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An Empirical Investigation on Compressed Natural Gas (CNG) and CO_2 Emission in Pakistan

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Abstract This study examines economic benefits of Compressed Natural Gas (CNG) vehicles in Pakistan where social cost is explained by CO_2 emission from transport (million metric tons), using time series data from 2000 to 2010 of Pakistan. The result shows that there exists a significant relationship of both economic & financial cost with CO_2 emission levels. Individual effects of variables/predictors included in the model are illustrated. All three variables are found to be statistically significantly at 0.1. Increasing number of converted CNG vehicles are negatively related to overall CO_2 emission through transport. It means CNG vehicles are reducing the social cost in Pakistan resulting in an overall economic benefit to society in terms of reduced CO_2 emissions. The results proved that, with an increase in 1000 CNG vehicles on the road, CO_2 emissions declined by .008 m metric tons. It is recommended that govt. of Pakistan should take some positive steps in order to improve economic and financial cost of CNG in Pakistan because in comparison with social cost of CNG in Pakistan, it can be deduced that financial/economic cost that has both positive and negative relationship. The results also show that CNG is contributing less in the overall pollution level in Pakistan as compared to other burning fuels.

Keywords CO_2 Emission, CNG Stations, Consumption, CNG Vehicles, Social Cost Reduction

1. Introduction

The objective of this study is to investigate which variable has a significant effect on economic and financial cost of CNG in Pakistan and by the help of this study it will be easier to reduce *CO_2 emission* in Pakistan once the important variables are identified. [1]For research purpose, annual time series data is collected from 2000 to 2010 as sample. Variables considered include *CNG Stations, Consumption, CNG vehicles.* This selection has been done by keeping in consideration the importance of each variable and the past studies conducted in this regard.

The CNG stations in Pakistan were 150 in 2000 but in 2010 the numbers of CNG stations has increased to 3331. The CNG vehicles in 2000 were 120000 but in 2010, they increased to 2740000. Moreover, the third variable identified as CNG consumption was 87259.27, in 2000, increased to 113321.1, in 2010.All of these variables show an increasing trend with the passage of time which suggests that CNG is being preferred by consumers as compared to other fuel sources because it is the most economical and environmental free source of fuel. When we compare the economic and financial cost of CNG with other fuels, we find that the social cost of CO_2 emission through CNG vehicles from transport (million metric tons) is significantly less than other fuel sources.

Over 2 million vehicles were converted to CNG as of march 2009, showing an annual increase of 35 percent. On average 29,167 vehicles are converted to CNG every month. All Pakistan CNG Association (APA) Sana-ur-Rehman has stated that CNG stakeholders have invested Rs.90 billion in this sector, while another Rs 20 billion have been invested in pipeline. CNG consumers have invested around Rs 60 billion in converting their vehicles to CNG. It has been replacing at least 6.12 billion liters of petrol every year and saving foreign exchange to the tune of billions in dollars. The CNG sector pays 24 percent sales tax and 4 percent withholding tax to the government. Moreover, the CNG is contributing tremendously towards maintaining the air pollution level since it emits almost 85 percent less harmful gasses, zero lead and zero particulate matter. Recent surveys have ranked Pakistan third, in the list of countries with the most natural gas vehicles. Data from Natural Gas Vehicles (NGV) Europe suggest that approximately 26 percent of the total vehicles in Pakistan consume natural gases.

The available data shows that the consumer price index (inflation) varies from 2000 to 2010.The GDP of Pakistan was 1780.236 in 2000 which then increased to 2720.53 in the year 2010. The total population accounted for137.53 in the survey conducted in the year 2000, with the passage of time a number of surveys have been conducted that shows an increasing trend in country's overall population. The total population of Pakistan was 173593383 in 2010, with an

[1]Source; OGRA, Ministry of Petroleum & Natural Resources and un.org

increase of 9% in 30 years.

However, Pakistan is facing a critical economic condition due to inflation resulting in a significant rise in commodity prices, making it very difficult for a common person to survive. Due to inflation, CNG prices rise day by day, thereby reducing purchasing power in the country. The three-day load-shedding schedule for CNG every week across the country also a major hurdle in the economic sustainability of the masses resulting in ever decreasing purchasing power and rising living costs.

