Assessing the Impact of Digital Connectivity and ICT Trade on Black Carbon Emissions in Sri Lanka from 2000 to 2022

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Introduction

Black carbon emissions (BCE) refer to the release of soot particles to the atmosphere from the incomplete combustion of fossil fuel, biomass and waste and they are major contributors to climate change and air pollution. Two main contributing factors to this situation are urbanization and industrialization. As a result it causes significant environmental and public health issues. During the covid-19 lockdown Sri Lanka has observed a significant decrease in air pollution like PM 2.5 levels. The literature highlights the importance of country specific studies on how technical and behavioral factors affect to mitigate BCE (Pushpawela et al., 2023). In the South Asian region BCE has significantly affected environmentally sensitive Tibetan Plateau as identified in the literature which demands global mitigation strategies.

Murshed (2024) argues that carbon emission growth rate can be reduces directly and indirectly using the internet penetration and digitalization effectively. A study by Anita et al., (2024) revealed that black carbon as a component of "Particulate Matter (PM2.5)" associate with significant health risks, especially among children under the age 5. The deaths due to PM 2.5 have reached approximately 306,800 during 2010 to 2014 in South Asia demanding the urgent need of effective air quality improvement initiatives. Further, ICT goods also significantly contributes environmental pollution (Bhujabal et al. (2021)). The negative effects include e-waste, carbon leakage and pollution in the manufacturing processes.

By focusing on Sri Lanka's BCE as opposed to the well-researched CO_2 emissions, this study fills a crucial research gap. It examines the often-overlooked impact of wireless and broadband adoption as well as the trade in ICT commodities on BCE and provide new insights for evidence-based mitigation solutions and policy initiatives.

Objectives

The research objective of this study is to examine the impact of mobile penetration, broadband penetration, ICT goods export, ICT goods import on black Carbon emissions in Sri Lanka.

Methodology

This study employed a panel data set spanning 2000 – 2022 using the secondary data sourced from the World Bank and Our World In Data. The descriptive statistics and MLR estimates generated using the STATA software. In Equation 1, the Multiple Linear Regression (MLR) model was used to analyze the considered variables of the study.

$$BCE_t = \alpha_0 + \alpha_1 MP_t + \alpha_2 BP_t + \alpha_3 IGE_t + \alpha_4 IGI_t + \varepsilon_t \quad (1)$$

In the equation, t represents the year taken into consideration while ε_t indicates the white noise error term. Also, MP represents mobile penetration, BP represents broadband penetration, IGE represents ICT good exports while IGI represents ICT good imports.

Results and Discussions

Tables 1 & 2 indicate the results of descriptive statistics and MLR estimates.

Table 1: Summary of descriptive statistics of variables

	Variables				
	BCE	MP	BP	IGE	IGI
Obs.	21	21	21	21	21
Mean	24274.42	77.38864	2.811489	.7190476	4.162857
SD	1056.154	50.13511	3.389991	.5305554	.8592854
Min.	22453.27	3.528818	.0016683	.19	2.95
Max.	26897.06	143.0794	10.5401	2.1	6.2

Table 1 summarizes the descriptive statistics for the BCE, MP, BP, IGE and IGI in Sri Lanka. Based on a sample size of 21 observations for BCE, MP, BP, IGE and IGI were considered.

Table 2: Estimates of MLR model

Variables	Coefficients	
MP	-14.61652	(7.424123)
BP	-190.4071*	(82.7188)
IGE	-1770.129***	(393.5815)
IGI	-150.7628	(209.8169)
Observation	21	
R^2	0.6575	
Adj – R-squared	0.5718	

Note: *, ** and *** represents the variables are statistically significant at 10%, 5% and 1% level of significant respectively; MLR denotes Multiple Linear Regression. Robust standard errors are given in parentheses.

Table 2 represents the main findings of MLR analysis. As per the results, only BP and IGE are negatively significant due to the remote work option which reduces the transportation emissions and the light manufacturing with the less direct combustion of diesel or biomass compared to heavy industries. Furthermore, MP and IGI show a negative relationship with BCE. This implies that in Sri Lanka, consumption vs product orientation, technological advancements and socio-economic factors could not significantly impact on increasing BCE until 2022 due to the financial instability, economic downturn and political conflicts (Sivaramanan, 2025). Furthermore, Saliya (2023) mentioned political instability in Sri Lanka leads to higher debt and lower reserves within the country. As a result of that, BP and IGE reduced the BCE since it drains government resources without generating the revenue for the country during the economic downturn in Sri Lanka. IGI and MP in Sri Lanka can lower BCE by promoting energy-efficient devices, telecommuting, and digital communication. These impacts are exacerbated by a greater reliance on digital solutions during times of economic uncertainty, like the 2022 crisis. According to Murshed (2020) ICT trade promotes environmental sustainability in South Asia by increasing access to cleaner fuels and energy efficiency.

Conclusion and Policy Recommendations

The current study shows a negative and significant relationship between BP and IGE on BCE, which is reasonable due to the limited access for the technological advancements within Sri Lanka. According to our study, Sri Lanka could mitigate black carbon emissions and the associated health risks by facilitating cleaner ICT imports, encouraging the export of energy-efficient ICT goods, and developing broadband infrastructure to support telecommuting and digital services. Campaigns for digital literacy and awareness can further optimize domestic and industrial procedures, addressing public health and environmental issues in the midst of the nation's economic crisis. Sri Lanka's commitment to the suggested actions can help the nation to lower its emissions, support global climate objectives and drive sustainable economic growth.

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