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Role of Carbon Taxation in Mitigation of GHG Emissions in the Energy Sector of Pakistan

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Abstract

A consensus has emerged among scientists and policymakers that global climate change represents a major threat to the well-being of humankind, environment, and biosphere. Scenarios of the probable consequences of such an increase differ substantially among regions, yet include sea level rise, lack of fresh water, droughts, floods, recurrent harsh forest fires, storms, severe heat and cold events, irrigation problems, more infectious diseases, and ecosystem degradation. Carbon emissions have devastating impacts on the environment as well as on human health. The severity is getting worse day by day with a continuous rise in carbon emissions. As per Glasgow Pact 2021, a net-zero transition would entail a significant and often front-loaded shift in demand, capital allocation, costs and jobs. The current study aims to investigate the effect of the carbon tax on carbon emissions and the economic growth of the provinces of Pakistan. Panel unit root test, panel co-integration test, and Autoregressive Distributed Lag (ARDL) test are applied to find the relationship between carbon tax, carbon emissions, and economic growth. Moreover, the Impulse Response Function (IRF) is used to project the dynamics of carbon emissions and economic growth till 2050. The study concludes that the carbon tax and carbon emissions have negative relationship, while carbon tax and economic growth have positive relationship. IRF shows that increasing the carbon tax by 2% every year will significantly reduce carbon emissions, and will significantly increase economic growth. This study recommends formulation of a comprehensive carbon mitigation strategy for the reduction of carbon emissions. There is a need to shift energy mix towards renewable/clean energy resources to cope with the overall emissions level.

Keywords: Carbon tax, Carbon emissions, ARDL, IRF, Economic growth

1. Introduction

Carbon emissions, including methane gas emissions, nitrous oxide, and other greenhouse gases (GHGs) emissions, lead to an increase in global temperature. The drastic impacts include rising sea levels, rainfall pattern shifting, growing severe storm incidents, and increased acidification of the ocean. Increase in GHG emissions have severe impacts on both humans and environment (EPA 2017; NASA 2018). According to the World Bank, the most vulnerable region in the world affected by carbon dioxide emissions is the Asian continent. East Asian countries are more dominant than the South Asian countries in carbon emissions. East Asia emits 6.2 Mt of carbon dioxide each year, and South Asia emits 1.46 Mt each capita of carbon dioxide per year. Korea, Japan, and China are the largest emitters in East Asia. On the other side, Sri Lanka, India, Bangladesh, and Pakistan are the dominant South Asian emitters. (CDIAC 2014)

Carbon emissions from the burning of petroleum by-products are normally considered as the primary cause of climate change. According to Lin & Ahmed (2017), Pakistan's carbon dioxide emissions are now less than they were previously. Research demonstrate that the carbon dioxide discharges will reach up to 251.5 Mt in the year 2025, according to the Business as Usual (BAU) scenario. The decrease impending the year 2025 is measured as 28.94 Mt and 55.02 Mt of carbon dioxide, according to direct and forceful outflow decrease situation, separately. (Lin, B., &Ahmad, I. 2017).

Pakistan contributes less than one percent in the global carbon emissions, but is highly vulnerable and ranks among top ten countries affected by climate change (Kreeft et al., 2016). Meanwhile, in 2010, the nation experienced severe environmental events, bringing about monetary damage to $6 billion dollars (CPEIR, 2015). The recent floods of 2022 run down the country stretching from South Punjab to Sindh and Baluchistan such that nearly one-third of the country went under water. Over 16,000 people died and more than 33 million have been impacted by the devastation caused by this flood. The approximate economic losses and damages caused by the 2022 flood is estimated at over US$ 30 billion. (Leghari, Salman, 2022)

At COP-21, Pakistan signed and presented Intended Nationally Determined Contributions (INDC) on the environment, part of Pakistan's Vision (2025), and NCCP (Intended Nationally Determined Contributions' policy 2012) As stated in Pakistan's initial NDC submission in 2016, the government of Pakistan would adhere to the GHG emissions trajectory of 1603 million tonnes of carbon dioxide equivalent (Mt CO2e) for 2030. The government of Pakistan is still dedicated to decreasing emissions to the greatest extent possible, realizing that doing so will help the Paris Agreement's goal of keeping global warming to 1.5–2 °C. The government of Pakistan has undertaken numerous transformative actions. Pakistan plans to set a cumulatively ambitious goal of conditional and voluntary contributions to reduce its projected emissions by 50% overall by 2030, with a 15% reduction below business as usual (BAU) from domestic resources and an additional 35% reduction below BAU subject to international financial support. (Nationally determined contribution, 2021).

