Economic efficiency and CO_2 impact of a clean cooking program in Ecuador

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1. Motivations underlying the research

Climate change has adverse effects on income inequality, agriculture, natural resources, and lifestyles. The United Nations Global Sustainable Development Agenda (SDGs) considers access to clean cooking a priority; however, in low- and middle-income countries, many families still use polluting cooking technologies that emit CO2 and can also affect health and increase the risk of carbon monoxide poisoning. In 2020, approximately 2 billion people had access to some form of electricity but still cooked using biomass fuel. As a solution, clean cooking programs have been implemented in many countries, with the aim of replacing polluting fuel technologies.

In 2014, Ecuador launched a clean cooking program called "*Programa de Eficiencia Energética para la cocción*" to improve environmental conditions for its population, reduce the large financial burden of liquid petroleum gas subsidies. This program includes the replacement of LPG-powered cookstoves and boilers by electric devices fed by electricity produced with hydropower. When this program started in 2015, households accounted for 75% of national LPG consumption. The price of LPG cylinders (1.6 USD) for households only covered 10% of the real cost, and 90% was subsidized by the public budget. During the PCE program (2015-2021), subsidies of LPG amounted to 2.1 billion USD. Initially, the Ecuadorian government planned to enroll about 3 million families in the PCE, but the final take-up was under 700,000 families.

To our knowledge, the environmental and economic impacts of this program have not been widely analyzed yet. Despite the participation rate not being as high as expected by the government, it is essential to study whether the subsidies spent in this program have been recovered by savings in LPG subsidies. Moreover, it is necessary to quantify the environmental benefits in terms of CO2 emissions related to households burning less LPG. These results are crucial for the identification of the strengths and weaknesses of this program and to identify potential areas of improvement for future cooking programs. In Latin America, the potential of Renewal Energy Sources from hydropower, wind, and solar is significant and can be part of the solution to deal with climate change.

2. A short account of the research performed

In this paper, we analyze the economic and environmental impacts of the Ecuadorian clean cooking program. To do so, we use official macro-data (2015-2021) instead of surveys, which is not common in the literature on these programs and provides consistent and robust results. The empirical approach we are following is an ARIMA model including the lagged endogenous variable. To avoid a potential bias related with the least squares method in the presence of lagged dependent variables, we use maximum likelihood estimators to perform all estimations. We control seasonality through the inclusion of dummy variables for quarter and year.

Our results show that residential electricity consumption acts a substitute good for LPG, and this effect increased during the program, highlighting its efficiency in replacing LPG devices by electricity. We find that this program saved 978,470 ktons of CO2 between 2015-2021 and reduced Ecuadorian LPG consumption by 3,845,808 barrels, resulting in a positive effect on the Ecuadorian balance of trade of 151 million USD. However, the economic rate of return of the subsidies spent on the program was below one, coming in at only 0.72463.

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We also determine that the subsidized electricity in this program was indeed generated with hydropower, as the government had promised. Our results confirm that electricity generation has not led to additional CO2 emissions, which can be explained by the use of dispatchable hydropower plants. However, the use of hydropower in Latin American countries may be affected by the environmental effects known as "*El Niño*" and "*La Niña*", which could alter hydropower generation. This may not be the case if other types of renewable production, i.e., wind or solar generation, are used instead.

3. Main conclusions and policy implications of the work

Based on our results, we provide several regulatory recommendations. First, we highlight the need to evaluate the national economic and environmental impacts of these programs using macro-data instead of local surveys or forecasts based on future scenarios and provide interesting results that can be used to improve the design of future programs. This study thus represents a step beyond the many studies based on local surveys or the forecasting of future scenarios.

Second, households require efficient economic incentives to switch from one energy source to another and the replaced fuel cannot remain highly subsidized, as was the case in Ecuador. The government and the regulator predicted excessive growth in future electricity consumption and allocated many economic resources to reinforcing the grids and commissioning new electricity-generation plants. This misguided allocation of resources limited, for example, the possibility of funding the purchase of induction stoves for the poorest households.

Finally, the generation technology used to cover subsidized electricity must be renewable in order to avoid problematic trade-offs. However, this requires a clear correlation between consumption and renewable generation profiles. In Ecuador, this worked because the energy was generated by dispatchable hydropower, but this could be different in the case of photovoltaics or wind power.