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Relative Efficacy and Economic Welfare Impacts Assessment of Command-and-Control and Economic Incentive Market-based Instruments on Environmental Pollution Associated with Energy Consumption in India

Adeyemi Ayobami EBO
Nottingham Trent Business School
Nottingham Trent University, Nottingham, United Kingdom
N1159808@my.ntu.ac.uk

or

yemwite@gmail.com
+44 7900 123275

Abstract

This study evaluates the relative efficacy and economic welfare impacts of command-and-control regulations and market-based instruments in mitigating environmental pollution resulting from energy consumption in India. Industrialisation has propelled India's economic growth, but it has also significantly contributed to environmental degradation, particularly through increased energy consumption and pollutant emissions. The study is grounded in Porter's Hypothesis, which posits that well-designed environmental regulations can stimulate innovation and enhance economic competitiveness. Using data from the World Development Indicators, the study employs a regression model to analyze the impacts of CO_2 Trading Schemes (market-based instruments) and Emission Limit Values (command-and-control measures) on Carbon Dioxide (CO_2) emissions, with GDP as a control variable. The findings reveal that both policy approaches significantly influence CO_2 emissions, with command-and-control measures exhibiting a stronger impact. However, there is a trade-off between the two strategies, as reflected in the perfect negative correlation between them. The results underscore the necessity of a balanced regulatory framework that integrates both market-based incentives and command-and-control measures to effectively address environmental pollution *while promoting economic welfare. The study concludes with recommendations for Indian policymakers to develop an integrated policy framework that leverages the strengths of both approaches, strengthens enforcement mechanisms, promotes sustainable development, and engages stakeholders in the pursuit of environmental and economic objectives.*

Word count: 208

Keywords: Command-and-Control, Economic Incentive Market-based Instruments, Environmental Pollution, Energy Consumption, India.

Introduction

Industrialization, often synonymous with rapid economic growth, seems to be a significant contributor to environmental degradation due to increased pollution it generates. Industries release pollutants such as carbon dioxide (CO_2), nitrogen oxides, sulphur dioxide, and particulate matter into the air through combustion processes, significantly impacting air quality (Krupa & Kickert, 1989). Additionally, industrial activities generate hazardous waste, posing threats to water bodies, air, and soil if not managed properly. Energy consumption, a focal point of this study, plays a crucial role in driving environmental pollution. The energy-intensive nature of industrialisation heavily relies on fossil fuels like coal, oil, and natural gas, contributing to air pollution and greenhouse gas emissions (Smith et al., 2021). This reliance on fossil fuels intensifies pollution and alters the ozone layer, exacerbating global warming and its associated impacts, such as rising sea levels and extreme weather events (Páez-Osuna, 2001).

As regards environmental pollution, governments worldwide have implemented pollution control measures, including command-and-control regulations and economic incentive market-based instruments. These measures aim to regulate emissions and promote cleaner technologies to combat pollution (Blackman et al., 2018). Market-based environmental regulations, such as environmental taxation and emissions trading schemes, offer polluters choices to either pay for emissions or invest in pollution abatement. Conversely, command-and-control regulations impose specific emission limits and penalties. The effectiveness of these measures in mitigating environmental pollution varies, depending on factors such as regulation mode and economic performance (Zhao, 2015).

India a good example of developing economy witnessed a surge in industrial output in the late 1960s, prompting policymakers to recognize environmental protection as essential. Escalating health concerns due to air, water, and soil emissions equally led to government measures to curb pollution and manage waste. Initially reliant on "command and control" (CAC) strategies, mandating cleaner technologies, India later shifted to "market-based instruments" (MBIs) like CO_2 trading schemes. This transition acknowledges CAC's resource-intensive nature and opts for fiscal incentives over strict regulations. This study therefore evaluates the efficacy and economic impacts of both approaches in curbing environmental pollution from energy consumption in India.

