Utilities Policy 34 (2015) 63–69

Contents lists available at ScienceDirect

Utilities Policy

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

An empirical examination of the distributional impacts of water pricing reforms

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ARTICLE INFO

Article history:
Received 21 October 2014
Received in revised form
18 December 2014
Accepted 19 December 2014
Available online 29 December 2014

Keywords:
Pricing
Demand
Equity

ABSTRACT

Water pricing reforms may promote conservation and economic efficiency. However, it is possible for water pricing reforms to be regressive. We estimate Stone-Geary and double-log residential water demand functions using data from the Capital Region District of British Columbia, Canada. Two price reforms are simulated: an across-the-board price increase and an increasing block rate structure. The distributional impacts depend on the specification of water demands. For the across-the-board price increase, the double-log model shows no change in the distribution of water expenditures while the Stone-Geary specification indicates a worsening of the inequality of water expenditures.

1. Introduction

Municipal water prices are frequently thought to be too low in Canada (OECD, 2010; Renzetti and Dupont, forthcoming). This situation may be seen largely as a result of municipalities choosing water rates without adequate regulatory oversight by provincial governments. Low water prices are often believed to play a role in inflating the quantity of water demanded, constraining investments in water systems and stifling innovation both on the part of water users and suppliers. In response to these concerns, pricing reforms were proposed as early as the 1960s. However, adoption of new and possibly higher water prices has been constrained due to a variety of real or perceived constraints including the potential for pricing reforms to have a disproportionately negative impact on lower income households (Dinar, 2000; McMaster and MacKay, 1998). While Canadian households rarely lose access to water service due to higher prices, there are nonetheless real concerns over the affordability of water supplies. Addressing these equity-related concerns is further complicated by differing views on the roles of water prices and whether access to water is a fundamental human right. Some argue that water is an economic good with economic value in all its uses for which efficient allocation should be an important objective (WMO Dublin Statement, 1992). In contrast, there are others who argue that, since water is necessary for life, it is a fundamental human right (UN News Center, 2010). The main policy objectives following from this view focus upon improving access and achieving equity and diminishing the role played by prices.

The primary focus of this study is to investigate the structure of residential water demand in order to better understand the distributional effects of water pricing reforms. In particular, we test the hypothesis that water pricing reform will place a relatively larger burden on lower income households. We do this by simulating the effects of different reforms on the budget shares spent on water for households with different income levels. Budget shares are obtained from estimated residential water demands using a panel of census tract observations over 11 years for the Capital Region District of British Columbia, Canada. Stone-Geary and double-log specifications are estimated in order to assess the impact of differing models of demand responsiveness on water pricing reforms. Using estimated price and income elasticities, price reforms are simulated: an across-the-board price increase and a move towards an increasing block rate structure. This research contributes to the growing literature that investigates equity concerns that have been raised in discussions surrounding water pricing reforms. The estimation results show that both price and income elasticities differ across model specifications and the simulation results show that the impacts of water pricing reforms depend on the specification of water demands. The remainder of the paper is organized as follows: Section 2 provides a review of related literature, Section 3 details our demand model, Section 4

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http://dx.doi.org/10.1016/j.jup.2014.12.004
0957-1787/

discusses the results of the estimation model and Section 5 presents the results of our pricing simulations. Section 6 concludes and considers the policy implications of our findings.

2. Literature review

The economics literature on water pricing has, for the most part, focused upon examining the potential efficiency gains to be made from pricing water more efficiently. For example, studies have estimated the efficiency gains from water pricing reform to range between 0.4% and 4% (Renzetti, 1992; Garcia et al., 2004). Comparison of various pricing models has shown that social welfare is maximized under a constant marginal cost pricing approach also known as a first best alternative (Ruijs, 2009; Ruijs et al., 2008; Hajispyrou et al., 2002).

However, the focus upon gains in aggregate social welfare or efficiency is considered inadequate by some because it ignores information on the extent of individual losses and how these are distributed across socio-economic groups. It is possible for pricing reform to increase aggregate social welfare while simultaneously reducing the well-being of some individuals who are, typically, in lower-income socio-economic groups. In order to understand how pricing reform may affect different members of a community, Agthe and Billing (1987) considered the sensitivity of different income groups to water price reform in Arizona. They found that lower income groups were more sensitive to price changes than higher income ones. Thus, price increases resulted in a larger reduction in consumption by the poor. This means that the conservation burden fell disproportionately more heavily upon the poor. Using California data, Renwick and Archibald (1998) obtained similar results. Hajispyrou et al. (2002) examined the move from an increasing block rate structure to a uniform marginal cost pricing system in Cyprus. This raised overall social welfare at the same time as it reduced the welfare of low-income households. In essence these households lost a previously enjoyed subsidy. Ruijs (2009) obtained similar results.