The primary sectors that should have been addressed to deal with the effects of climate change are energy, transportation, agribusiness, livestock, forestry, town planning, and energy. As per Glasgow Pact 2021, a net-zero transition would entail a significant and often front-loaded shift in demand, capital allocation, costs and jobs. Pakistan has also agreed to keep utilizing domestic coal but will no longer create projects involving imported coal. Furthermore, in an effort to reduce methane emissions, Pakistan recently joined the Global Methane Pledge as well.

Pakistan's energy sector is the most important contributor to carbon emissions when examining the country's various sectors' emissions. Total emissions from the energy sector of Pakistan are 157 million per ton according to the scenario of 2007-2008; which are 51% of the country's total emissions (0.45% of the overall world). Emissions from other sectors are comprised of in such a proportion that 39% emissions are contributed from livestock and agriculture, 6% from industrial sector and only 1% from waste. Thus, 90% of greenhouse gas emissions come from the agriculture, livestock and energy sector. Therefore, the energy sector is the area where the carbon emissions mitigation strategies need special attention. (Khan, 2010).

Pakistan generates about 76.1% of emissions from energy sector according to Hydrocarbon Development Institute of Pakistan (HDIP, 2019). In the COP 27, at Sharm ul Shaikh in Egypt, a global initiative has been launched at increasing the jurisdictions around the world which put a price on carbon. The initiative aims for 60% of global greenhouse gas emissions to be covered by a carbon price by 2030, up from around 23% which is put in place today. (Martin, 2022). A tax on carbon emissions will generate revenue for the country and play a significant role in increasing that country's GDP. Global Commission on the Economy and Climate (GCEC) finds that the strong action on climate might convey at any rate $26 trillion in financial advantages by 2030 (UNFCCC, 2018). This essential research, delivered by the Global Commission and above 200 specialists, features verification purposes of the worldwide move to the de-carbonize the economy and recognizes tactics to quicken activity in five parts: energy, urban areas, land use, water, and industry. (UNFCCC 2018).

Tax on carbon emissions plays a vital role in the reduction of greenhouse gas emissions. Most of the literature reflects the effect of taxes on reducing hazardous gases, which pollutes the environment up to a dangerous level. Implementation of taxes is useful to protect the environment and create continuity in the sustainable production of energy. Jawed Anwar (2014) analyzed the impact of carbon taxation and supply portfolio on the energy resources diversification, supply-side technology mix, and the demand side of the technology mix. The paper suggests two policy implications to improve energy security. One is renewable portfolio supply, and the other is the carbon tax. Both may lead to improve the energy security of Pakistan.

Carbon tax also engenders some developmental benefits. High carbon outflows lead to a higher pace of newborn mortality also, indirect connections are found between newborn mortality and carbon outflow, instead of direct. The world must reduce carbon emissions to improve a newborn child’s well-being in any event, over the long run. Measure to check population growth is essential to stop newborn mortalities. The reduction of carbon dioxide emissions can bring down the number of child deaths in the long run. (Hasnain, M. I. U., Haider, A., Salman et. al., 2016)

Governments could utilize carbon tax revenue to facilitate the weight of tax collection on labourers by bringing taxes down according to personal pay and finance charges. Carbon tax income could likewise support profitable speculations to help accomplish the United Nations Sustainable Development Goals, including diminishing hunger, poverty, imbalance, and ecological damages. (Ian Parry, 2019)

Taxes on emissions could significantly increase the revenue naturally (cost-advantage). Based on the assumption given by the literature, if the U.S. government used this revenue as an income tax, then the carbon tax could save the cost up to $20 billion per year using the equivalent trade-cape system, which did not damage the recycling revenue approach. (Burtraw, Palmer, Bharrirkar, and Paul, 2002.)

Climate change is happening due to various gas emissions. These gas emissions are high if generated by fuel and oil stock. Oil taxation is considered an instrument of climate change to bring the demand of oil down. But fossil fuel-producing countries are counteracting the climate policy by subsidizing oil in the market. (Wei, J., et al. 2012).

The gasoline tax policy, greenhouse gas emissions tax, and water and waste tax policy of overall Europe, demonstrated the environmental taxation and all tax policy in the whole of Europe. According to Sterlin and Cohlin, environmental taxes played a vital role in protecting the environment in Europe. (Sterner, T., & Köhlin, G. 2003).

Gowdy and Salman conducted a study on adjustment to environmental change as opposed to mitigation procedures. According to them, adapting to climate change is progressively testing, and will become an ever-increasing troublesome as worldwide temperatures rise. (Gowdy, J., & Salman, A., 2007).