This study is hinged on Porter's Hypothesis which challenges the traditional view that environmental regulations necessarily impose significant costs on businesses and the economy. Instead, it suggests that well-designed environmental regulations can stimulate innovation and competitiveness, leading to both environmental improvements and economic benefits. According to the Porter Hypothesis, stringent environmental standards can act as a catalyst for innovation within firms leading to reputation for environmental stewardship, attracting environmentally conscious consumers and investors and potentially securing a competitive edge in the marketplace.

Literature Review

Environmental Regulations

Various studies explore the nexus between environmental regulations and productivity, yielding divergent findings. While some argue that regulations impede firm productivity by diverting resources to emission reduction (Albrizio et al., 2017; Yang, 2012), others present conflicting views (Li, 2017). Short-term benefits of regulations on green total factor productivity are noted in China (Yuan, 2018), but long-term effects are uncertain. Debates persist regarding energy efficiency, such as the ineffectiveness of policies in Denmark (Dirckinck-Holmfeld, 2015). Environmental regulations affect international capital flows, with strict regulations potentially prompting relocation to less regulated countries (Rezza, 2013; Bokpin, 2017). However, contrasting views, like the halo effect hypothesis, suggest a negative FDI-environmental pollution association (Rudolph, 2017). Studies on pollution emissions yield mixed results, with some advocating for emissions trading schemes (Calel, 2016), while others suggest they promote renewable energy use, aiding CO_2 abatement (Zhao et al., 2013). Nonetheless, the relationship between regulations and CO_2 emissions varies (Guo and Chen, 2018), requiring a nuanced understanding.

Environmental Regulations and Its Relationship with Environmental Pollution

Various environmental regulations aim to address diverse environmental issues (Stavins, 1996), with distinct impacts based on their types (Xie et al., 2017). These regulations typically fall into two categories: command-and-control and market-based. Zhao et al. found that command-and-control policies, including emissions standards and fines, enhance technological innovation significantly (Zhao, 2015). Similarly, Du et al. observed that emissions cap policies effectively reduce carbon emissions (Du et al., 2016). Market-based regulations, like emissions trading schemes, show cost-saving impacts on CO_2 emissions (Cui et al., 2014). Zhao et al. demonstrated the efficacy of market-based policies in enhancing efficiency and CO_2 abatement (Zhao et al., 2015). Xie et al. highlighted the productivity-friendly nature of market-based regulations (Xie, 2017). While some studies advocate for market-based regulations' superiority (Lade et al., 2018; Alesina and Passarelli, 2014), others argue for the necessity of command-and-control regulations (Montero, 2002).

Methodology

This study uses data sourced from UK data services, specifically the World Development Indicators, to conduct an analysis of the impact of command and control policies versus market-based instruments on environmental pollution resulting from energy consumption, as indicated by carbon emissions (CO_2). In this context, CO_2 emissions encompass those arising from electricity and heat production, manufacturing industries and construction, and other sectors, excluding residential buildings. To capture the market-based approach of the government,

CO_2 Trading Scheme values were generated, while Emission Limit Values were likewise computed to reflect command and control measures. Additionally, Gross Domestic Product (GDP) data for the selected country during the estimation period were collected to gauge the level of production activities within the specified nation.

Model of the Study

$CO_2\ it = \beta 0 + \beta 1 CTSit + \beta 2 ELVit + \beta 3 GDPit + \varepsilon it$

$CO_2 it$ represents carbon monoxide emissions in year tt for sector ii.
$CTSit$ represents the CO_2 Trading Scheme value for sector ii in year tt, reflecting the implementation of market-based instruments.
$ELVit$ represents the Emission Limit Value for sector ii in year tt, reflecting command-and-control measures.
$GDPit$ represents the Gross Domestic Product in year tt, indicating the level of production activities.
$\beta 0,1,\beta 2,\beta 3 \beta 0,\beta 1,\beta 2,\beta 3$ are coefficients representing the relationship between the variables and carbon dioxide emissions.
$\varepsilon it \varepsilon it$ is the error term representing unobserved factors influencing carbon dioxide emissions.

This equation model enables the examination of how the CO_2 Trading Scheme, Emission Limit Values, and GDP influence carbon monoxide emissions, providing insights into the effectiveness and economic implications of different policy approaches in mitigating environmental pollution associated with energy consumption in India.

