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Sources of change in the demand for energy by Indonesian households: 1980–2002

Joyce J. Chen [a,b,*], Mark M. Pitt [c]

[a] The Ohio State University, United States
[b] IZA, Germany
[c] Brown University, United States

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ABSTRACT

This paper describes the energy transition in Indonesia and examines the determinants of energy demand, by fuel. The key innovation of this paper is the documentation of how these relationships have evolved over time. We present a new method to combine econometric analysis and index decomposition analysis to examine household energy transition. This approach also allows us to consider a broad range of demographic and structural factors, while providing a clear and concise representation of our findings. We find that the composite indices mask important underlying patterns. In particular, our results indicate that energy transition in Indonesia cannot be confidently attributed to any one index. Rather, it has been driven predominantly by the triple interaction of demographics, income growth, and change in demand/supply parameters. Our findings point to the importance of utilizing time-series data in studying both the characteristics and determinants of energy transition in developing countries.

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1. Introduction

The study of energy usage and fuel choice has become increasingly important and urgent as scientific research reveals the environmental impact of carbon emissions and the adverse effects of indoor air pollution. In particular, researchers and policymakers alike have turned their attention to developing countries as these populations become ever larger consumers of energy. Households are also thought to experience an "energy transition" or to move along an "energy ladder" (Leach, 1992; Barnes and Floor, 1999; Barnes and Qian, 1992; Hosier and Kipondya, 1993), whereby broader trends in economic development generate a shift in the fuel mix towards commercial fuels and away from biomass. But, as Jiang and O'Neill (2004) point out, the characteristics of this phenomenon have not been well-documented, and it is unclear whether the declining share of biomass energy represents a net reduction in absolute biomass use. Moreover, the existing literature has not adequately explored the relationship between energy transition and demographic transition. Static links between fuel choice and demographic characteristics have been well-documented, but the connection with demographic *change* remains much less clear. As the demographic transition often precedes economic development in today's developing countries, effective energy policy must take into account how demographic change within a population may influence both the timing and the path of the energy transition.

This paper has two main contributions. First, we describe trends in energy usage in Indonesia, in terms of both quantity and composition. Careful and detailed descriptions of energy use, over time, have been conducted for several countries but has not, to date, been conducted for Indonesia (Permana et al., 2008, presents a case study of Bandung City, the capital of West Java province in Indonesia for a single point in time). We focus on the two decades in which Indonesia experienced its most significant economic expansion to date (1980–2002). This growth was precipitated by falling oil prices in the 1980s, which prompted the Indonesian government to diversify away from oil exports and towards manufactured exports, accelerating industrialization (Elias and Noone, 2011). Indonesia is now the fifth most populous country in the world with the 9th largest economy, based on PPP-adjusted GDP. Between 1980 and 1997 (before the Asian Financial Crisis), Indonesia's GNI per capita experienced an annualized growth rate of 4.16%. Indonesia is also ranked 23rd in the world in crude oil production, and 25th in crude oil exports, and the nation has even greater stores of natural gas, ranking at 12th in both production and exports (CIA, 2016). This period also marks a dramatic shift in Indonesia's demographic transition. After reaching its peak in the early 1970s, the population

* Corresponding author at: 324 Agricultural Administration Building, 2120 Fyffe Road, Columbus, OH 43210, United States.
E-mail address: chen.1276@osu.edu (J.J. Chen).

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growth rate began decreasing, with fertility falling by half, nearly to the replacement rate, by the turn of the century. Life expectancy increased from 58 to 65, the population growth rate fell from 2% to 1%, and primary school completion rates increased from 58% to 99%. Urbanization also increased rapidly, from 22.1% in 1980 to 43.6% in 2002 (World Bank, 2012).

These features make Indonesia both a key component of world energy use and an instructive case for examining the relationship between fuel choice and demographic change. The relationships we estimate can provide insight into the energy transition for other countries at a similar point in the development process – that is, in the early stages of industrialization, urbanization, and demographic transition. Within this group, our findings may be particularly relevant for other oil-producing and/or resource-rich countries, such as Nigeria (McNicoll, 2011), given Indonesia's natural resources. However, Indonesia's growth during this time was due largely to industrialization rather than resource extraction, suggesting that our findings may apply more broadly. Additionally, as discussed below, our analysis allows us to disentangle and differentiate the impacts of demographic, economic, and structural change, so that we can consider the impact of, say, demographic change alone, without the accompanying economic and structural change observed in Indonesia during this period.

