ISCTE Business School and School of Social Sciences and Humanities

Department of Economics

Behavioural Water Resource Economics

Behavioural applications to the residential water sector

Ricardo Emanuel Sarmento Correia

Thesis specially presented for the fulfillment of the degree of Doctor in Economics

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Jury

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Ao meu Irmão, Miguel Correia,

Ao meu marcante Pai

À eterna Mulher da minha vida

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"Toda a teoria deve ser feita para poder ser posta em prática e toda a prática deve obedecer a uma teoria. Só os espíritos superficiais desligam a teoria da prática, não olhando a que a teoria não é senão uma teoria da prática, e a prática não é senão a prática de uma teoria. Na vida superior a teoria e a prática completam-se. Foram feitas uma para a outra."

Fernando Pessoa

"Não se vai de uma teoria para uma prática, começa-se sempre por uma prática e depois organiza-se uma teoria. Uma teoria que mais ou menos explica essa prática. Também ninguém começou por elaborar uma teologia para justificar um Deus, começou-se por afirmar a existência de Deus e depois elaborou-se a teologia que vai explicá-lo."

José Saramago

"In theory, theory and practice are the same. In practice, they are not."

Albert Einstein

Abstract

Water is a natural resource whose scarcity is very likely to rise in the future (Griffin, 2006), in spite of recent breakthroughs regarding the promotion of economic instruments (European Commission, 2007) and governance principles (OECD, 2015), as well as the declaration of water and sanitation as human rights since 2010 (Albuquerque and Roaf, 2012). Behavioural economics has been on the agenda of European Union policies (Van Bavel et al., 2013), however there is no bridge linking these two fields. This thesis focuses on this unexplored relationship, suggesting behavioural water resource economics.

Firstly, after the general introduction on chapter 1, a literature review is conducted on chapter 2 where four seminal ideas of behavioural economic applications to water management are identified: reference block pricing, asymmetric elasticities, reference transaction, and social comparison using reference consumption.

Chapter 3 contributes to a profile of Portuguese residential water consumers, especially focused on consumer perceptions. Consumers appear to exhibit some misperceptions and low awareness of average price and monthly water consumption, although they exhibit high awareness of their bill.

Chapter 4 continues to explore the effects of consumer perceptions, in this case, on the decision to adopt outdoor and indoor water-saving behaviours, as well as new extensions to modern billing standards, such as direct debit payment and electronic billing. The findings of chapter 3 lead to the study of factors influencing the consumer's probability to have reference points (for the average water price, monthly water consumption and bill). Overall, the behavioural findings suggest that price (un)fairness plays a role on water choices. Moreover, results show a perceived price fairness (PPF) effect that affects the reference point about water price, a novelty in the literature. Additionally, the factors driving the decision to prefer to drink tap water are analysed. Consumer perception about price fairness seem to influence this choice.

These last evidences lead to the development of a conceptual framework to systematically measure PPF, as a global index, on chapter 5. This study proposes a conceptual model and variables to measure the determinants of PPF: price clarity, distributive fairness, consistent behaviour, price reliability, price honesty, respect and regard for the partner and fair dealing.

Chapter 6 presents a new discrete/continuous model for consumer choice with reference-dependent preferences. The main theoretical results are based on three scenarios of reference points. In the case where the first block is a reference point,

consumers in the second block will suffer a loss effect which will decrease their consumption. When the second block is the reference, the first-block consumers will increase their consumptions influenced by a gain effect. In the last case, when the reference is the average price, "bunching" will occur around the point where block shifts happen.

Finally, chapter 7 discusses the main contributions. Overall, these contributions may be helpful to reshape water management and consequently water policies, through the use of behavioural findings. This work advocates a holistic approach of neoclassical and behavioural theories and further avenues to promote sustainable water consumption are proposed.

JEL Classification: D03, D12, D63, Q25.

Keywords: water management, consumer behaviour, tap water, water-saving behaviours, direct debit, electronic billing, perceived consumption, water bill perception, price perception, perceived price fairness, prospect theory, behaviour economics.

