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How much should customers be compensated for interruptions in the drinking water supply?

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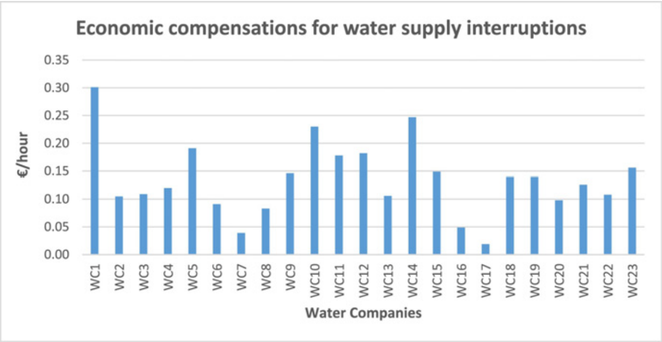
HIGHLIGHTS

- Shadow price approach is used to estimate compensations for water supply interruptions.
- The compensation for an hour of interruption is 10.8% of the fixed charge of the water tariff.
- Compensations for water interruptions should be different for each water company.

GRAPHICAL ABSTRACT



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ABSTRACT

Water supply interruptions directly affect customers, and customers should be compensated accordingly. However, few water regulators have applied compensation policies given the difficulty of estimating the economic value of compensation to customers. In this study, a pioneering approach based on the concept of shadow prices is proposed to determine the compensation that customers should receive for unplanned water interruptions. The Chilean water industry was selected as a case study because there is an ongoing policy discussion between the use of penalties or compensation as an incentive to prevent water supply interruptions. The estimated results indicate that for 2014, the value of compensation ranges between 2.4% and 35.4% of the fixed charge of the water tariff. The methodology and findings of this study are of great relevance to water regulators in defining incentives to prompt water companies to provide reliable water service.

1. Introduction

In the framework of the Sustainable Development Goals defined by the United Nations, not only must access to drinking water be guaranteed but customers' rights must also be protected. These rights typically

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include receiving reliable water service and not paying for services not received. Given that water companies provide water services in monopoly regimes, quality of service issues acquire special relevance. When customers are dissatisfied with a utility service, they cannot switch to another provider (Costello, 2012). However, water regulators should develop policies to guarantee specific levels of quality of service for customers (Pinto et al., 2016). In other words, water regulators should motivate utilities to provide highly reliable services.

As reviewed by Haider et al. (2014) and Nogueira Vilanova et al. (2014), water agencies and regulators have defined several indicators to evaluate the quality of service provided by water companies. In this context, the health and social benefits of having a continuous supply of drinking water, i.e., an uninterrupted supply of water, are widely recognized (Brocklehurst and Slaymaker, 2015). Hence, indicators about this issue, such as water supply interruptions per 1000 customers, the number of unplanned interruptions (UI) and the number of interruptions per connection, are essential for evaluating the quality of service of water companies (Blokker, 2007). They provide information about the time that customers are without water supply service, the conservation status of the network and the percentage of leakage. The issue of the continuity of the water supply has not been resolved but is becoming increasingly important due to two main factors. The first is the increasing water scarcity associated with climate change and demographic scenarios (Latinopoulos, 2014). Secondly, in many European and American cities, the ageing water infrastructure is nearing the end of its useful life, which translates into a large number of pipe breaks (Agbar, 2011; ASCE, 2013).

The challenge for water regulators is to ensure that water companies meet standards for the continuity of water supply. Thus, in many countries such as Brazil, Chile, Uruguay, among others, existing regulatory policies involve imposing economic sanctions on water companies in the case of water supply interruptions (Marques, 2010). An alternative approach is paying compensation to customers, i.e., water companies must economically compensate customers when the water supply service is interrupted, usually due to UIs. Compensation has many positive features. It (i) prevents interruptions and minimizes service restoration, (ii) can provide guaranteed service to customers based on some standards and, (iii) economically incentives water companies to provide a reliable service (Costello, 2012). In spite of these advantages, water regulators have scarcely used the policy of compensation to customers for service interruptions. This is more extensively used in the electricity sector (Kang et al., 2009). A notable limitation for more widespread use is to estimate the value of the economic compensation that customers should receive by water supply interruptions.