Presentation of Results

Table 1: Summary Statistics

	CO_2	CO_2 Trading Scheme	Emission Limit Values	GDP
Mean	43.44797	0.431818	0.568182	5.54E+11
Maximum	56.88778	1.000000	1.000000	2.04E+12
Minimum	21.54577	0.000000	0.000000	6.74E+10
Standard Deviation	11.61408	0.501056	0.501056	5.59E+11
Probability	0.087241	0.025427	0.025427	0.000186
Observation	44	44	44	44

Table 1 presents the summary statistics of the data generated for the study: CO_2 emissions mean around 43.45 units, with a standard deviation of 11.61, showcasing significant variability (range: 21.55 to 56.89 units). Market-based instruments' mean values (CO_2 Trading Scheme: 0.43, Emission Limit Values: 0.57) and GDP (mean: 5.54E+11) demonstrate policy variation and economic activity. These findings are crucial for assessing command-and-control policies versus market-based incentives' efficacy on energy-related pollution. Carbon dioxide emissions' variability suggests complex influences, emphasizing the need for nuanced policy approaches. The diverse values for market-based and command-and-control measures underscore the importance of tailored policies for environmental outcomes. Additionally, GDP's association with pollution highlights the economic implications of regulations, stressing the necessity for balanced policies. These statistics provide a robust foundation for informed decision-making to address pollution while fostering economic welfare.

Table 2: Correlation Matrix

	CO_2	CO_2 Trading Scheme	Emission Limit Values	GDP
CO_2	1.000000	-0.895761	0.895761	0.618729
CO_2 Trading Scheme	-0.895761	1.000000	-1.000000	-0.599670
Emission Limit Values	0.895761	-1.000000	1.000000	0.599670
GDP	0.618729	-0.599670	0.599670	1.000000

The correlation matrix in Table 2 provides an insight into the dynamics between CO_2 emissions, regulatory policies, and economic activity. Notably, CO_2 emissions exhibit a strong negative correlation with market-based incentives like the CO_2 Trading Scheme (-0.896) and a strong positive correlation with command-and-control measures represented by Emission Limit Values (0.896). This indicates that as market-based incentives decrease emissions, stricter command-and-control policies lead to higher emissions, highlighting the effectiveness of each approach in different contexts. Moreover, the perfect negative correlation (-1.000) between market-based and command-and-control measures highlights the trade-off between these strategies, where the intensification of one tends to diminish the other.

Additionally, the moderate positive correlation (0.619) between GDP and CO_2 emissions suggests that economic growth often accompanies increased emissions, aligning with the environmental Kuznets curve hypothesis. This correlation highlights the intricate interplay between regulatory interventions, economic activity, and environmental outcomes. Policymakers can leverage these insights to design holistic strategies that balance environmental protection with economic prosperity, ensuring sustainable development while mitigating pollution.

Table 3: Summary of Regression Analysis of the Significant Influence of Market Based Instrument and Command and Control on CO_2 emission

Variables	Coefficient	t-statistics	Probability
CO_2 Trading Scheme	31.19083	25.57842	0.0000
Emission Limit Values	50.18339	27.85405	0.0000
GDP	2.65E-12	1.508377	0.1391
Dependent Variable: CO_2 Emission			

The regression analysis in Table 3 reveals significant influences of market-based instruments (CO_2 Trading Scheme) and command-and-control measures (Emission Limit Values) on CO_2 emissions. The coefficients for both variables are statistically significant with very low p-values (0.0000), indicating strong evidence of their impact on CO_2 emissions. Specifically, the coefficient for the CO_2 Trading Scheme is 31.19083 with a t-statistic of 25.57842, while the coefficient for Emission Limit Values is 50.18339 with a t-statistic of 27.85405. These high coefficients and t-statistics suggest substantial effects of both policy approaches on reducing CO_2 emissions. In contrast, the coefficient for GDP is not statistically significant, as indicated by its higher p-value of 0.1391 and a t-statistic of 1.508377. This suggests that changes in GDP do not have a significant influence on CO_2 emissions in this regression model. In terms of ranking the influence of each variable on the dependent variable (CO_2 emissions), both market-based instruments and command-and-control measures demonstrate significant impacts, with Emission Limit Values having a slightly higher coefficient than the CO_2 Trading Scheme. However, GDP does not appear to have a statistically significant influence on CO_2 emissions in this analysis. Therefore, in terms of influence on CO_2 emissions, Emission Limit Values rank highest, followed by the CO_2 Trading Scheme, while GDP ranks lowest.