Carbon taxation plays a vital role in the reduction of Greenhouse gas emissions, specifically carbon emissions. This study will determine the ratio of mitigation of greenhouse gas emissions by using carbon tax in every province of Pakistan, also a better policy would be recommended for future. Furthermore, this study will also visualize the trends and variation of total emissions in all provinces of Pakistan. Moreover, the study will also describe how much carbon taxation will generate revenue for the country's regions. For the researchers, this study will help them uncover the critical areas in Pakistan's energy sector that many researchers were unable to find out.

2. Data and Methodology

This study used panel data from all the four provinces of Pakistan in between 1997 and 2018. Gross value-added data, which is the gross domestic product's proxy (GDP), collected from the public expenditure review, 2012 and public expenditure review, 2017. Data on natural gas, coal, and crude oil was collected from Pakistan statistical review 2007 and Pakistan statistical review 2018. Data of electricity was compiled from the energy yearbook of Pakistan. The study also involved interviews of some experts related to carbon tax and environmental law, making the survey more authentic and reliable. Thus, due to both quantitative and qualitative data, the study made a triangulation between both types of data. $8/tons of the tax rate was applied to Pakistan's energy sector, which would increase by 2% every year. This carbon tax rate was used after comparing Pakistan with Malaysia and Sir Lanka because of the similar GDP, similar emissions from the energy sector, and equivalent emissions covered by the provinces.

This study used the formula of van Dijk, (2011) to find the carbon emissions, which is also used by N. Fatima and A. Salman in 2017; that is quite similar to the previous literature and van Dijk (2011) formula, implying emissions generated from energy resource. The procedure was as follows:

$$\text{Carbon emissions (eq)} = \text{Amount of Coal} \times CO_2 \text{emissions} + \text{Amount of Coal } (0.3\% \times CO_2 \text{ emissions} \times \text{GWP for } CH_4 \text{ of } 21) \quad \ldots\ldots(1)$$

2.1. Econometric modelling

According to previous literature, carbon emissions are the function of natural gas, crude oil, and coal. This study used the following equation to analyse the linkage between carbon emissions, economic growth, and carbon taxation.

$$ln(TE_{it}) = \beta_1 lnNG_{it} + \beta_2 lnCO_{it} + \beta_3 lnCOAL_{it} + \beta_4 ln\ electricity_{it} + \beta_5 carbon\ tax_{it} + DV + \mu \dots\dots\dots (2)$$

$$ln(GDP_{it}) = \beta_1 lnNG_{it} + \beta_2 lnCO_{it} + \beta_3 lnCOAL_{it} + \beta_4 ln\ electricity_{it} + \beta_3 lnTE_{it} + \beta_4 carbon\ tax_{it} + \mu \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

N.G. is used for natural gas (metric ton), C.O. stands for crude oil (metric ton), T.E. stands for total emissions.
GDP is for the gross domestic product (Million Rupees), and DV is the Dummy variable for checking the government laws for the environment from 1997 to 2018. L.N. is the log of variables. I indicate the number of cross-sections, and t shows the period.

2.2. Descriptive Statistics

Descriptive statistics show the mean, median, maximum, minimum, and standard deviation of all the variables. The mean and median of all the variables are like each other. This study is province-based, so the minimum value shows the province's lowest value in the panel, and the maximum value shows the highest value of the area in the panel. The average value of T.E. is 6.5 along with a standard deviation of 0.77, and GDP has an average value of 6.09 along with a standard deviation of 0.35. The total number of observations is 88 in number.

Table 1 Descriptive statistics

Variables	T.E. (Tons)	N.G. (Metric ton)	GDP (Million Rs)	COAL (Metric ton)	C.O. (Metric ton)	Electricity (MWh)
Mean	6.579576	4.817733	6.090142	5.724105	3.633528	16.20372
Median	6.531093	5.321798	6.014449	5.941050	3.917954	16.10686
Maximum	8.164619	6.022223	6.746139	6.345257	7.230815	18.05997
Minimum	4.876718	0.000000	5.482896	4.379668	0.000000	14.32594
Std. Dev.	0.775537	1.603084	0.351426	0.519011	2.313435	0.960568
Observations	88	88	88	88	88	88

Source: Author's own calculations

2.3. Panel unit root test

Panel unit root test is applied to check the stationarity of the data series (T.E., N.G., GDP, coal, electricity, and C.O.). All the sequences are statistically insignificant at one level but statistically significant at the first difference level. It means that all the data series are stationary at the first difference level.