In order to obtain estimates of price and income elasticity values needed to examine the impacts of price changes, the researcher needs to make a decision about the functional form to be used. The double-log model, based upon logarithmic preferences, has been commonly employed in the literature because of its tractability and ease of determining estimates for the income and price elasticities of demand (Espey et al., 1997; Dalhuisen et al., 2003; Nauges and Thomas, 2003; Garcia and Reynaud, 2004; Olmstead et al., 2007; Schleich and Hillenbrand, 2009; Sebri, 2014). If a researcher's interest is only in obtaining a point estimate of the price elasticity, then meta-analysis suggests that this is not sensitive to the choice of functional form (Espey et al., 1997). However, if one wants to use the model results for forecasting purposes, then, as Gaudin et al. (2001) noted, the double-log specification is lacking in an important way since it provides a constant price elasticity of water demand. This imposes the restriction that the entire amount of water demanded by a household is responsive to any price change, however small, and regardless of the volume of water being consumed for some households consuming at low or threshold levels of water consumption, this may not be a valid assumption.

Al-Qunaibet and Johnston (1985), using data from Kuwait, highlighted the use of an alternative specification to the double-log model. This is the Stone-Geary specification. In contrast to the double-log model, the Stone-Geary allows for a non-constant price elasticity of demand; that is, one that is sensitive to the price of water. A second feature that is suitable for the purpose of this paper is that the function allows us to model the level of consumption that is unresponsive to price changes. This can be thought of as the subsistence level (for uses such as bathing, drinking and cooking) that is compatible with both theory and real-world experience (Al-Qunaibet and Johnston (1985); Gaudin et al., 2001; Martinez-Espineira and Nauges, 2004; Schleich, 2009; Dharmaratna, 2012).

3. Empirical model

In this section we describe the empirical models used to investigate the structure of residential water demands. Our approach is similar to that adopted by Gaudin et al. (2001) and Schleich (2009) in that we estimate two alternative water demand functions: a double-log and a Stone-Geary.[1]

In each case the dependent variable is the average annual amount of water (Q_W) consumed in cubic metres by the households in a geographically defined area called a Census Tract (CT). This has approximately 2500 to 8000 people living in it and is defined by Statistics Canada (2012). The units of observation are per CT per year and there are 627 observations in total over a period of 11 years. Our choice of independent variables employed to explain water consumption levels for both the double-log and Stone-Geary models is informed by economic theory, previous studies, and characteristics of our data (Espey et al., 1997; Dalhuisen et al., 2003; Ruijs et al., 2008; Ruijs, 2009; Mazzanti and Montini, 2006; Schleich and Hillenbrand, 2009; Sebri, 2014). Economic theory suggests the inclusion of both the price of water (PRICE) and income (INCOME) as determinants of water consumption. PRICE is defined as the unit cost per cubic metre. In our sample, the price varies across municipalities and across time but it is not a function of the quantity consumed. Previous studies guide other choices. For example, Espey et al. (1997), Dalhuisen et al. (2003) and Sebri (2014) are particularly useful since their meta-analyses identify which variables are consistently important in published work in the literature. Thus, we include the following set of weather and policy variables: precipitation (PRECIP), degree days (DD), and BAN (a dummy variable to indicate whether water use restrictions are in place). In addition, we include a number of variables to reflect differences within the census tract area. These include a number of property-related factors including the average number of persons in a household (PERHH), the value of the property (VALUE), percentage of houses built between 1982 and 2000 (S81TO00), and the percentage of houses built after 2000 (POST2000). The socio-demographics are described by: the percentage of the population with post-secondary education (EDUSHARE), percentage of the population under 19 (UNDER19), and the percentage of population over 65 (OVER65).

The data utilized for this study cover the period 2000–2010 and were compiled from a number of sources. Water consumption data was obtained from the Capital Region District (CRD) in the province of British Columbia. The CRD regional municipality is comprised of 13 individual municipalities on the southern part of Vancouver Island. It has a population of approximately 359,802 (Capital Region District, 2013). The CRD serves as the bulk water supplier for the municipalities and as a retail provider for two communities, Westshore Communities and Sooke (Capital Region District, 2013). The municipalities serve as retail providers and handle the billing in their respective areas, thus pricing and non-pricing conservation policies are different across the various municipalities. The Capital Region District water agency data provided account-level water

[1] The residential water demand equation could have been estimated using other functional forms. The linear model, for example, has been employed in past research. However, surveys of the recent empirical water demand literature do not provide support for the key feature of the linear demand model, namely that the absolute value of the price elasticity of demand rises as consumption falls (Worthington and Hoffman, 2008).