Resumo

A água é um recurso natural que se encontra sobre risco de escassez no futuro (Griffin, 2006), apesar dos avanços recentes quer na promoção do uso de instrumentos económicos (European Commission, 2007) e de princípios de *governance* (OECD, 2015), bem como na declaração da água e do saneamento como direitos humanos desde 2010 (Albuquerque and Roaf, 2012). A economia comportamental tem sido tema central na agenda política da União Europeia (Van Bavel et al., 2013), contudo não existe nenhuma ponte que unifique estas áreas. Esta tese centra-se nesta relação inexplorada sugerindo a economia comportamental aplicada aos recursos hídricos.

Em primeiro lugar, após a introdução geral do capítulo 1, é realizada uma revisão da literatura no capítulo 2 e são identificadas quatro ideias seminais de aplicações económicas comportamentais na gestão dos recursos hídricos: bloco tarifário de referência, elasticidades assimétricas, transação de referência, e comparação social usando um consumo de referência.

O capítulo 3 contribui para definir um perfil dos consumidores domésticos portugueses de água, especialmente sobre as suas perceções. No geral, conclui-se que os consumidores apresentam algumas perceções que divergem da realidade, tendo reduzido nível de conhecimento sobre o preço médio e o consumo mensal de água percebidos. No entanto, apresentam um elevado nível de conhecimento da sua conta de água mensal (CAM).

O capítulo 4 continua a explorar os efeitos da perceção do consumidor, neste caso, na adoção de comportamentos de poupança de água em usos exteriores e interiores, bem como novas extensões aos hábitos modernos de pagamento, tais como a utilização de débito direto e de fatura eletrónica. Adicionalmente, os fatores que determinam a decisão de beber preferencialmente água da torneira são analisados, sendo que a perceção sobre o preço ser justo parece influenciar moderadamente a escolha de beber água da torneira. As evidências do capítulo 3 fomentaram a análise dos fatores que influenciam a probabilidade do consumidor ter ou não pontos de referência (*i.e.*, preço médio de água, consumo de água mensal e CAM percebidos). As evidências comportamentais sugerem que a (in)justiça de preço percebida afeta os comportamentos analisados, bem como a existência de um efeito de justiça de preço percecionada (JPP) que afeta o ponto de referência relativo ao preço da água e constitui uma novidade na literatura.

Estas últimas evidências incentivaram o desenvolvimento de um quadro conceptual para medir sistematicamente a JPP, sob a forma de um índice global, de acordo com o capítulo 5. Este estudo propõe um modelo conceptual de JPP e variáveis para

medir os seus determinantes, nomeadamente: clareza do preço, justiça distributiva, comportamento consistente, credibilidade do preço, honestidade do preço, respeito e consideração pela contraparte e tratamento justo.

O capítulo 6 apresenta um novo modelo de escolha discreta/contínua com preferências baseadas em referências. Os principais resultados teóricos são baseados em três cenários de pontos de referência. No caso do primeiro bloco como ponto de referência, os consumidores no segundo bloco sofrem um efeito de perda que os fará diminuir os seus consumos. Quando o segundo bloco é a referência, os consumidores do primeiro bloco irão aumentar o seu consumo devido a um efeito de ganho. No último caso, quando a referência é o preço médio baseada nos dois blocos anteriores irá ocorrer uma situação de "concentração" em torno do ponto onde as mudanças de bloco ocorrem.

Finalmente, o capítulo 7 resume as principais contribuições. Esta tese constitui um contributo que poderá ser útil para reformular a gestão dos recursos hídricos, e consequentemente, as políticas públicas de água, através da utilização de evidências comportamentais. Este trabalho advoga uma abordagem holística das teorias neoclássica e comportamental e propõe novas direções de investigação para promover o consumo sustentável da água.

Classificação JEL: D03, D12, D63, Q25.

Palavras-chave: gestão de recursos hídricos, comportamento do consumidor, água da torneira, comportamentos de poupança de água, débito direto, fatura eletrónica, consumo de água percebido, perceção da conta de água mensal, perceção de preço, justiça de preço percecionada, *prospect theory*, economia comportamental.

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and discussions with participants of Young Water Professional Forum (Lisboa).

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Finally a word about the unfortunately unexplored path of this research, namely the design of a field experiment in the Portuguese water sector, with collaboration of some water utilities. First, thanks to Michael Price for his preliminary, but priceless insights on this issue. Secondly, to all water utilities that showed enthusiasm towards this project, although some factors turned out to be outside our control. I still believe one day will be the day. Any omissions and remaining errors, inevitably, present in this work are the responsibility of the author.

I am very grateful to all.