The second key contribution of this paper is to identify the determinants of the observed energy transition. We estimate the household demand for energy, disaggregated by type, accounting for a wide variety of demographic characteristics and allowing their influence on energy use to vary over time. Previous studies generally have two main limitations. First, those that have been able to obtain data over a longer time period tend to estimate a single average effect, held constant over time, and for only one factor at a time. Barnes et al. (2005) find a clear positive relationship between household size and use of biomass, and vice versa for modern fuels, using data from the World Bank's Energy Sector Management Assistance Programme (ESMAP). However, their calculations are done by stacking all years of data (1984–1999) together, which may mask important changes in this relationship over time and throughout the energy transition. Taking a historical perspective, Gales et al. (2007) estimate that growth in per capita income accounted for 55% of the change in energy consumption in Sweden, the Netherlands, Italy and Spain between 1870 and 2000 but, again they do not allow the effect of income to vary over time.

Alternatively, there have been several papers to examine the effect of multiple factors, economic and demographic, simultaneously, but these rely on a single cross-section of data, precluding any analysis of how these relationships may have evolved over time. Jiang and O'Neill (2004) and Pachauri and Jiang (2008) examine a wide range of demographic characteristics (sex, education, and occupation of household head; household size and structure; geographic location) in addition to household income for China and India, utilizing a single cross-section of data in each case. Heltburg (2004) utilizes data from eight diverse countries and examines the relationships between fuel choice and income, household size and education. Again, the data are drawn from a single point in time, but it is evident that the estimated relationships, although generally consistent with an energy transition, differ substantially across countries in terms of not only magnitude but also sign. One exception is Campbell et al. (2003), which utilize data over a five year period (1994–1999) and do treat each time period separately. Their calculations suggest that rates of changes for electricity and kerosene use do not differ across income groups. They do not, however, document or account for the effect of other correlated demographic characteristics, which are likely to affect the observed relationship between income and fuel choice.

Another notable exception is the large literature on index decomposition analysis (IDA). The IDA methodology utilizes time-series data to separate changes in energy use into their component parts (e.g., sectoral/industrial composition, energy efficiency), generally by using observed shares/intensities (see Ang and Zhang, 2000 for an overview). More recently, this approach has been extended to consider changes in not only industrial energy use, but household energy demand as well. Nie and Kemp (2014) use the logarithmic mean Divisa index (LMDI, Ang et al., 1998) to examine changes in household energy use in China between 2002 and 2010. Song and Zheng (2012) and Zhang (2013) utilize both IDA and econometric analysis to estimate the determinants of the energy transition in China and the transition economies of Eastern Europe and Central Asia, respectively. In this paper, we present a new method to combine econometric analysis and index decomposition analysis (IDA) to examine household energy transition. This approach also allows us to consider several different energy sources along with a very broad range of demographic and structural factors, while providing a clear and concise representation of our findings.

We examine the share of the household fuel budget allocated to each type of fuel (including firewood, charcoal, kerosene, liquefied petroleum gas (LPG), city/natural gas, and electricity). We utilize a Tobit (Tobin, 1958) specification, which allows us to capture both the decision to use a particular fuel as well as the quantity that is ultimately consumed. Our data permit the estimation of energy demand equations that are flexible in a number of important dimensions. In particular, the estimated demand equations:

(1) incorporate detailed information on the demographic composition of households,
(2) allow the household response to income change to be very flexible,
(3) permit preferences for energy, by type, to change over time and independently of income and demographic changes,
(4) allow the effects of demographic change to vary with household income and household size,
(5) control for province-level unobserved heterogeneity in energy demand through the use of fixed effects, and
(6) identify the impact of the geographic distribution of the population, separate from the distribution between rural and urban areas, on energy demand.

Flexibility is obtained by allowing double and triple interactions between variables, and by allowing the full set of parameters to vary over time without restriction. The benefit of this approach is that it better captures the complex ways in which energy demand evolves over time in a rapidly changing developing country. The challenge is that individual regression parameters are not easily interpretable. For example, calculating the effect of a change in the number of household members on the demand for any particular type of energy requires evaluating an expression involving dozens of parameters and variables. Instead, we borrow methods from index decomposition analysis to summarize the effects of demographic change, income growth, and changes in preferences on the demand for various fuels in Indonesia between 1980 and 1999.

2. Data and context

The data are drawn from the 1980, 1984, 1987, 1990, 1993, 1999 and 2002 Indonesian National Socioeconomic Surveys, commonly known by the acronym SUSENAS. The SUSENAS is a series of surveys initiated in 1963–1964 and conducted periodically by the national statistical agency, Biro Pusat Statistik (BPS). Although the initial rounds covered only selected provinces due to funding constraints, the sampling frame has been nationally representative throughout the 1990s. In 1993, the sample size was extended from 65,000 households to 202,000 households. Each survey consists of a core questionnaire to collect basic demographic data such as relationship to the household head, sex, age, marital status, and educational attainment of all household members. In 1992, the core questionnaire was extended to include critical indicators of individual and household welfare such as

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