The negative economic cost of CNG borne by the people of Pakistan includes increased engine maintenance cost, the space CNG cylinders occupy in the vehicles. In addition, people are compelled to spend precious time, waiting in queues at CNG stations as it is only available for 4 days a week in Pakistan even though reports show that there were 3331 CNG stations in 2010. But due to high demand of the CNG in the country, people are willing to bear these costs. Further, since ambulances, big busses and mini buses have also been converted on CNG. They have to face significant shortage due to load shedding of CNG in our country. But due to high demand consumers still seem will to spend a lot of their time, as it is the cheapest alternative source of the fuel.

2. Empirical Literature

The literature on the impact of Population and Inflation on Unemployment is older and quite clear. And there are well established theories that clearly identify their causal effects.

Masood (2013) identified that Pakistan's Gas Crisis due to Gas Theft …& Unaccounted for Gas (UFG) until 1999, the government tightly controlled the oil and gas industries of Pakistan. No decision could be made without referring to the higher instances, and when decisions were made, they were often based on political as opposed to economic considerations. Since early 2000, an ambitious, pro-market, reform program was being implemented, and gradually, the straightjacket under which the industry used to operate was being dismantled. The result indicates that the sector has changed dramatically over the past five years, and Pakistan now leads South Asia in sector reform. Pakistan has been lucky to have a number of natural gas discoveries in the past 4 to5 years with an output potential of more than 1 billion cubic feet of gas per day within the next few years. The government always has encouraging fast-track development of these discoveries through different incentives to bring the additional gas in the national pipeline network.

Yang et al (2012) determined that China decontrolled coal prices; its coal price has risen steadily and been unusually volatile. In 2011 in particular, high coal prices and capped electricity prices in China discouraged coal-fired power generation, triggering widespread power shortages. They suggest that the coal-price disturbances could be symptomatic of a major change in pricing dynamics of global fossil-fuel markets, with increasing correspondence between coal and oil prices globally. Historically, global coal prices have been more stable and lower than oil and natural gas prices on a per-heat basis. In recent years, however, coal prices have been increasingly volatile worldwide and have tracked other fossil fuel prices more closely. Meanwhile, the recent development of unconventional gas has substantially decoupled US natural gas and oil prices. Technically, low US natural gas prices, with potential fuel switching, could drive US domestic coal prices lower. However, this effect is unlikely to counteract the overall trend in increasing coal consumption globally. China's market size and unique, partially-controlled energy system make its reform agenda a key force in the global economy. Policymakers in the US, E.U. and elsewhere should monitor China's economic reform agenda to anticipate and respond to changes accompanying China's increasing importance in the global energy economy.

Muhammad et al (2012) indentified that Natural gas has a dominant fuel in Pakistan. It offers the cheapest and a cleaner alternative source of energy. Variables were considered Natural gas consumption, real capital, labor and real exports are positively affecting the economic growth in Pakistan. Furthermore, they support the natural gas consumption-led-growth hypothesis and suggest that the natural gas conservation policies may retard the rate of economic growth. This paper examines the relationship of natural gas consumption and economic growth in Pakistan. It includes capital, labor and exports in the model with multivariate framework. The ARDL bounds testing approach to co integration and innovative accounting approach were employed to investigate the dynamic causality relationships among the variables. Result shows that they found the existence of long-run relationship among the variables.

Park and Tak (2011) investigated the aims to analyze the effectiveness of the compressed natural gas (CNG) bus program on air quality in seven metropolitan cities in Korea. Two hundred and fifty-nine cases from monthly panel data covering from June 2005 to June 2008. Natural and sociological characteristics in each city were included as control variables. The Chinese Air Pollution Index was also considered based on previous studies demonstrating that air quality in Korea is adversely affected by Tran's boundary pollution from China. The relationship between five air pollutants (SO_2, NO_2, O_3, CO, and PM10*)* and the CNG bus ratio was analyzed by panel data analysis. The key findings were as follows. CO and PM10 significantly decrease with an increase in the CNG bus ratio. On the other hand, SO_2 and NO_2 demonstrate no statistically significant relationship with CNG bus ratio, while O_3 appears to have a slightly positive relationship. The results show that air pollution from China contributes to the increase in PM10 and O_3 in Korea approximately at the threshold of 100 in Chinese Air Pollution Index. It is recommended that introducing CNG buses can reduce the level of PM10; it might also be increased due to the pollutants from China.

