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Household energy choice and consumption intensity: Empirical evidence from Bhutan

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ABSTRACT

This paper uses data from three Bhutan Living Standard surveys (BLSS 2003, BLSS 2007, and BLSS 2012) to examine the trends and patterns of household energy consumption, and identify and analyze the factors that influence household energy choices, consumption intensity and the per capita household expenditure on energy sources in Bhutan. During the last decade significant numbers of Bhutanese households have switched to cleaner energy sources. Empirical results show that a household's choice of cleaner energy sources is driven by income level and household wealth, the age, gender and education of the household heads, access to electricity, and location. Education and income have a differential role on the choice of clean or dirty fuel; wealthier and more educated households use and rely more on clean sources of energy like electricity and liquid petroleum gas while poorer households use and rely on dirty fuel such as fuelwood and kerosene. The study shows that female-headed households are more likely to choose cleaner fuels and, above all, the availability of a clean and cost-effective source of energy within proximity to the household is an important factor in the adoption of clean energy. Several models using a variety of alternative independent variables, such as proxies for education and wealth, were estimated and confirmed the robustness of the results.

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Abbreviations: ADB, Asian Development Bank; BLSS, Bhutan Living Standard Survey; JICA, Japan International Cooperation Agency; LPG, Liquid Petroleum Gas; NSB, National Statistical Bureau; OLS, ordinary least squares; PHCB, Population and Housing Census of Bhutan; UNDP, United Nations Development Programme; PSUs, Primary Sampling Units

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1. Introduction

Access to adequate clean and affordable energy is essential for overall socio-economic and human development [1] as it is critically associated with the provision of the most basic facilities required for the sustenance of human life such as food, shelter, clothing and health services. Hence, the pursuit of sustainable and inclusive economic growth and development is directly linked with the quality and quantity of household energy consumption [2]. It is estimated that about 1.4 billion people worldwide lack access to electricity and that 2.7 billion people rely on the traditional use of biomass for cooking [3,4]; heavy use of firewood as cooking fuel has greatly contributed to aggregate carbon emissions [5,6]. In this context, the international community faces two key challenges: (1) to ensure an adequate and affordable energy supply to millions of poor people, and (2) to reduce the contribution of energy consumption to global warming and climate change. In order to address these two challenges, the large-scale use of renewable energy has been promoted in various areas [7–11]. More importantly, with the rising concern about the adverse effects of global warming and climate change, the focus of energy policies has now shifted from so-called 'dirty energy', usually derived from solid fuels and biomass such as fuelwood, to clean sources of energy such as electricity and liquid petroleum gas (LPG), especially in the context of developing countries [4].

Households in Bhutan, as in many developing countries, rely heavily on fuelwood and other solid fuels for their daily domestic uses. Availability of fuelwood, lack of access to clean and reliable energy sources and their affordability are the three main reasons for the rampant use of solid fuels in developing countries in general and South Asia and Bhutan in particular [4,12]. Households in developing countries typically face socioeconomic, cultural and environmental barriers to changing their energy-use patterns and moving towards the use of cleaner and renewable sources of energy [4].

The private cost of energy is a factor that tremendously influences a household's decision to change to cleaner energy sources. The increased quality and convenience of fuels are usually accompanied by a higher energy cost, leading to a tradeoff between quality and cost [4]. A gradient of quality, convenience and cost can be observed, rising from solid fuels such as firewood and charcoal at the bottom, to liquid fuels such as gas and oil, and, finally, electricity at the top [13]. As a result, the use of fuelwood, dung and crop waste is prevalent among poor households, while households with a higher income move to the use of electricity and LPG [12]. This so-called energy transition ladder [13,14] elucidates the relationship between income and types of energy used. It postulates that in response to higher income and other factors, households will shift from traditional biomass and other solid fuels, to more modern and efficient cooking fuels such as LPG, kerosene, natural gas, or even electricity. There is a clear link between household energy consumption and the human development index [15], illustrating a strong association between income, education, life expectancy, and energy consumption. Apart from the quantity, the type of energy used also changes with income [16], with a shift towards modern fuels [17], in particular electricity [18].

Besides access to affordable sources of energy, the quantity of household energy consumption is affected by income [19] and the level of education. A large body of empirical studies which have documented the existence of the energy ladder and/or the factors influencing a household's decision to switch to cleaner fuel with an increase in household income [20]. In addition, household demographic features, consumption habits and gender may play a significant role in energy-choice decisions of households. Hence, identifying the relative importance of the above factors that influence a household's choice of fuels and the extent of energy consumption is imperative for policy making in the context of Bhutan.

In Bhutan, the major sources of energy used at the household level are firewood, kerosene, LPG and electricity. Thus the hypothetical energy ladder at the micro-level for Bhutan constitutes firewood at the bottom, kerosene in the middle, and LPG and electricity at the top [4]. The poor tend to use solid fuels domestically, which is damaging to the environment and to health [21–23]; when income increases, they generally, but not always, switch to cleaner fuels [24,25]. Thus, it is important to understand the factors other than income that play a role in a household's choice of energy in Bhutan, and design appropriate policies for promoting the transition from dirty to clean fuels.

Bhutan is an interesting case because, despite the commissioning of mega-hydropower projects, rapid economic growth, rise in per capita income, and an ambitious rural electrification project, a significant proportion of Bhutanese households still uses dirty fuels such as firewood, straw, manure, and kerosene as sources of energy for lighting, cooking and heating. The authors in [26] were the first to examine domestic energy consumption in Bhutan, but this study was limited to a descriptive analysis without investigating the factors that influenced the choice patterns. In addition, the study only covered urban areas in a few districts and the sample was not representative of the whole of Bhutan. The most comprehensive study on household choice of energy in Bhutan by the authors in [4] used the representative dataset from the Bhutan Living Standard Survey of 2007; however, it focused merely on the choice and did not provide the extensive robustness test to establish the relationship between clean energy and wealth, and clean energy and education. The results of the present study largely confirm the findings in [4] beyond doubt.

The contributions of this paper to the existing body of knowledge are five-fold follows. First, no such energy study has been carried out using large nationally-representative household datasets from three time periods (BLSS 2003, 2007 and 2012) covering over 20,000 households. This allows us to examine the trends and patterns of household energy choice, their consumption intensity of different energy sources, and expenditure on different energy sources over the three time periods. Second, the results confirm the energy ladder hypothesis in three different time periods consistently, which further strengthen the inverse relationship between the levels of household income and energy consumption. Third, uniquely, this paper uses more advanced econometric models to analyze the factors influencing a household's choice of energy sources, the intensity of energy consumption and household expenditure on different energy sources. A multivariate probit model has been used to identify the determinants of a

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