



Socio-economic determinants of charcoal expenditures in Tanzania: Evidence from panel data[☆]



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ABSTRACT

Compared to firewood, charcoal is a relatively clean and convenient fuel. Nevertheless, the mass production of charcoal can contribute substantially to deforestation, rendering it imperative to regulate charcoal use. This article uses nationally representative panel data on Tanzania conducted in 2008 and 2010 to examine how charcoal expenditures change over time within any given household. The focus of the analysis will be on identifying certain socio-economic factors that affect charcoal use at the household level. The framing of the analysis on variation in time within each household addresses the omitted variable bias that often undermines inference from comparisons across different households. We find that while charcoal expenditures increase with household income, the rise in charcoal use with income is relatively gradual. Household size is unrelated to charcoal expenditures, but urban–rural differences in fuel choice are large even though we include household fixed effects in all specifications. In this regard, policymakers and urban planners need to pay particular attention to the role of urbanization in predicting trends in charcoal expenditures in developing countries like Tanzania.

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1. Introduction

Household choice of cooking fuel has important social, economic, and health effects in developing countries. Traditional biomass, such as firewood and dung, contributes to indoor air pollution, causing major respiratory health problems among the billions of people who continue to rely on it (Bailis et al., 2009; Ezzati and Kammen, 2001; Ezzati et al., 2004). One technologically simple alternative to traditional biomass is charcoal. Produced from firewood, charcoal is a relatively clean fuel that could reduce the disease burden in the developing world (Zulu and Richardson, 2013: 127). Moreover, charcoal is often more affordable than other clean alternatives, such as electricity and liquefied petroleum gas (Maliti and Mnenwa, 2011). In spite of these benefits, charcoal use presents a major governance challenge, as unregulated production could further deforestation (Msuya et al., 2011).

The choice of charcoal as a fuel presents a potential issue, given the commercial nature of most charcoal production in developing countries during rapid rates of urbanization. High rates of population growth

compounded by accelerated urban development lead to a surge in energy demand. This spike in demand, in turn, leads to an increase in relative prices of conventional fuels (Sander et al., 2013), making charcoal a more economical choice as a fuel source. Furthermore, charcoal production, transportation, and use generate more greenhouse gas emissions that cause global warming than traditional firewood collection per unit of energy (Maes and Verbist, 2012).

The demand for charcoal, fueled by rapid population growth in urban areas (Mwampamba, 2007; Mwampamba et al., 2013), has long been on the rise in Tanzania (Allen, 1985; Hosier and Kipondya, 1993), and currently, the slope of the trend is increasing at a particularly fast rate (World Bank, 2009) in urban areas. According to Sander et al. (2013), around 95% of urban households consume some portion of charcoal within their household fuel composition. Sander et al. (2013) also note that the value of charcoal production in Tanzania is approximately USD 650 million, comparable to the country's annual USD 700 million receipt of foreign direct investment. While Hosier and Kipondya (1993) observed a shift away from charcoal toward electricity and kerosene two decades ago, the extent of such a shift appears limited. Therefore, understanding the energy economics of charcoal use in Tanzanian households is essential for achieving sustainable urbanization.

In addition to the challenge of creating appropriate national and sub-national regulations for managing the rapid growth of charcoal use and its

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effect on deforestation, charcoal use presents another major challenge for the Tanzanian energy sector. Growing demand could increase the price of charcoal and expose poor households reliant on the fuel to adverse price shocks (Hosier and Kipondya, 1993). In Tanzania's urban regions, where charcoal is by far the dominant cooking fuel, residents would be particularly vulnerable to such price shocks. With few affordable substitutes, fuel cost hikes would reduce household purchasing power and potentially drive some into poverty. While charcoal currently seems to be an affordable fuel in urban Tanzania, this situation may change with rapidly increasing demand.

Given these challenges, there is a clear need for research on the household determinants of charcoal use in Tanzania. Understanding the socio-economic characteristics of households reliant on charcoal can help address the duality of the challenge. First, Tanzania's rapid demographic transition – as described below, the population is growing and urbanizing fast – will change the charcoal consumer profile in the coming decades. Research examining the association between certain characteristics, such as income and charcoal use, can help predict the magnitude of the change and inform policy. Second, identifying major consumers of charcoal can help target policy interventions designed to insure poor households against adverse income shocks from price surges. Similarly, a consumer profile could help policymakers target initiatives that hold promise for controlling charcoal consumption, such as improved cookstoves, the use of which has so far suffered from low demand among households (Lewis and Pattanayak, 2012; Mobarak et al., 2012).

