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Household energy elasticities and policy implications for Pakistan

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ABSTRACT

This study estimates fuel expenditure and price elasticities of household fuels in Pakistan. The burning of biomass is harmful to health and the environment and may cause preventable morbidity and mortality. It is important to investigate how households' fuel choices are linked to prices, so that governments can consider appropriate steps to enhance the consumption of clean fuels. Using three pooled cross-sectional surveys from Pakistan and applying the Linear Approximate Almost Ideal Demand System (LA-AIDS) model, we found that all fuel types except natural gas were price inelastic at the national level and for urban households. In rural areas, natural gas and LPG were found to be more price elastic compared to urban areas. Simple policy simulations based on our results suggest that in order to reduce indoor air pollution by encouraging the adoption of clean fuels (LPG and piped natural gas), governments should subsidies clean fuels rather than imposing taxes on solid fuels. Moreover, in the case of Pakistan a subsidy for LPG should be preferred over a subsidy for piped natural gas, as it produces a more cost-effective reduction in solid fuel use.

1. Introduction

It is broadly recognized that energy is a key resource for economic growth and development (Sahir and Qureshi, 2007). Energy consumption in developing and middle-income economies (Middle East, Southeast Asia, South America, and Africa) will exceed that of developed countries (North America, Australia, New Zealand, Japan, and Western Europe) by 2020 (Pérez-Lombard et al., 2008). Due to limited resources and increasing demand, especially from developing and middle-income countries, the price of energy sources has risen over time (Hadjipaschalis et al., 2009). Consequently, the gap between the demand for and the supply of fuels is increasing, especially in developing and middle-income countries. The growing demand for energy and the reliance of countries on limited sources of energy mean that adequate energy provision will be one of the world's major problems in the next century (Khan and Ahmad, 2008).

Globally, more than two billion people depend upon solid fuels such as charcoal, coal, animal dung, firewood, and crop residues[1] for cooking and heating purposes (Larson and Rosen, 2002). When burned, such solid biomass fuels emit a multitude of complex chemicals including carbon monoxide, nitrogen dioxide, formaldehyde, polycyclic aromatic hydrocarbons (PAH), cilia toxic, and other inhalable particulates, damaging the environment and people's health (Cooper, 1980; Torres-Duque et al., 2008). Solid fuels are generally burned in exposed fires or in three-stone stoves, leading to the emission of high levels of these noxious chemicals (Fatmi et al., 2010). Mostly as a result of solid fuel use, almost 1.6 million people around the world die prematurely each year due to indoor air pollution, and millions more suffer from serious diseases such as asthma, lung infections, eye infections, sinus problems, tuberculosis (TB), cancer, and cardiovascular diseases (Mishra, 2003; Kim et al., 2011; Kim et al., 2011; Lakshmi et al., 2012; Sehgal et al., 2014).

The consumption of solid fuels not only affects the population, but also damages the environment. The forests of developing countries are progressively depleting due to wood usage as a household cooking fuel (Arnold et al., 2006; Bhatt and Sachan, 2004). Forests are necessary for economic, ecological, social, environmental, and health benefits, and provide food, medicines, forest products, and social resources, as well as helping to reduce global warming (Bonan, 2008). Despite the adverse effects of biomass fuel on health and the environment, the use of solid fuels for cooking, lighting and heating purposes remains very common in developing and middle-income countries.

Like many other middle-income countries, electricity, firewood, natural gas, crop residues, animal dung, and Liquefied Petroleum Gas (LPG) are the main cooking and lighting fuels in Pakistan. Usually, electricity is used for lighting whereas other fuels are more commonly used for cooking and heating. In rural areas, the consumption of solid fuels such as firewood, dry animal dung, and crop residues is higher than in urban areas. On the other hand, the consumption of clean energy sources such as natural gas is higher in urban areas than in rural

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[1] These residues include cotton sticks, bagasse, husks, wheat straw, roots, corn stalks, stubble, leaves, seed pods, etc.

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areas.

Pakistan has a population of 185 million[2] and ranks as the sixth most populous country in the World. The number of annual deaths attributed to acute respiratory infections (ARI) among children under age five years in Pakistan has been estimated to be 51,760, with a further 18,980 annual deaths due to chronic obstructive pulmonary disease (Colbeck et al., 2010).[3] The total primary energy consumption of Pakistan was 2.54 Quadrillion British Thermal Unit (QBTU) in 2011 (U.S. Energy Information Administration (EIA)). The per capita energy consumption of Pakistan in 2013 was 475 kg of oil equivalent per year and Pakistan was ranked at 133rd globally.[4]

The six panels of Fig. 1 show the overall energy consumption by Pakistani households of natural gas (Panel a), LPG (Panel b), fuelwood (Panel c), bagasse or agricultural waste (Panel d), animal dung[5] (Panel e), and kerosene (Panel f). The consumption of most fuels have an increasing trend, with the exceptions of LPG (which increased to a peak in 2006 then decreased) and kerosene oil (which exhibits a decreasing trend). The reduction in the consumption of LPG may be associated with the increase in the consumption of natural gas. The fluctuation in the in the consumption of the bagasse and crops residues may be because of various factors such as water availability, weather conditions, pests, and relative crops prices.

Pakistan has sufficient energy resources to satisfy demand (Ali et al., 2015). In recent years, the demand for energy has significantly increased, but due to inadequate policies this increase has not been catered for. Pakistan's energy sector is poorly managed, there is extensive theft of gas and power, and service quality is low. Consequently, power shutdowns (blackouts or brownouts) are very common (Khan and Ahmad, 2008), which is not only impeding the development of the country, but also badly affecting quality of life (Javed et al., 2016).