Table 2 Results of Panel Unit Root Tests							
		I (0)			I (1)		
Variables		**LLC**	**IPS**	**Breitung**	**LLC**	**IPS**	**Breitung**
TE	Constant and Trend	0.65270 (0.7430)	0.75746 (0.7756)	-0.97852 (0.1639)	-6.20294* (0.000)	-5.32242* (0.000)	-6.11210* (0.0000)
NG	Constant and Trend	0.50695 (0.6939)	-0.70260 (0.2412)	-0.17440 (0.4308)	-3.37973* (0.0004)	-3.89198* (0.0000)	-3.10515* (0.0010)
GDP	Constant and Trend	2.22602 (0.9870)	2.52484 (0.9942)	0.39788 (0.6546)	-6.25942* (0.0000)	-4.33470* (0.0000)	-6.45215* (0.0000)
Coal	Constant and Trend	-0.01977 (0.4921)	-0.63150 (0.2639)	-1.14279 (0.1266)	-7.31898* (0.0000)	-8.17160* (0.0000)	-3.82842* (0.0001)
CO	Constant and Trend	0.24506 (0.5968)	-0.61501 (0.2693)	-1.20903 (0.1133)	-7.75403* (0.0000)	-5.36044* (0.0000)	-6.98096* (0.0000)
Electricity	Constant and Trend	0.12301 (0.5489)	2.50688 (0.9939)	-0.81627 (0.2072)	-2.96671* (0.0015)	-3.50599* (0.002)	-1.73232* (0.0416)
All variables are significant at 1% level							

2.4. Panel Co-integration test

The Pedroni co-integration test was applied to assess the long-run relationship. The results of co-integration tests for all data sets are reported in table 3. The co-integration tests are statistically significant; eight tests are substantial out of eleven tests. It means that the variables are highly co-integrated with each other. A long-run relationship exists between the variables.

Table 3 Panel Co-integration Test

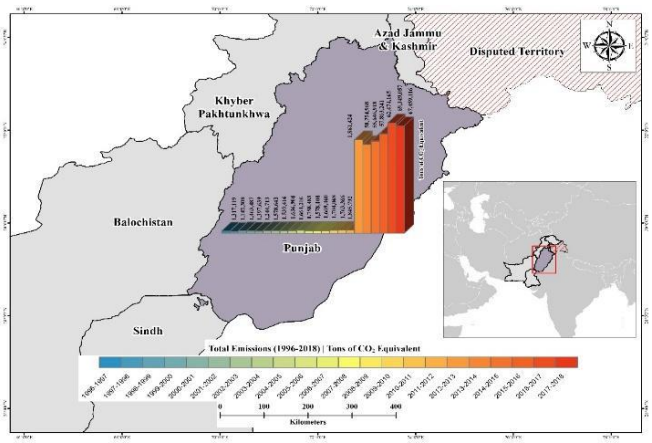
Panel statistic	**Statistic**	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	1.659052	0.0486*	1.106778	0.1342***
Panel rho-Statistic	0.235800	0.5932	0.327362	0.6283
Panel PP-Statistic	-0.903222	0.1832***	-0.775053	0.1329***
Panel ADF-Statistic	-2.491375	0.0064*	-1.524974	0.0636*
Group statistic	**Statistic**	**Prob.**		
Group rho-Statistic	1.033522	0.8493		
Group PP-Statistic	-0.598385	0.1804***		
Group ADF-Statistic	-2.015673	0.0219*		

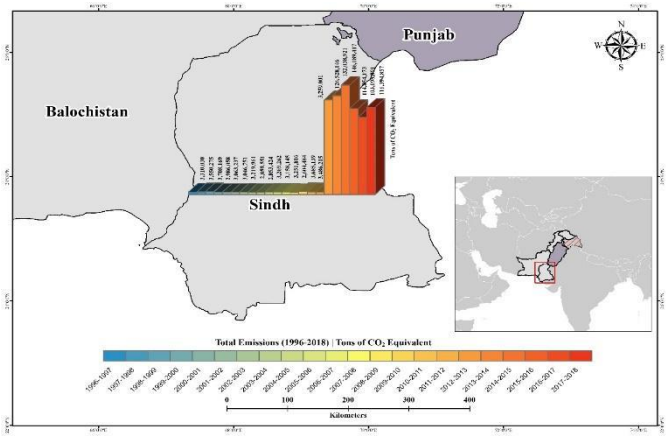
*, ** and *** indicate level of stationarity 1%, 5% and 10%, respectively.