Goyal and Sidhartha (2003) identified the present scenario of air quality in Delhi, relating to CNG implementation, natural gas is used as a fuel in vehicles and this was initiated in 2001, Delhi boasted CNG in nearly 2200 buses, 25,000 three wheelers, 6000 taxis and 10,000 cars. However, more than half of the vehicles are yet to be changed to CNG. Carbon monoxide (CO), Sulphur dioxide (SO_2), suspended particulate matter (SPM) and oxides of nitrogen (NOX), emitted from transport sector, from 1995 to 2000 (without CNG) and the year 2001 (with CNG) has been made in order to assess the impact of CNG vehicles on ambient air quality in Delhi. It has been found that concentration contribution of above pollutants have been reduced considerably.

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Worrell et al (2001) investigate the emission of carbon dioxide gas from the global cement industry. In this study we identified that 5% of carbon dioxide is released from cement industry, globally. Carbondioxde is released in power generation and calcinations process of limestone data is used from 1994 to 2000 in which the current data includes the process emission. In 1994, 307 million metric tons carbon, 160 metric tons of carbon from process carbon emissions, and 147 metric tons carbon from energyuse. Result shows that in 1994, 63% of carbon dioxide is emitted by the top ten cement producing countries. Emission mitigation includes many options for energy efficiency improvement, to low carbon fuels, application of waste fuels, increased use of additives incement making and CO_2 removal from flue gases in clinker kilns.

Boland and Sather (1992) identified the new concept for natural gas fired power plants which simplifies the recovery of carbon dioxide. In this paper performance and cost of natural gas, carbon dioxide can removed by flue gas by amine scrubbing removal of water from CO_2 (drying), compression to pipeline pressure, and transport from the Norwegian coastal line to a North Sea oil/gas field (250 km) where it is disposed. The evaluation of the design of two power plants concepts with feed of oxygen from an air separation plant, and thereby avoiding the need for downstream removal of CO_2 from the flue gas before compression, drying and pipeline transport is also investigated in this paper.

Hye & Riaz (2008) determined the direction of causality between energy consumption (EC) and economic growth (EG), using annual data from 1971 to 2007. In our empirical analysis, they use the test co-integration and an augmented form of the Granger causality to identify the direction of the relationship between these variables both in the short and long run. Their findings suggest bidirectional causality between EG and EC in the short run; in the long run they find unidirectional causality from EG to EC. EC does not lead to EG in the long run because higher energy prices (oil prices) increase the cost of business, leading to a negative effect on EG. Additionally, when energy prices fluctuate, they create uncertainty that also affects economic growth. The study recommends direct investment in local energy resources.

3. Methodology

In accordance with the empirical studies, the equations for CO_2 emission by transport (million metric tons) are CNG Stations, Consumption, CNG vehicles. Following equation is used to examine the effect of CNG stations, Consumption, CNG vehicles on CO_2 emission through transport.

$$CO_2 \text{ emission} = \alpha + \beta 1 \text{ (CNG station)} + \beta 2 \text{ (Consumption)} + \beta 3 \text{ (Vehicles)} + e$$

In equation, all three variables are found to be statistically significant at 0.1 levels. All the data sets used in this study from 2000 to 2010 are taken from various issues of Pakistan economic survey.

4. ADF Unit Root Test

In order to test for the stationarity of the vari-of ADF test are given in appendix Tables, we use ADF unit root test The results

5. Estimation and Result

In this section, variables related to the topic are analyzed. The variables representing financial and economic cost of CNG includes yearly gas consumption, CNG Stations and CNG converted vehicles in Pakistan. Social cost can examine by CO_2 emission from transport. The technique used to analyze the relationship between financial and social cost is 'regression'. Descriptive study is also carried out to evaluate comparison between the two factors. Data for the period of 11 years, from 2000 to 2010 has been used and collected from OGRA, Ministry of Petroleum & Natural Resources and un.org.