Despite the importance of understanding patterns of energy demand in Pakistan, there is a lack of research that adequately addresses energy demand. The setting of optimal energy prices, levels of subsidies, and levels of taxation for solid and clean fuels continues to be problematic for the government. Prices, subsidies, and taxes play a vital role in household energy choices and consumption. In order to examine the impact of increases or decreases in the prices of energy sources at the household level, accurate estimates of the price and income elasticities of fuels are imperative. However, extant studies for Pakistan have mostly estimated only the demand elasticities of electricity, while the elasticities of other household fuels have been neglected. We have found only two prior studies that have estimated elasticities in Pakistan for household fuels other than electricity, those being Iqbal (1983) and Burney and Akhtar (1990). Unfortunately, both studies are now very dated, and their results are somewhat dubious (see Section 2 for further details). Similarly, few studies have estimated separate demand functions for rural and urban areas of developing countries, including Gundimeda and Köhlin (2008) for India and Arthur et al. (2012) for Mozambique.

The objective of this study is to estimate the uncompensated own price and fuel expenditure elasticities for household cooking and heating fuels in Pakistan. This study contributes to the literature by providing new estimates of these elasticities for Pakistan, disaggregated between rural and urban households. Moreover, we extend this analysis with simple simulations designed to suggest which of two clean fuels (LPG or piped natural gas) should be subsidised in order to encourage the greatest number of households to adopt these clean fuels. Answering this latter question is important for policy in many developing countries, where indoor air pollution (from burning solid fuels) is a significant and growing problem.

To undertake the analysis, we pool three national level micro survey data sets (Pakistan Social and Living Standard Measurement Survey (PSLM) for 2007–08, 2010–11, and 2013–14). The data are comprehensive and cover all the cooking and heating fuels used by households. We model energy demand as a multistage budgeting problem, and the allocation of fuel expenditures are analyzed using the Linear Approximate Almost Ideal Demand System (LA-AIDS) model. The LA-AIDS specification was proposed by Deaton and Muellbauer (1980), and is widely used to estimate price and expenditure elasticities when expenditure share data are available, but not unit prices. Although alternative models for the estimation of elasticities have been suggested that would allow for time varying elasticities (Barnett and Kanyama, 2013), Sherafatmand and Baghestany (2015) argue that the LA-AIDS model is preferable when the aim is to estimate linear parameters. Moreover, although our dataset includes several waves of the PSLM, households are not linked between waves, which does not lend itself to the efficient estimation of time-varying models.

Overall, we find that all fuel types except natural gas are price inelastic at the national level and for urban households. In rural areas, natural gas and LPG are more price elastic than in urban areas. Our policy simulations suggest that in order to reduce indoor air pollution, the Pakistan government should subsidise clean fuels rather than imposing taxes on solid fuels, and the preference should be for subsidising LPG rather than piped natural gas.

The remainder of the paper is organized as follows. Section 2 discusses relevant literature, and in Section 3 we discuss the data and methodology. Section 4 presents the main results, Section 5 presents simple policy simulations, and Section 6 concludes.

2. Literature review

There is a limited literature on household demand for fuels used in cooking and heating in developing and middle-income countries (Ngui et al., 2011). Studies such as Filippini and Pachauri (2004) in India, Atakhanova and Howie (2007) in Kazakhstan, Athukorala and Wilson (2010) in Sri Lanka, Shi et al. (2012) and Lin et al. (2014) in China, have mainly estimated the demand for electricity only. Few studies are available for Pakistan, such as Jamil and Ahmad (2011), and Nasir et al. (2008), but again they are also limited to demand for electricity.

In the Ogun state of Nigeria, Shittu et al. (2004) estimated income elasticities for fuels by applying logit models for poor, average, and wealthy households. They found that wood had a negative income elasticity with values of − 5.02, − 4.94, and − 4.31 for poor, average, and wealthy households respectively. Gundimeda and Köhlin (2008) calculated households' price and expenditure elasticities in India by applying the LA-AIDS model, and found positive expenditure elasticities for low, medium, and high income groups in both rural and urban areas. The own price elasticities of electricity, kerosene, fuelwood, and LPG, were almost the same in both rural and urban areas. Fuelwood and LPG were almost unitary elastic for all groups.

Arthur et al. (2012) investigated the price and income elasticities of domestic energy using the Mozambique National Household Survey on Living Conditions 2002/3. Surprisingly, fuelwood and charcoal were found to be more price inelastic (with values of − 0.41 and − 0.28 respectively) than electricity (− 0.60) or candles (− 0.88). On the other hand, candles, kerosene, and electricity were more sensitive to income changes than firewood and charcoal. Similarly, Akpalu et al. (2011) found that the price elasticity of demand in Ghana was inelastic in the case of charcoal, firewood, and LPG, while kerosene was price elastic. Furthermore, they found that LPG was the most preferred fuel, followed by charcoal, firewood, and kerosene.

In Kenya, Ngui et al. (2011) estimated expenditure elasticities and own and cross price elasticities. The researchers found uncompensated price elasticities − 0.28, − 0.62, − 0.67, − 0.69, and − 0.88 for LPG, fuelwood, charcoal, kerosene and electricity respectively. Surprisingly, kerosene oil was found to be expenditure elastic (1.06), implying that a

[2] https://data.worldbank.org/indicator/SP.POP.TOTL?locations=PK.

[3] See also: http://www.who.int/indoorair/publications/indoor_air_national_burden_estimate_revised.pdf?ua = 1.

[4] http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE.

[5] Data are not available for animal dung after 2006.