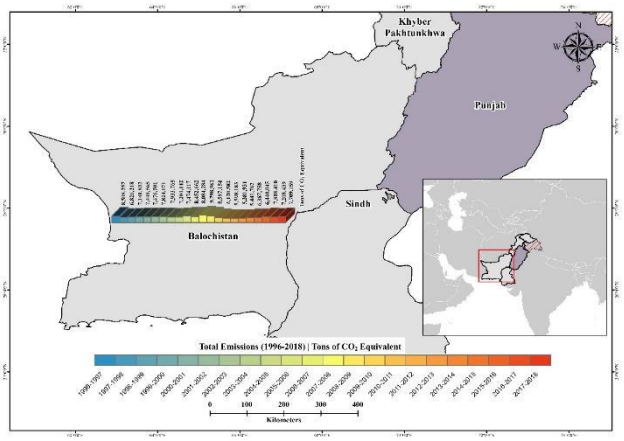
Source: Author's own calculations

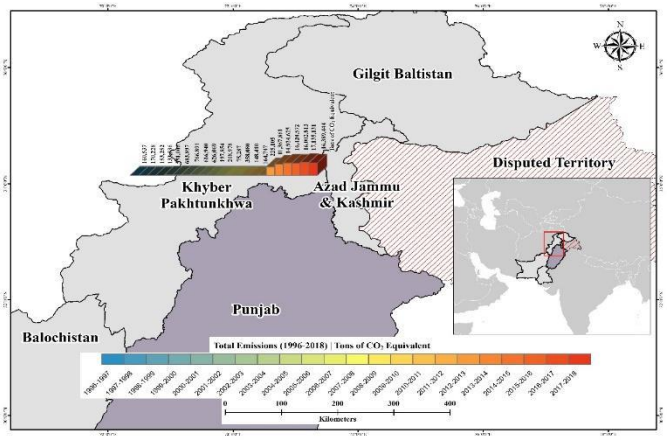
2.5. Graphical presentation by using GIS

The geographic information system is a unique system designed to visualize, manipulate, manage, and analyse the data. GIS arc map was used to visualize all the four provinces of Pakistan's total emissions. Maps show Punjab, KPK, Sindh, and Balochistan emissions from 1997 to 2018. The entire map shows the trend of total emissions on an annual basis. In comparison, the highest emissions are coming from Sindh, after that Punjab, then Balochistan, and at the end KPK. The increase in Punjab and Sindh's emissions is due to the rise in non-renewable resources over time and increase in the energy projects in both provinces.









3. Results and discussion

Table 4 Results of ARDL

Dependent Variable: D(LN_TE)						
	Natural gas	Coal	Crude oil	Electricity Consumption	Carbon tax ($8/ton of CO_2)	Dummy
Punjab	0.003320	0.499701	0.505580	0.478618	-0.034478	0.021239
	(0.009)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sindh	0.096180	0.570397	0.552624	0.236401	-0.068923	0.023952
	(0.01)	(0.00)	(0.00)	(0.015)	(0.02)	(0.00)
KPK				0.811805		
				(0.016)		
	0.394177	0.886685	0.535332		-0.027012	0.077440
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Balochistan	0.023470	0.983745	0.007409	0.002932	-0.005184	-0.000257
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Source: Author's own calculations

The result shows significant relationship between dependent and independent variables. The dependent variable is the total emissions, while the independent variables are natural gas, crude oil, coal, electricity consumption, carbon tax, and one dummy variable. The most important variable is the carbon tax, which is a theoretical variable. Finally, dummy variable was added, which described how much the previous government was proactive regarding environmental laws. All the variables have a significant relationship at 1% level. Natural gas, coal, crude oil, and electricity consumption have a positive relationship with total emissions in all four provinces, which means that increases in energy resources will increase all provinces' emissions. Our finding is related to Khan et al., 2020, Awodumi, O., 2020, Bruvoll, A., 2004). Their discovery also describes the significant and positive relationship between carbon emissions and non-renewable resources. A climate expert has said:

With the increase in the population and natural resources, our carbon emissions increase, because carbon is the main component of all these natural resources. Other sources of carbon emissions are affluent waste, which covers a lot of areas in Pakistan. Like in industries, that waste or hazardous material also generates carbon emissions. Sea and forestry are two primary sources of eradicating carbon emissions. The sea capacity is almost at its last stage, which means that no more carbon will be absorbed by the sea. Because of the increase of carbon content in the ocean, aquatic life is in danger, and mangroves' production is also declining. Forestry is another option, but due to structural collapses and fiscal deficits, bowing trees are not perfect, so a carbon tax is a better solution that will eradicate the carbon emissions and will take part in economic growth. The government is not concerned about environmental laws and environmental problems (Khalid Mahmoud, 55, Karachi).