Abbreviations and Acronyms

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AD	**A**ggregate Data
AIC	**A**kaike Information Criterion
AIE	**A**symmetric Income Elasticity
AIF	**A**verage Index Function
APE	**A**symmetric Price Elasticity
ASF	**A**verage Structural Function
BIC	**B**ayesian Information Criterion
EAD	**E**xperimental Aggregate Data
EHD	**E**xperimental Household Data
ERSAR	**W**ater and Waste Services Regulation Authority
FCT	**F**undação para a Ciência e a Tecnologia
GMM	**G**eneralized Method of Moments
HD	**H**ousehold Data
HES	**H**ouseholds and the Environment Survey
IBR	**I**ncreasing Block Rate
INE	**N**ational Statistical Institute of Portugal
IPMA	**P**ortuguese Sea and Atmosphere Institute
IV	**I**nstrumental Variables
JEL	**J**ournal of Economic Literature
JOPA	**N**úcleo de Jovens Profissionais de Águas
LPM	**L**inear Probability Models
NGO	**N**on-Governmental Organisations
OECD	**O**rganisation for Economic Co-operation and Development
PPF	**P**erceived Price Fairness
PTA	**P**ortuguese Tax Authorities
RWD	**R**esidential Water Demand
SL	**S**ignificance Level
VAT	**V**alue Added Tax
VIF	**V**ariance Inflation Factors
WFD	**W**ater Framework Directive
WS	**W**ater Supply
WU	**W**ater Utility
WW	**W**aste Water

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1. GENERAL INTRODUCTION

1.1 Behavioural water resources economics - a new subfield of behavioural economics

Since the first decade of the twentieth-first century, at least, behavioural economics has been in the European Commission agenda, with the promotion of conferences[1] and studies. The European Commission has been especially focused on enhancing public policy design (Van Bavel et al., 2013) and the libertarian-paternalism approach of nudges (Umpfenbach, 2014) to positively influence consumers towards better decisions. Overall, the European Commission recognizes and recommends the development of behavioural applications, highlighting potential benefits for consumers. Despite these great efforts at the policy level, in academia the situation is different.

At the European level, the European Commission revealed consistent efforts to incorporate behavioural economics in policy making. The aim seems to be to better serve citizens, with particular focus on consumer decision-making. Behavioural economics has attracted policy-makers' attention due to its focus on how people make decisions in reality, using an interdisciplinary approach with insights from social sciences, like psychology and economics. Ciriolo (2011) attributes the seminal behavioural study by the European Commission to the report about consumer choices in the retail investment services (Chater et al., 2010), which used experimental and behavioural economics. One of the major findings of this study was that consumers seem to have difficulties to make optimal investment decisions.

In September of 2015, an executive order from president Barack Obama (2015)[2] stated the importance of the field of behavioural economics and behavioural science insights (*i.e.* empirical research findings from that field) for a better design of public policies. This policy directive is a breakthrough towards the development of

1. So far three conferences were organized by the European Commission (European Commission, 2015) The first, in 2008, approached how behavioural science insights can improve public policies with impact on consumers. The 2010's conference tackled why these insights are relevant to policy-makers. The last conference in 2013 was about application of behavioural economics to policy design. The information on European Commission's website was accessed on 9th October 2015.

2. Executive Order - Using Behavioural Science Insights to Better Serve the American People (www.whitehouse.gov/the-press-office/2015/09/15/executive-order-using-behavioral-science-insights-better-serve-american), information was accessed on 9th October 2015.

behavioural science insights applied to policy, where higher relevance is given to how information is presented and frames the consumers and other economic agents.

Surprisingly, Barberis (2013, p.173) states that it is *"curious, then, that so many years after the publication of the 1979 paper, there are relatively few well-known and broad applications of prospect theory in economics. One might be tempted to conclude that, even if prospect theory is an excellent description of behavio[u]r in experimental settings, it is less relevant outside the laboratory. In my view, this lesson would be incorrect."* One of the reasons for this fact is that prospect theory (Kahneman and Tversky, 1979) that explains how people derive utility from "gains" and losses is not a "ready-made" framework. It appears that the formation of reference points and the accurate context-specific determination of what are gains and losses have been a topic with weak guidance in the work of Kahneman and Tversky (1979), as stated by Barberis (2013). Another reason pointed out is that although clarification about gains and losses has been attempted with success by (Kőszegi and Rabin, 2006), so far is unclear how to conciliate references and consumption levels and why the gain-loss framework matters, as we will discuss further on chapter 6. These challenges seem to explain the poor success of economic applications using prospect theory, although it contains important insights that can be incorporated into mainstream economics.

