Energy Policy 109 (2017) 782–793

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The long-run performance of increasing-block pricing in Taiwan's residential electricity sector

Ming-Feng Hung*, Bin-Tzong Chie

Department of Industrial Economics, Tamkang University, Tamsui District, New Taipei City 25137, Taiwan, ROC

ARTICLE INFO

JEL classification:
Q41
Q48

Keywords:
Residential electricity
Increasing-block pricing
Efficiency
Income distribution
Family size

ABSTRACT

This article examines the performance regarding efficiency and equity of increasing-block pricing (IBP) in Taiwan's residential electricity sector. By using long-term nationwide household data (1999–2014), actual variations in IBP rate structure are explored. Empirical results show that cross-subsidization under IBP have resulted in inefficient over-consumption by the poor and inefficient under-consumption by the rich. In addition, the financial burden increased with decreases of household's income levels and a relatively high percentage of subsidies mistakenly went to non-poor households. The upward price adjustments and broadened first block in recent years have increased the household's financial burden and the rates of wrongly excluding the poor and wrongly including the rich to enjoy the subsidy. Being unable to take family size into consideration and send correct price signals to all users are two serious problems for IBP, which may hinder the achievement of equity and efficiency in electricity use.

1. Introduction

In Taiwan, energy-related resources are rather scarce. Of the total energy supply, imported energy consists of nearly 98% and the remaining 2% is provided by domestic supply. However, the total energy consumption has grown greatly over the past two decades. In particular, around half of the final energy consumption is in the form of electricity. The residential consumption of electricity has increased from 25,329 to 45,174 GWh and electricity consumption per capita has nearly doubled from 5,941 to 10,791 kWh in the 1995–2014 period. Under such an energy-dependent and increasing electricity-demand situation, a well-performing rate structure for electricity is very important for its demand-side management.

Increasing-block pricing (IBP) has long been used to charge electricity in Taiwan since 1986. Under IBP, the amount of electricity use is specified into a number of ordered blocks and the charge increases with blocks. This rate structure is proposed in order to meet multiple objectives of electricity use such as economic efficiency, equity, resource conservation, and revenue neutrality of utility. For example, the initial block of a certain subsistence amount of electricity is charged below the average tariff which makes electricity affordable to poor households. By charging higher marginal tariffs for larger blocks, income distribution and equity are hoped to be improved through cross-subsidization. Meanwhile, cross-subsidization might also make the electric utility break even. In addition, the higher tariffs for large users could force them to conserve and use resource efficiently.

However, it is important to note that IBP has not performed as well as expected in practice. Some studies of rate structures in electricity sector show that IBP does not target subsidies to the poor households well and its quantity-based subsidy is highly regressive in developing countries (see Wodon et al., 2003; Komives et al., 2005, 2006, 2007; Angel-Urdinola and Wodon, 2007). Affordability is a problem for low-income consumers in developing countries (Komives et al., 2005; Fankhauser and Tepic, 2007). Borenstein (2012) analyzed the effect of California's IBP regime on electricity and found that IBP results in modest wealth redistribution, but the deadweight loss associated is likely to be large relative to the transfer. Some researches designed and examined the proposed IBP structures in China. They found that IBP could improve equity and efficiency and promote the electricity saving (see Lin and Jiang, 2012; Sun and Lin, 2013; Sun, 2015). Khanna et al.

* Corresponding author.
E-mail address: eureka@mail.tku.edu.tw (M.-F. Hung).

http://dx.doi.org/10.1016/j.enpol.2017.07.052
Received 7 February 2017; Received in revised form 22 July 2017; Accepted 23 July 2017

(2016), however, found that IBP does not have a statistically significant relationship with lowered residential electricity consumption in China.[1]

From the literature review, it can be concluded that the commonly used IBP hardly achieves its stated goals, yet effects vary across different cases. This motivates us to examine the performance of IBP in Taiwan's residential electricity, since the IBP regime has been in effect for almost three decades, while its empirical results have not yet been well-examined. In the past few years, the rate structure of IBP was more frequently adjusted due to various reasons including: the increasing electricity consumption per capita, volatile international energy costs, CO_2 reduction requirements, and the huge financial deficits recorded by the monopolistic public electricity utility, among others. It has even become a flexible version where the rates can float with the production cost regularly twice a year since 2015. However, all these adjustments are still based on the design of IBP. It is therefore very important to examine the performance of IBP. This empirical study will show important policy implications for the demand-side management of electricity use and regime reforms.

In this article, we compile a long-term nationwide household data set (1999–2014) in Taiwan to empirically examine the effects regarding efficiency and equity for IBP. It has three main contributions to the literature. First, this article analyzes the case of a newly industrialized country which supplements the existing literature where developing countries are the main objects of study. In this case differences and similarities of IBP performance among different kinds of countries can be explored. Second, we perform a more complete examination of IBP performance. There are two major strands of IBP-performance literature: one uses demand estimates to examine changes in consumer surplus; the other proposes affordability and distributional measures assuming inelastic demand to analyze the effects on income redistribution (Barde and Lehmann, 2014). In this article we unify these two strands as we estimate the residential electricity demand function and examine measures for both consumer surplus as well as affordability and income distribution. Third, unlike the existing literature studying the IBP performance at a particular point in time and comparing a status quo with a proposed rate structure change, this article examines IBP effects for a country over a long period of time. Because in Taiwan, the IBP rate structures have changed several times during this long period, we can study the results of actual rather than proposed rate structure changes.