Vertically, Sindh has the highest ranking in generating numerous emissions from all these resources. Punjab scores second, KPK is at the third number, and Balochistan is the last. According to the carbon tax scenario, the emissions and carbon tax have a negative and significant relationship, which means that if carbon tax is applied, the total emissions will be reduced. In Punjab, if an $8 carbon tax is applied, 3% carbon emissions will be reduced. 6% carbon emissions will be reduced, if $8 carbon tax will be used. KPK will decline 2% of carbon emissions by applying an $8 carbon tax. Balochistan has low carbon emissions, where only 0.5% of carbon emissions will be reduced by using an $8 carbon tax. Thus, all the provinces will reduce their emissions if an $8 carbon tax is applied to their energy sector. Many previous studies also reveal the negative relationship between carbon emissions and carbon tax, which

means that carbon emissions are reduced by applying carbon tax. (Bruvoll, A., & Larsen, B. M 2004, Lin, B., & Li, X 2011). After the 18th amendment, responsibilities were divided among provinces, so this study used dummy variables to determine how much of all political parties worked for the environment at the provincial level. The dummy variable explains that all the governments made environmental laws in the previous era. The results show that except for Balochistan, all the other provinces have environmental regulations. An environmental lawyer said,

"Different laws are made by the government for environmental protection. After the 18th amendment, the provincial government also considered climate change very seriously and made laws regarding the environment. But the main problem is the implementation of these laws. The implementation of these laws was fragile. There has been no implementation seen in the last five or six years of any law regarding the environment. The UNFCCC and many other NGOs have played a great role in some successful projects linked with the environment. The government was proactive for the environment only on paperwork. Physical completion of all those laws and projects were never on-screen". (Ahmad Rafay Alam, 47, Lahore)

Dummy shows positive and significant results for Punjab, Sindh, and KPK but a negative and meaningful relationship with Balochistan, which means that Balochistan government did not take any measures concerning the environment. Khan et al., (2018) describes the current political party's attraction towards the environmental law. Another study also reveals the summary of major laws relevant to environmental main streaming and efforts of successive Pakistani governments. (Qayyum, M. 2019).

Table 5 Dependent Variable: D(LN_GDP)

Provinces	Natural gas	Coal	Crude oil	Electricity Consumption	Total emissions	Carbon tax ($8)
Punjab	-0.187917	-0.548447	-0.257555	0.347151	0.507298	0.035583
	(0.0018)	(0.0446)	(0.0462)	(0.1439)	(0.1979)	(0.0110)
Sindh	0.166450	0.489828	0.030184	0.199519	-0.029251	0.04848
	(0.0143)	(0.0005)	(0.1839)	(0.1341)	(0.6571)	(0.0470)
KPK	-0.151192	0.217122	0.160930	0.173582 (0.0196)	-0.305351 (0.0007)	0.041271
	(0.0000)	(0.0017)	(0.0001)			(0.0699)
Balochistan	-1.150793	-9.706642	-0.088265	1.145963	0.04063	0.014736
	(0.0364)	(0.1061)	(0.0000)	(0.007)	(0.7866)	(0.0003)

Source: Author's own calculations

The ARDL model was applied to find the relationship between GDP, natural gas, crude oil, electricity consumption, total emissions, and carbon tax. Results showed that the growth would increase by applying a carbon tax on emissions. Using carbon tax is not the killer of the economic development of the country. GDP will grow by applying carbon tax (Metcalf, G. E., & Stock, J. H. 2020, May). The carbon tax's primary purpose is to reduce emissions, but likewise, the revenue will also be generated by applying carbon tax. As the results show, a positive and significant relationship between the carbon tax and the growth variable. One of the taxation lawyers said,

Pakistan's taxation system is based on income. Every sector has a different type and amount of tax. Tax implementation is based on other rules and ordnance passed by the federal government in additional years like finance ordinance 2007, income tax rule 2001, etc. If we compare Pakistan's taxation system with other countries, Pakistan's tax to GDP ratio is meagre. Still, there is no such word as a carbon tax in the taxation system of Pakistan. The government has never thought about this type of tax ever. In my opinion, the Carbon tax will increase economic growth and will play a significant role in Pakistan's financial condition. This tax would improve Pakistan's economic situation and it would also play a vital role in making technologies green instead of standard machinery (Farrukh Zulfiqar, 37, Lahore).