Prospect theory states that people's willingness to take risks depends on the way a choice is framed as a gain or a loss, thus the choices are context-dependent. The Prospect theory's seminal paper (Kahneman and Tversky, 1979) shows that people make decisions that are not optimal and it's one of Econometrica's most cited papers and a major reference to behavioural economists as an empirical and theoretical framework.

Economists (especially behavioural economists) struggled with two major issues: i) prospect theory is not a "ready-made" theory for applications in economics and ii) behavioural sciences insights needed to be incorporated into mainstream economics. This was the starting point of this thesis. Due to the broad potential applications of prospect theory we narrow our main goals to the study of potential applications of reference points and what factors affect the formation of these points in the residential water sector. This reference point framework is based on the idea that economic agents have reference terms used in their decision-making processes. In the work of Kahneman and Tversky (1979), reference points are used in prospect theory to divide the space of outcomes of the value function into gains and losses. In practice, these (neutral) points act as consumer anchors to make decisions, or they may be associated with an expected level the consumer wishes to achieve. Nevertheless, as we will discuss later on, reference terms can have other applications, from price

perceived price fairness that evolved from the standards of justice on price based on the reference-transaction framework (Kahneman et al., 1986b) to social comparison (Festinger, 1954).

The importance of reference points has been implicitly accounted for in early stages of development of behavioural science insights in the European Union policy design. For instance in consumer protection legislation, as early as 1997 there is a consumer right to cancel a contract during the cooling-off period, another example is the protection against framing effects on health and nutritional claims (*e.g.* low fat product) in 2006 (Ciriolo, 2011). The latter protects the consumers *"(...) since in the past consumers were often misled by changes in the reference point (a cheese containing 20% was often labelled as 80% fat-free)"* as stated by Ciriolo (2011, p.2).

One of the underrated paths is the development of behavioural economics in water management, which is the main research topic of this thesis. We approach this issue acknowledging that behavioural insights can be useful to mainstream economics, but as an non-rival approach, in some cases. Instead of a dichotomy, we argue that reasonable research should account for the advantages of both fields. The researchers of conventional economics, but also from behavioural economics, are subject to the natural tendency to look and overvalue confirming evidence, also known as confirmation bias (Thaler, 1987), which could jeopardize the findings of these studies. In this thesis, we argue for a hybrid approach, since both behavioural and neoclassical economics can bring insights that would benefit water resource economics, and especially the residential water sector.

Overall, the Portuguese residential water sector can be characterized by acceptable affordability conditions of the water utility services (Martins et al., 2013), whose charges representing 0.84% of the average household disposable income in 2013 (ERSAR, 2014c). This is a value within the range of affordability levels in the OECD (Organization for Economic Co-operation and Development) countries (OECD, 2010). The average bill for mainland Portugal was 21.9 € per 10 cubic meters in 2013. The average water prices for a thousand litres (or one cubic meter) of water supply (WS) and wastewater (WW) collected were 1.2 € and 0.7 €, respectively (ERSAR, 2014c). The cost recovery ratios in mainland Portugal in WS and WW changed, respectively, from 0.87 and 0.57 (INAG, 2005) to 0.87 and 0.67 between 2005 and 2013 (ERSAR, 2014c).

News that exhibit information about consumers often focus on typical "bad news", such as price increases for water utility services (Jornal de Notícias, 2015; Castanho, 2014; Tomás, 2014; Henriques and Filipe, 2011). The media has also reported social protests against water price rises (Henriques and Filipe, 2011; Mirante,

2011). Moreover, in the past Portuguese residential water consumers exhibited a low willingness to pay more to ensure a higher quality of water utility services, according to a national survey performed in 2007 based on around 1,000 face-to-face interviews (Pires, 2007). The results show that 70% of the sample was unwilling to pay more. The major reasons presented to explain this were that consumers already considered their charges to be too high, had concerns about paying more for nothing to change, and assumed that the WS and WW services were already too expensive. Notice that this survey was performed before the economic-financial crisis, so additional concerns could be raised today about about consumer acceptability of pricing strategies, such as water tariff increases.