The remainder of this paper is organized as follows. In Section 2, we describe the methodology and data applied in this article. Different measures for the examination of IBP performance are introduced. In Section 3, empirical results are studied and discussed. Section 4 concludes.

2. Methodology and data

In this section, we first introduce the data and rate structure. Next, we specify the residential electricity demand function, which is necessary for the measurement of economic efficiency. We then describe in detail the indices and measures we use to study the effects of IBP on efficiency and equity.

2.1. Data

The data used is the official "Report on the Family Income and Expenditure Survey" in Taiwan, which is nationwide and has been produced since 1964. This survey adopts a stratified two-stage random sampling method in each year to generate the sample. The Ts'uns/Lis (the basic local administrative units in Taiwan) in cities and counties are stratified from three to six strata according to the employment structure by sector and education level. In the first stage of sampling, 20% of the Ts'uns/Lis in each stratum are drawn by systematic sampling. In the second stage of sampling, households are selected by systematic sampling from the sampled Ts'uns/Lis based on proportional allocation. This survey contains more than 10,000 household observations each year. It also covers a large range of household characteristics, such as income and various expenditures, including electricity expenditure. However, because one important variable, family size, for the estimation of electricity demand function is not available in the survey until 1999, we compile the data from 1999 to 2014 to analyze the performance of IBP taking family size into account. It should also be noted that because the sampled households are different every year, the data set is not longitudinal.

For this kind of nationwide and publicly available data, the monthly data on household electricity consumption is not provided directly and should be computed from the annual household electricity expenditure. We construct consumption by taking advantage of the monthly percentage of residential electricity expenditure and the corresponding rate structures. To be specific, we first divide the total monthly electricity consumption of the residential sector (reported by the Bureau of Energy, Taiwan) by the number of household users (reported by Taiwan Power Company) to obtain the individual monthly electricity consumption of an average household. We then calculate the individual monthly electricity expenditure of this average household by using the corresponding rate structure. Next, the individual monthly percentages of electricity expenditure are calculated. We assume that all households in the data set have the same monthly percentage of electricity expenditure and use these percentages to further spread the annual electricity expenditures of individual households into household monthly electricity expenditures. The households monthly electricity consumption can then be derived by using the households monthly electricity expenditure and the corresponding rate structures. Finally, the household monthly electricity consumptions for June, July, August, and September are averaged to be summer monthly electricity consumption; the monthly electricity consumptions of other months are averaged to be non-summer monthly electricity consumption. In addition, the average monthly price of electricity in summer (non-summer) period is computed by dividing the sum of monthly electricity expenditures in summer (non-summer) months by the sum of monthly electricity consumptions in summer (non-summer) months.

It should be noted that this data procedure is used in order to distinguish summer and non-summer electricity consumptions. Due to different rate structures and temperatures in summer and non-summer months in Taiwan, the above-mentioned method is better than simply dividing the annual electricity expenditure by twelve to obtain the monthly electricity expenditures and consumptions.

As indicated by Fell et al. (2014), the estimates based on imputed data could suffer bias from both measurement error and simultaneity.[2] To deal with these problems, most previous studies used an exogenous

[1] There are also a number of studies which examine the performance of IBP in the urban water sector. Whittington et al. (2015) indicated that there is broad consensus in this literature that quantity-based subsides under IBP are poorly targeted in most developing country contexts (see e.g., Boland and Whittington, 2000; Komives et al., 2005; Komives et al., 2006, 2007; Angel-Urdinola and Wodon, 2007; Dahan and Nisan, 2007). This finding mainly results from the fact that low-income households do not have a piped connection to piped water or sanitation networks. In addition, large households (which are also likely to be the poor) may need to pay higher average prices under IBP because of their higher household water consumption. Ruijs et al. (2008) and Ruijs (2009) found that a progressive block price may result in a more equalized income distribution while endanger the financial situation of the water company and average welfare. Schoengold and Zilberman (2014) showed that IBP has a limited capacity to address equity while maintaining a balanced budget.

2Fell et al. (2014) reviewed the literature studying residential electricity demand and classified them into three sets according to the data they applied: the set used nationwide panel data (often aggregated at the state level); the set employed household-level data that are also public and national in scope, but some important information such as household level prices are often missing; and the set employed household-level data, but some pieces of private electricity billing or rate structure information are involved. The estimates of elasticity from the first set may be subject to misspecification bias due to aggregation over electricity usage and price. The second set, in which we are included, could bear the bias from measurement and simultaneity. The data for the third set is often proprietary and one should be cautions in applying estimates from these area-specific studies to all areas of the country.