In Punjab, the revenue will increase up to 3% by applying a carbon tax of $8. In Sindh, revenue will rise by 4%, and KPK revenue will increase up to 4%. In Balochistan, the emissions produced by energy resources were not too high, so the area's revenue will not increase too much; it will be just 1%. A lot of studies show the positive and significant relationship between the carbon tax and economic development. Our finding is closely related to Fang, G et al. 2013, Loganathan, N. et al., 2014, W. Wissema, R. Dellink, (2007) which shows the positive impact of carbon taxation on economic development. Furthermore, GDP's relationship with total emissions in all the provinces except Balochistan is positive and significant.
Balochistan has an insignificant relationship with GDP, which means that with the increase in economic development, the carbon emissions will increase continuously. The empirical evidence from 28 countries indicates a significant positive impact of CO_2 emissions on four global panels' energy consumption. Economic growth also has a positive effect on energy.
(Saidi, & Hammami 2015).

Table 6 Projections

Variables	2020	2025	2030	2035	2040	2045	2050
Total emissions	-0.318854	-0.131752	-0.035154	-0.003899	-0.003114	-0.002671	-0.001011
GDP	0.007324	0.039734	0.103933	0.141311	0.188320	1.975794	6.226735

All values are significant on 1%, 5% and 10% level

Source: Author's own calculations

Using the impulse response function, projections are up till year 2050 to check the long-run relationship between carbon tax, total emissions, and growth. The result shows a significant relationship between carbon tax, total emissions, and GDP, as a climate scientist said:

In the present situation, if we compare Pakistan's carbon emissions even on a provincial level with other countries, we have seen that emissions are very low. Climate conditions suggest that the country could produce enough power to cover domestic needs and export, along with associated equipment and technology. In the future, carbon emissions will increase due to the increasing projects in Pakistan, like CPE, so putting a carbon tax on carbon emissions is a feasible option. It is an excellent indirect policy option that will control carbon emissions in the future. (Dr. Fahad Saeed, 42, Austria)

One side projection shows the reduction of emissions, while on the other side, increase in growth of the country by applying a carbon tax of $8. According to the scenario, the carbon tax rate will continue to increase by 2% every year up till 2050. The results show that as the carbon tax increases yearly by 2%, the total emissions will also decrease. In 2020, the emissions

were 31% but continuously increasing carbon tax can reduce the emissions in 2050 up to 0.01%. Saleem, M. (2015) shows a similar relationship between the carbon tax and carbon emissions, (Saleem, M. 2015) while projecting 2040. The carbon tax will increase the country's revenues by increasing the carbon tax rate. Results show that revenues will continuously improve, as in the above table, by increasing the carbon tax by 2%. Fang, G et al., (2013) has found the impacts of the carbon tax on energy intensity and economic growth in China which verifies our results. Loganathan, N., (2014) also discussed the link between green taxation and economic growth on CO_2 emissions in Malaysia, which also shows the positive relationship between economic development and carbon tax.

4. Conclusion and Policy Recommendations

The study addresses the impact of the carbon tax on economic growth and carbon emissions' reduction in all the four provinces of Pakistan: Punjab, Sindh, KPK, and Balochistan, from 1997 to 2018. The study establishes the relationship between carbon tax, carbon emissions, and economic growth. For this instance, this study uses different econometric techniques to check the relationship between the variables. The study uses the GIS Arc map technique to visualize the total emissions of each province of Pakistan. GIS Arc map shows total emissions for every single year. ARDL model is used to determine the carbon tax impact on both carbon emissions and economic growth. Projections up to 2050 were calculated by using the impulse response function.

Total emissions are visualized by using the Arc map GIS technique. Data shows the trend and variation of total emissions in all four provinces of Pakistan. The reasons behind the variation in total emissions are shown in the maps, presenting the increasing, decreasing, and constant trend of emissions in all four provinces of Pakistan.

All the variables of the 1st model are significant at a 1% level. Results of 1st model demonstrate that carbon emissions from all the provinces led to a reduction when a carbon tax of $8 was applied. Results showed a positive and significant relationship between the dependent and independent variables. By using an $8 carbon tax, Punjab's emissions were declined by 3%, Sindh's carbon emissions were lessened by 6%, the decreased carbon emissions of KPK were 2%, where Balochistan's carbon emissions were declined by 0.5%. Results show that significant laws relevant to environmental mainstreaming and successive Pakistani governments exist in all provinces, except Balochistan. Dummy shows a positive and meaningful relationship between Punjab, Sindh, and KPK with carbon emissions, but Balochistan did not ensure a lot of effort for the environment.