Given the previous facts about residential water consumption, it is reasonable to look at non-pricing strategies or hybrid approaches. The recommendations of ERSAR (ERSAR, 2012a), the Water and Waste Services Regulation Authority, and recent legislation for the Portuguese water sector (Assembleia da República, 2014) reflect concerns about the need for more transparency and better data quality to enhance consumer perceptions. The Decree Law 114/2014 (Assembleia da República, 2014) provides the necessary procedures to implement a better billing system with clearer and more detailed information on average costs and revenue transfers from amounts paid by water consumers. This may potentially contribute to enhance consumer perceptions, but still there is a long path ahead.

Nowadays, water stress in river basins is an issue for 40% of the population in the world (OECD, 2015), urging the development of water governance principles to cope with challenges in the sector. Water pricing is linked with two foremost challenges: i) the increasing competition for water use and ii) ensuring sustainable access to WS and WW services (OECD, 2010). Economic market analysis (*e.g.* pricing, demand estimation, costs) has been on the main agenda of environmental economists studying water consumption. Promotion of economic instruments became a European Commission priority, but there is a lack of an integrated approach with behavioural science insights. The literature review on residential water demand in chapter 2 shows that there is scant evidence of the incorporation of psychological findings. In this vein, we identify behavioural economic applications that can have policy implications for water management and can be further extended to energy, gas or waste management. The empirical findings of this thesis are mainly obtained through the collection of data by a household-level survey using a telephone questionnaire during the summer of 2012.

The main research questions, motivations and behavioural theoretical frameworks used in each chapter are summarized in table 1.1.

Tab. 1.1: Synopsis of the studies developed in the thesis

Chapters	Study name	Main research questions	Main motivations	Research frameworks
Chapter 2	Behavioural Economics in Water Management - An Overview of Behavioural Economics Applications to Residential Water Demand	- What is the state-of-art of behavioural economics in the field of water resource economics? - Which behavioural applications can be suggested based on the literature?	- European Commission stresses the relevance of economic instruments in the water sector - The 3Ts (taxes, transfers and tariffs) approach was questioned with the financial crisis - Unsustainability in water sector	- Prospect theory - Asymmetric price elasticity - Reference transaction - Social comparison (and reference consumption)
Chapter 3	Do you know how much you pay for water?	- What is the profile of residential water consumers in terms of perceptions?	- Studies show low awareness of water price and consumption - Scant evidence of the overestimation or underestimation of key elements of the water bill, such price, number of blocks or consumption	- Water consumer habits and residential water demand literature - Behavioural pricing literature
Chapter 4	Water consumer behaviours and perceptions	- What factors influence the water consumer's probability to have reference points (*i.e.* average water price, monthly water consumption and bill)? - Is perceived price fairness a factor affecting the formation of reference points? - Do perception factors affect the household's probability to adopt outdoor and indoor water conservation choices, modern billing standards and the choice to drink tap water?	- The determinants about the formation of reference points were never studied - Water-saving literature often neglects water bill information, consumer perceptions and fairness concerns - Direct debit payment of the water bill and the electronic billing, as well as perceived price fairness are underresearched subjects	- Consumer perceptions and reference points literature - Behavioural pricing literature - Indoor and outdoor water conservation literature - Averting behaviour to drink tap water and water quality literatures
Chapter 5	Perceived Price Fairness (PPF) - Determinants in residential water sector in Portugal	- What are the potential determinants of PPF, for Portuguese households?	Absence of a clear conceptual framework for price fairness applied to water sector that incorporates price awareness	- Reference transaction literature - Price fairness and behavioural pricing studies
Chapter 6	Nonlinear pricing with reference dependence	- Can block price structures create specific reference effects?	- Consumers often have to deal with nonlinear prices from water and energy services to cellphone and internet bills - Nonlinear pricing has mostly been analysed in the traditional utility-maximization framework	- Residential water demand literature - Prospect theory and reference-dependence models

Source: author's analysis.

Chapter 2 provides an overview of behavioural economics applications to the residential water sector, suggesting a new subfield of research, Behavioural Economics in Water Management. We try to address two issues: to describe the state-of-art of behavioural economics and applications of social sciences in the field of water resource economics and identify potential behavioural economic applications[3].