In spite of the importance of this line of research, there is little quantitative research on the determinants of charcoal consumption in Tanzania and other developing countries. Most studies of fuel switching, fuel stacking, and the energy ladder do not focus on charcoal in particular, but rather instead limit themselves to comparing firewood and modern alternatives in general (van den Kroon et al., 2013). Mwampamba (2007) analyzes a small, non-representative sample of urban households in Tanzania. While she finds few differences across income categories, large households seem to economize by using less charcoal per capita, similar to earlier findings that larger households tend to be more efficient in fuelwood consumption (Cline-Cole et al., 1990). In an analysis of a small urban sample from Mozambique's capital, Maputo, Brouwer and Falcão (2004) find that household size is positively associated with charcoal use, though the result is not statistically significant. According to Khundi et al. (2011), charcoal producers in Uganda are wealthier than other households in the same area, but the analysis of consumption patterns is not included. Ouedraogo (2006) performs a multinomial logit model for charcoal users in Burkina Faso, finding a significantly positive relation between household income and choosing charcoal (compared to 'other fuels'), and an inverse relationship with household size, the total sample size demanding charcoal is small and restricted to households in Ouagadougou. Other than these studies, statistical analysis of charcoal consumption patterns has received little attention, especially in comparison to the large body of literature on fuelwood consumption (Arnold et al., 2006).

To address this research gap, this article uses two recent national surveys from Tanzania conducted by the Tanzanian government's National Bureau of Statistics to characterize the socio-economic covariates of charcoal expenditures (National Bureau of Statistics, 2010, 2012). In both 2008 and 2010, more than three thousand Tanzanian households were surveyed for their consumption expenditures and other relevant characteristics. The majority of the set of households surveyed in 2008 were also surveyed in 2010, allowing for more accurate inference and the ability to exploit variation *within* a given household over time. The surveys allow us to test conventional and new hypotheses on cooking fuel expenditure. We investigate both rural and urban households, given that charcoal use is far from trivial in both areas. Even in rural areas, our data show that more than one in ten households use charcoal for cooking. Focusing on urban areas only would be highly problematic in a predominantly rural developing country.

The analysis estimates the effect of various relevant variables on household expenditures across the country, with the following main findings:

- Household income, measured as monthly non-energy expenditures, has a strongly positive effect on charcoal expenditures. In the main specification, a 1% increase in household income raises charcoal expenditures by 0.4%. From this finding, we find charcoal to be an inelastic, normal good.
- Controlling for other factors that shape charcoal consumption, household size does not have a statistical association with charcoal expenditures. This could be explained by the fact that a charcoal stove requires a fixed amount of charcoal regardless of the amount of food cooked. In spite of having fewer members in the family to feed, smaller households still require the same fixed amount of charcoal as households with more members to make use of a charcoal stove. While the cross-sectional analysis shows that, among charcoal users, household size is positively correlated with charcoal expenditures, the panel analysis indicates that this correlation could be spurious and driven by omitted variable bias.
- The demand for charcoal is greater among urban households than that among rural households. Given the greater availability of free firewood in rural areas, rural households have weaker incentives to purchase charcoal.

The findings both confirm some previous results and add new insights. One of the most interesting points to note from the findings is that a boost in household income causes only small increases in the use of charcoal compared to the magnitude of the effects of urbanization on charcoal use. Additionally, with all else held constant, such as fundamental changes in lifestyle and cooking preferences, small family size cannot be equated with less charcoal consumption.

The findings have important implications for energy policy in Tanzania. According to the results, the key factor that will condition the evolution of charcoal consumption in Tanzania in the coming decade is urbanization. As Tanzania's urban population grows, so will the consumption of charcoal, while growth in household wealth is less important as an explanatory variable. To improve the regulation of charcoal and guard against deforestation, policymakers need to focus on identifying the sources of rapidly growing urban areas and create policies specifically tailored to addressing the needs of the growing urban demographic. Of particular concern is the rapid growth of Tanzania's largest city, Dar es Salaam. The governance of charcoal production to serve households in this city may require particularly aggressive policies. At the same time, economic growth and changes in family size across different regions of Tanzania are less important for policy analysis and planning.

Globally, urban population shares are projected to increase from a measured 45% in 1995 to 61% by 2030 (McMichael et al., 2006). This trend will be especially apparent in developing countries, such as Tanzania, experiencing substantial population growth. According to the World Factbook provided by the United States Central Intelligence Agency, the urban population currently comprises around 26.7% of the total population of Tanzania, and the annual rate of change in urbanization for the 2010 to 2015 period is estimated at 4.77%. In this regard, there will be a need for aggressive policies specifically tailored to these urban clusters, given the rapid urbanization expected for Tanzania in the coming decade. The significance of the issue is further emphasized by the equally rapid growth of cities in other African countries (Parnell and Walawege, 2011).

2. Charcoal expenditures of Tanzanian households: three hypotheses

There are few econometric studies to build on, and those available often analyze small, non-representative samples (Mwampamba,

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