Table 4: Relative Efficacy and Economic Welfare Impacts of the Instruments

Relative Efficacy	Economic Welfare Impacts	Potential Trade-offs
The results of the study highlight the significant influence of both market-based instruments (CO_2 Trading Scheme) and command-and-control measures (Emission Limit Values) on CO_2 emissions. This suggests that a combination of regulatory strategies is essential for effectively mitigating environmental pollution resulting from energy consumption. The strong correlations between policy interventions and CO_2 emissions indicate that both market-based incentives and command-and-control measures can contribute to	While market-based incentives and command-and-control measures demonstrate efficacy in reducing CO_2 emissions, their economic welfare impacts may vary. Market-based instruments, such as emissions trading schemes, can provide flexibility and cost-effectiveness by allowing firms to trade emission permits. This can incentivize emission reductions where they are most economically efficient, potentially minimizing compliance costs and promoting innovation. On the other hand, command-and-	The findings suggest potential trade-offs between policy effectiveness and economic welfare impacts. While market-based incentives may offer greater efficiency in achieving emission reductions, command-and-control measures may be necessary to ensure regulatory certainty and environmental integrity. Policymakers must carefully balance this trade-offs and consider the broader socio-economic implications of regulatory interventions. For example, while market-based instruments may offer cost savings for some industries,

emission reduction efforts. However, the perfect negative correlation between the two approaches highlights the trade-offs involved, necessitating a balanced regulatory framework that leverages the strengths of each strategy.	control measures may impose stricter regulatory standards and compliance requirements, which could lead to higher costs for industries. However, these measures may also provide greater certainty and accountability in achieving emission reduction targets.	command-and-control measures may be essential for protecting vulnerable populations and ensuring equitable distribution of environmental benefits.

Implications of Findings

The findings from both the regression analysis and the correlation matrix provide valuable insights into the efficacy and impact of different policy approaches on CO_2 emissions and their relationship with economic activity. Starting with the correlation matrix, the strong negative correlation between CO_2 emissions and market-based instruments (CO_2 Trading Scheme) alongside the strong positive correlation with command-and-control measures (Emission Limit Values) indicates the effectiveness of both regulatory strategies in influencing CO_2 emissions. This suggests that a combination of market-based incentives and command-and-control measures may be necessary to effectively address environmental pollution resulting from energy consumption. Additionally, the perfect negative correlation between CO_2 Trading Scheme values and Emission Limit Values echoes the trade-offs between these policy approaches, highlighting the need for a balanced regulatory framework that leverages the strengths of each approach. The regression analysis further elucidates the significant influence of both market-based and command-and-control measures on CO_2 emissions.

The high coefficients and statistically significant t-statistics for both variables affirm their substantial impacts on reducing CO_2 emissions.

However, the insignificant influence of GDP on CO_2 emissions suggests that reducing economic activity may not necessary drive meaningful reductions in emissions, emphasising the importance of targeted policy interventions. From these findings, a robust discussion can be generated regarding the optimal mix of policy instruments for mitigating CO_2 emissions while promoting economic welfare. While market-based incentives like the CO_2 Trading Scheme demonstrate efficacy in reducing emissions, command-and-control measures represented by Emission Limit Values also play a crucial role, particularly in setting strict regulatory standards. A combination of these approaches may provide a comprehensive framework for addressing environmental pollution effectively. Moreover, the lack of significant influence of GDP on CO_2 emissions underscores the need for policies that decouple economic growth from environmental degradation, emphasising the importance of sustainable development strategies.