One main motivation for this study was that within a context of unsustainability for water resources management the European Commission promoted the development of economic instruments in the water sector (European Commission, 2007), as a first stage in the implementation process of the Water Framework Directive (European Parliament and Council, 2000). The promotion of economic instruments is an essential part of efficient water management everywhere. Afterwards, the mainstream approach to the water sector was questioned with the economic-financial crisis since 2008, which could potentially lead to a paradigm shift.

We discuss the potential of economic instruments in a new light, looking into four behavioural economic applications that can have implications for water management. Namely, we suggest: reference block pricing, asymmetric elasticities of residential water demand, reference transaction implications for cost recovery and tariff acceptability and fairness, and social comparison based on reference water consumption. Some potential questions that emerge from this review for our study addressing these behavioural applications are: Can block price structures create specific reference effects? Are consumer reactions to price increases quantitatively different from those to decreases? Do consumer perceptions of price fairness hinder cost recovery efforts? How do social norms on consumption affect water use?

In order to improve the understanding of consumer perceptions a household survey was performed in the summer of 2012[4]. In chapter 3, we review a group of studies which highlight the low awareness about water price (Frondel and Messner, 2008; Carter and Milon, 2005) and water consumption (Martins and Moura e Sá, 2011; Tralhão, 2011) in the residential water sector. We identify the profile of residential water consumers in terms of perceptions, especially whether they know how much they pay for water and what are their average price and monthly water consumption.

Chapter 4 is an empirical study that approaches the formation of reference points, water consumer behaviours and perceptions, given particular relevance to concerns about perceived price fairness. The perceived price fairness appears to be understudied in this context, especially regarding the formation of reference points. The reference points considered were the perceived values of residential water

3. The work developed for the thesis was published in 2014 (Correia and Roseta-Palma, 2014)

4. Survey developed under the project PTDC/EGE-ECO/114477/2009, with financial support from *FCT - Fundação para a Ciência e a Tecnologia* (Science and Technology Foundation). Additional information can be provided upon request.

consumers about their average water price, monthly water consumption and bill. In this context the accounting for endogeneity could be important, especially with discrete variables, for which special regressor methods (Dong and Lewbel, 2015; Lewbel, 2014, 2000) emerge as a potential general approach. Another rational motivating this chapter was the scant incorporation of information about the water bill and consumer perceptions in the literature on water-saving behaviours and the preference to drink tap water. Additionally, the relevance of modern billing standards such as the use of direct debit to pay the water bill and electronic billing are undervalued. The main research questions posed are focused on understanding how perception and fairness factors affect the probability of forming reference points, of adopting outdoor and indoor water conservation choices, modern billing standards, and the decision of drinking tap water.

Chapter 5 proposes a conceptual model of perceived price fairness (PPF) and identifies some factors that may explain PPF in the residential water sector in Portugal. In this sense, the main research goal of this chapter is to achieve a set of measures needed to identify each one of the determinants. At the European level, recent studies of consumer perceptions indicate that the majority of Europeans agree with the user-pays and polluter-pays principles (European Commission, 2012), and highlights that hunger, poverty and shortage of drinking water are the most serious issues worldwide (European Commission, 2014). Additionally, there is some reluctance to accept the increase of water price, which is perceived as unfair, although oddly there are relatively good affordability conditions with respect to water tariffs. Thus PPF may be a relevant factor in the analysis of water consumption decisions, despite the absence of this issue from water demand literature, as far as we know. This chapter could have different implications from reference transaction literature (Kahneman et al., 1986b) to price fairness (Diller, 2008) and behavioural pricing studies (Krishna, 2009).

Chapter 6 was based on the previous empirical evidence of chapters 3 and 4 about residential water consumers and aims to develop a theoretical framework to study nonlinear pricing with loss aversion, in the case of increasing block rates (IBR), *i.e.* when price increases as the consumption level increases beyond specific levels of consumption.

Nonlinear pricing has been the subject of growing interest in several industries (Lambrecht et al., 2007). The use of nonlinear pricing schedules is common from communication and subscription services to many utilities, including water, electricity and gas, as a way to recover costs while taking into consideration consumer demand profiles. In this literature, the consumer is typically modelled as an individual who maximizes utility with a nonlinear budget constraint. However, in reality the

consumers may be influenced by a reference point. Based on the traditional approach that consumers are price-takers and empirical evidence that consumers have high awareness of their total expenses we analyse two potential references: reference price and reference expense. We take the discrete/continuous model of consumer choice that has been widely used for demand analysis (Hewitt and Hanemann, 1995) under block rates and modify it to include reference-price effects. Moreover, we develop a model to include reference-expense effects. In particular, we show how loss aversion with IBR changes consumption decisions when the consumer treats a higher-than-reference price (or expense) as a loss. Finally, we discuss implications for utility pricing policies and services with nonlinear pricing, as well as potential implications of reference-expense behaviour.