Table 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CNG Stations	11	150	3331	1250.5455	1118.00674
CNG vehicles in thousands	11	120	2740	1087.2727	833.77564
Consumption	11	87259.27	113321.1	99451.208	8729.49109
CO2 gas % of total	10	34.19	46.51	41.4862	4.42171
CO2 from Transport m tons	11	24.92	32.66	28.3973	3.18464

In the above table, descriptive statistics of financial and social cost variables are presented. Numbers of CNG stations have increased from 150 to 3331 in year 2010. Similarly average converted CNG vehicles in these 11 years are about 1.087 million. Consumption of CNG is also increasing each year with a mean value of 99,451 units. Considering social cost variables CO_2 gas emission as percentage of total emission has the mean value of 41% which shows lower amount of pollution as compare other fuel based transport vehicles. CO_2 from transport in million metric tons has also an increasing trend, where the average amount equals 28.4 million metric tons

Table 2. Regression Results

Variable	Coefficient	t-Statistic	Prob.
C	-21.424	-1.306	0.233
CNG vehicles	-0.000008	-1.995	0.086
Consumption	0.001	2.831	0.025
CNG Station	0.004	2.395	0.048
Adj. R^2 0.896		F-Statistics 20.033	
D.W2.858		Prob.0.001	

The above table is explaining the overall result of the ordinary least square model with a p value of 0.001 i.e. explaining significant relationship. F value of 20.03 is showing the combine effect of the selected variables.

In the table, R square is equal to 89.6% which describes the amount of variance explained. Adjusted R square equals 85.1% showing the true explanatory power of the model.

In table – 4, individual effects of variables/predictors included in the model are illustrated. All three variables are found to be statistically significant at 0.1 levels. Value of D.W statistics shows negative autocorrelation in the model. To confirm the problem we have applied serial correlation LM test. Value of F-statistics is 1.622 and its prob. Value is 0.249 which show that autocorrelation does not exist in the model. Increasing number of converted CNG vehicles are negatively related to overall CO_2 emission from transport. It means CNG vehicles are reducing the social cost in Pakistan. According to the results, with an increase in 1000 CNG cars on the road, CO_2 emission reduce by .008 m metric tons. But the results deviate by using the other 2 financial and economic cost variables that are CNG stations and Natural gas consumption. Both are having positive significant relationship with CO_2 emission levels.

6. Conclusions and Recommendations

It is concluded that as comparison with social cost of CNG in Pakistan, it can be deduced that financial/economic cost has both positive and negative relationship. It has also found that CNG is contributing less in the overall pollution level in Pakistan as compare to other burning fuels. So the theory further demonstrates that economic and financial cost of CNG will result to pursue the investor to invest in industrial sector, etc to have more benefit so this act will result in reduction of pollution and will result as green environment.

Appendix

Null Hypothesis: CO_2 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.641469	0.1169
Test critical values:	1% level	-4.297073	
	5% level	-3.212696	
	10% level	-2.747676	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 10

Null Hypothesis: $D(CO_2)$ has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.353525	0.0479
Test critical values:	1% level	-4.582648	
	5% level	-3.320969	
	10% level	-2.801384	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 8

Null Hypothesis: CNGS has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.943842	0.9987
Test critical values:	1% level	-4.420595	
	5% level	-3.259808	
	10% level	-2.771129	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 9

Null Hypothesis: D(CNGS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.860713	0.3328
Test critical values:	1% level	-4.420595	
	5% level	-3.259808	
	10% level	-2.771129	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 9

Null Hypothesis: D(CNGS,2) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.422737	0.0152
Test critical values:	1% level	-4.803492	
	5% level	-3.403313	
	10% level	-2.841819	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 7

Null Hypothesis: CNGV has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.742219	0.9998
Test critical values:	1% level	-4.297073	
	5% level	-3.212696	
	10% level	-2.747676	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 10

Null Hypothesis: D(CNGV) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.415522	0.8666
Test critical values:	1% level	-4.420595	
	5% level	-3.259808	
	10% level	-2.771129	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 9

Null Hypothesis: D(CNGV,2) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.136870	0.2371
Test critical values:	1% level	-4.582648	
	5% level	-3.320969	
	10% level	-2.801384	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations

and may not be accurate for a sample size of 8

Null Hypothesis: CNDC has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.144499	0.6464
Test critical values:	1% level	-4.420595	
	5% level	-3.259808	
	10% level	-2.771129	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
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