Conclusion

In conclusion, the findings suggest that a combination of market-based incentives and command-and-control measures, complemented by sustainable development initiatives, may provide a comprehensive framework for effectively mitigating CO_2 emissions while promoting economic welfare. This highlights the importance of adopting a multifaceted approach to address environmental challenges, ensuring a sustainable and prosperous future for all.

Recommendations

Based on the findings of the study, the following recommendations were suggested:

1. Indian policymakers should develop and implement an integrated policy framework that combines market-based incentives, such as emissions trading schemes or carbon pricing mechanisms, with command-and-control measures, including emissions standards and regulations. This approach should be specifically tailored to address the diverse challenges and opportunities within India's energy sector,

considering the unique characteristics of different regions and industries.

2. Given the scale and complexity of India's economy and energy infrastructure, there is a need to strengthen monitoring and enforcement mechanisms to ensure compliance with environmental regulations and the effective implementation of policy interventions. This may require investments in advanced monitoring technologies, capacity building for regulatory agencies, and collaboration with industry stakeholders to improve transparency and accountability.
3. India should prioritize sustainable development initiatives that aim to decouple economic growth from environmental degradation. This could include scaling up investments in renewable energy infrastructure, promoting energy efficiency measures in industrial and residential sectors, incentivising green innovation and technology adoption, and fostering sustainable transportation solutions. By promoting sustainable development practices, India can address environmental challenges while unlocking new opportunities for economic growth and job creation.
4. There is a need for effective stakeholder engagement and public awareness campaigns to garner support for environmental policies and encouraging behavioral changes towards sustainable practices. Indian policymakers should engage with a diverse range of stakeholders, including industry associations, civil society organizations, academic institutions, and the general public, through consultations, outreach programs, and educational initiatives. By building consensus and raising awareness about the importance of environmental conservation, India can mobilize collective action towards achieving emission reduction goals and building a more sustainable future.

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Appendix

Date: 05/05/24 Time: 06:08
Sample: 1960 2020

	CO	CO_TRAD...	EMISSION_L...	GDP
Mean	43.44797	0.431818	0.568182	5.54E+11
Median	47.78716	0.000000	1.000000	3.09E+11
Maximum	56.88778	1.000000	1.000000	2.04E+12
Minimum	21.54577	0.000000	0.000000	6.74E+10
Std. Dev.	11.61408	0.501056	0.501056	5.59E+11
Skewness	-0.533623	0.275299	-0.275299	1.467366
Kurtosis	1.766386	1.075789	1.075789	3.872086
Jarque-Bera	4.878165	7.343864	7.343864	17.18418
Probability	0.087241	0.025427	0.025427	0.000186
Sum	1911.710	19.00000	25.00000	2.44E+13
Sum Sq. Dev.	5800.130	10.79545	10.79545	1.34E+25
Observations	44	44	44	44

	CO	CO_TRAD...	EMISSION_L...	GDP
CO	1.000000	-0.895761	0.895761	0.618729
CO_...	-0.895761	1.000000	-1.000000	-0.599670
EMISS...	0.895761	-1.000000	1.000000	0.599670
GDP	0.618729	-0.599670	0.599670	1.000000

Dependent Variable: CO
Method: Least Squares
Date: 05/05/24 Time: 06:01
Sample (adjusted): 1971 2014
Included observations: 44 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO_TRADING_SCHEME	31.19083	1.219419	25.57842	0.0000
EMISSION_LIMIT_VALUE	50.18339	1.801655	27.85405	0.0000
GDP	2.65E-12	1.76E-12	1.508377	0.1391

R-squared	0.812777	Mean dependent var	43.44797
Adjusted R-squared	0.803644	S.D. dependent var	11.61408
S.E. of regression	5.146440	Akaike info criterion	6.180234
Sum squared resid	1085.920	Schwarz criterion	6.301883
Log likelihood	-132.9651	Hannan-Quinn criter.	6.225347
Durbin-Watson stat	0.412739		