Results of the 2nd model reveal that economic growth, carbon emissions, and carbon tax have a significant and positive relationship. Results demonstrate that revenues are generated in all the provinces by applying carbon tax. 3% revenue can be generated in Punjab by using carbon tax. 4% in Sindh, 4% in KPK as well, and 1% in Balochistan. Moreover, the result shows the positive impact of carbon taxation on economic development. Furthermore, GDP's relationship with total emissions in all the provinces except Balochistan has been positive and significant.

The base year for the tax case scenario regarding carbon tax, is 2020. $8 carbon tax will be applied in 2020, which will increase by 2% every year. The projection was investigated up till 2050 for carbon emissions reduction and revenue generation using the impulse response function. The result shows the significant relationship between carbon tax, total emissions, and

growth. The result shows that the carbon tax will increase by 2% every year, the carbon emissions will be reduced, and revenue will increase.

4.1. Policy recommendations for Sindh

It is highly recommended that Sindh's carbon emissions are more than all the other provinces, which were calculated as 54%, so the Sindh government should make an appropriate plan to reduce its emissions. Most of the coal power projects are in Sindh, which is the leading cause of emissions. Sindh's government should move toward green development and cleaner technology to combat carbon emissions. As new industries come into being, because of the CPEC projects in the future, carbon emissions will increase. So, the policy recommendation for Sindh is as follows:

- The government should be proactive by taking out irregularities and insufficient strategies in arranging, building up, and executing policies.
- A spread-out arrangement for sustainable national development should be planned, which targets surveying and organizing supportable and environment-friendly forms, prompting alleviation and adjustment.
- Government should spend a budget on research and development instead of giving subsidies to different products. R&D provides statistics through which most of the solutions to various problems such as poverty level, health problems, water problems, and carbon emissions can be generated. This way, the government can solve all these problems more appropriately.
- The Sindh government should strictly put a carbon tax on all the firms' non-renewable resources to reduce carbon emissions.

4.2. Policy recommendations for Punjab

The Punjab government should also take serious action for the mitigation of carbon emissions. Punjab has carbon emissions of 27%. Hence, it comes on 2nd number after Sindh. Punjab uses a lot of energy resources to make the country's economy strong, but with these developments, the emissions are also rising. Policies for Punjab are given below:

- There should be a special team to implement a carbon tax on emissions-generating industries and to collect these taxes. Government should use these taxes on other green technologies to overcome future emissions in the future.
- Different organizations and the Punjab government should pool their efforts and implement strategies for lessening human interference in natural sites.
- Punjab's government should likewise shape a positive strategy to energize manufacturing industries and private vitality, which consume energy towards green ventures like reimbursements on import or acquisition of machinery, which are energy-efficient and sustainable power sources.

4.3. Policy recommendations for KPK

KPK is producing 11% of carbon emissions from its energy sector. Although KPK government is doing an excellent job of mitigating its emissions like billion tree tsunami projects, the KPK government should concentrate more and reduce its emissions level. Policies for KPK are:

- The government of KPK should build up a policy that should permit less expensive credit to industrial and private buyers to introduce sustainable power sources like solar

energy vitality, which won't only lessen the weight of supply of energy on the government but also diminish carbon emissions along with the private institution.

- There was a deficiency of qualitative investigations with complete examination and clarification of carbon emissions in the province. Moreover, it is recommended that a more profound assessment of different areas ought to be directed, that will influence atmosphere. Greater part of the retreat and flow investigation centers around explicit viewpoints yet needs a point-by-point assessment of sectorial causes and effects of environmental change.
- De-carbonization technologies, which lead towards green growth, must be used.

4.4. Policy recommendations for Balochistan

Balochistan's province is producing only 7% of carbon emissions out of the total emissions of Pakistan. Balochistan is generating its emissions from natural gas and coal, contributing to the total emissions of Pakistan. The Balochistan government has not done anything about its carbon emissions. It should concentrate on a plan to mitigate its carbon emissions. Policies for Balochistan are:

- To reduce the fragmentation of roles and responsibilities, a climate change cell should be constituted in the P&D department to coordinate and oversee all climate-relevant investment and planning.
- A Climate Change Authority should be established. This Authority should be responsible for formulating and enforcing climate-relevant laws and rules forming the basis for climate action
- The public should approach with their experience and comprehension of the climatic circumstance, which can add to the improvement of alleviation and adjustment techniques to a higher degree.

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