Some previous studies have estimated the willingness to pay (WTP) to reduce or fully address the problem of water supply interruptions. Using a choice experiment approach, MacDonald et al. (2005) estimated the WTP for decreasing the duration of water service interruptions in Adelaide (Australia), whereas Latinopoulos (2014) conducted a similar study in New Propontida (Greece). In spite of the usefulness of these previous studies, the WTP approach presents three main limitations. Firstly, it implicitly assumes that the regulator established a certain level of quality, and if customers want higher levels of quality, it is the customers' responsibility to pay for this higher quality. However, customers expect a certain standard of quality, usually defined by the water regulator, and if it is not met, consumers ought to be compensated (MacDonald et al., 2010). Secondly, the WTP of each household or customer is estimated for a specific time period, such as a year or month, but it does not take into account the duration of the water supply interruption. Thirdly, the WTP approach does not allow us to differentiate between planned interruptions and UIs. The former are to accommodate maintenance and new developments whereas the latter are due to unforeseen circumstances causing further damage to customers.

To overcome these limitations, the main objective of this paper is to provide a scientific approach to estimate the economic value of the compensation that customers should receive by UIs in the drinking water supply. In doing so, based on the concept of the directional distance function, the shadow price of UIs was computed. Moreover, this approach makes it possible to compute the value of compensation from the perspectives of water companies and customers. An empirical application was developed focusing on the Chilean water industry. Chile is an interesting case study since, currently, the water regulator has the faculty of imposing sanctions to water companies in case of UIs in water supply. However, in 2013, the Chilean Bill about Compensations to Customers for Water Supply Interruptions was approved, which should be voted by the Senate to be a law. Hence, although currently customers are not compensated by water supply interruptions, the Chilean society has recognized the importance of compensating customers in the case of problems with the continuity of the water supply. Water authorities and policy makers in other countries can learn some lessons from the Chilean case.

Several earlier papers have been devoted to explore theoretical and application aspects of computing shadow prices of undesirable outputs (Zhou et al., 2014). Thus, earlier studies mainly focused on air pollutants such as SO_2 and NO_x since long time the market has been an instrument used for its control. Later, with the growing stringent environmental regulations worldwide alternative pollutants have been considered. Zhou et al. (2014) provided a review of the pollutants whose shadow price has been estimated using efficiency models. As they reported, shadow prices of these pollutants are computed to approximate their marginal abatement cost for policy support.

This paper innovates by proposing a novel approach to determine the economic value of compensation that customers should receive for water supply interruptions. Thus, it is the first time that the concept of shadow price is proposed to determine the compensation that customers should receive for unplanned water interruptions. From a policy perspective, this issue is essential to improving the quality of service of water supply because in the absence of mandatory compensation, water utilities become more indifferent about the reliability of its service (Costello, 2012). Hence this study is of great interest for both water regulators and customers. On the one hand, being able to estimate the economic compensation that customers should receive for failures in water supply continuity is a fundamental first step for regulators in developing policies to prompt water companies to reduce water supply interruptions. Finally, this study also demonstrates that customers have the property rights to a certain level of continuity in the water supply and they ought to be compensated for any reduction in the standards usually defined by the water regulator.

2. Methodology

2.1. The directional distance function

To estimate the compensation that customers should receive for interruptions in the water supply, the shadow price for the number of hours with water supply interruptions due to UIs was calculated. In doing so, this followed the methodological approach introduced by Färe et al. (1993), which assumed that the production of desirable outputs (drinking water in this study) involves the simultaneous generation of undesirable outputs (water supply interruptions). The shadow price approach has been widely implemented to estimate the environmental cost of productive processes (Zhou et al., 2014). Moreover, recently its application has been extended to other fields including the water industry. Thus, Molinos-Senante et al. (2016a) estimated the environmental and resource cost of water leakage in water distribution systems in Chile by computing its shadow price.

From a mathematical point of view, there are two main approaches to computing the shadow prices of undesirable outputs namely: (i) the distance function (Färe et al., 1993) and (ii) the directional distance function (Färe et al., 2006). As reviewed by Zhou et al. (2014), both approaches have been widely applied to compute the shadow prices of a