A. K., Agyemang, A. O., & Boahen, H. A. (2022). Assessing the impact of oil and gas trading, foreign direct investment inflows, and economic growth on carbon emission for OPEC member countries. Environmental Science and Pollution Research, 29(28), 43089-43101.

Mujtaba, A., & Jena, P. K. (2021). Analyzing asymmetric impact of economic growth, energy use, FDI inflows, and oil prices on CO2 emissions through NARDL approach. Environmental Science and Pollution Research, 28, 30873-30886.