Overall, the development of behavioural economics appears to have been made with baby steps within the economic sciences, in general, and within environmental economics in particular. Only since the beginning of the twenty-first century has this field emerged in research areas, such as forest management (Knetsch, 2005), climate change (Brekke and Johansson-Stenman, 2008) and energy economics (Pollitt and Shaorshadze, 2011). Knetsch (2005) argues that economic analyses of natural resources can be significantly enhanced through behavioural science insights. The lack of behavioural economic applications in water management was one of the main drivers that lead to the development of this thesis, a modest contribution to the new subfield of behavioural water resource economics.

2. BEHAVIOURAL ECONOMICS IN WATER MANAGEMENT

2.1 Introduction

Water consumption is an essential component of human activities, yet it has only recently been acknowledged as an economic good that can be provided through markets, albeit imperfect or incomplete ones. Traditionally, water management was mostly held to mean supply management, such as the provision of reservoirs, distribution networks and other infrastructure, whereas demand management is now understood to be crucial. Moreover, the quantity and quality of water decisively affect all ecosystems on Earth, which means that the costs and benefits of water use are rarely captured fully in market mechanisms. Economists have therefore focused both on market analysis (pricing, demand estimation, costs) and on the study of external effects such as the negative impacts of human-induced scarcity and the losses brought about by water pollution. In the European Union, the Water Framework Directive (European Parliament and Council, 2000) Article 9 requires that water prices provide an appropriate incentive for the efficient use of the resource as well as recover costs, including environmental and scarcity costs. Nonetheless, recent evaluations (European Commission, 2007) show that economic instruments still play a very limited role in water management, while significant problems persist in ecological water status. The European Commission has thus identified the promotion of economic instruments as a priority action.

On the other hand, economists have also come to accept that traditional utility-maximization models often do not appropriately describe actual decisions of economic agents. Through the influence of many significant experiments and insights provided by psychologists, an interesting cross-fertilization process took place between the two fields, giving rise to what is now known as behavioural economics. To ascertain the potential of economic instruments in a new light, in this chapter we use the behavioural economics framework to identify possible implications for water management, using references from psychology and marketing that we believe have been overlooked. We suggest four behavioural economic applications (hereafter behavioural applications), namely: reference block pricing; asymmetric elasticities; reference transaction; and social comparison through reference consumption.

There are some surveys with extremely well-organized information which

discuss water demand models, both generally, at a global level (Worthington and Hoffman, 2008) and at a European level (Schleich and Hillenbrand, 2009), and focus on price specifications and price elasticities (Arbués et al., 2003). Nevertheless, they all implicitly exhibit a common feature: the absence of behavioural economics in the residential water demand literature. In this work we corroborate this finding through a brief review of similar studies over the last decade, which differs from the previous surveys in that our analysis focuses on the behavioural perspective. We refer to the existing (slender) literature about behavioural economics in water management and sketch our proposals for the four behavioural applications mentioned already. Furthermore, we stress the importance of experimental data versus nonexperimental data, besides the usual division between aggregate data and household data.

First we discuss reference block pricing, which relates primarily to the issue of choosing the most appropriate price structure. There is a significant amount of literature on block-tariff structures in regulated water utilities, yet none of it explains the popularity of increasing block tariffs, since the nature of the water supply infrastructure recommends constant or decreasing tariff structures (Elnaboulsi, 2009, 2001). In Portugal, for example, most utilities charge prices with a fixed and a variable component, and the latter is usually an increasing block rate (IBR) of three or more blocks, especially for residential use, where the IBR structure is seen by water managers as a way to signal scarcity and promote resource conservation.

Recent work on residential water demand (Monteiro and Roseta-Palma, 2011) has shown that if water demand and costs respond to weather conditions, increasing marginal prices could indeed be explained by water scarcity and customer heterogeneity in a setting where utilities maintain a balanced budget. However, the implications for tariff design of asymmetric value functions with loss aversion (Kahneman and Tversky, 1979) have never been considered, and we believe such a framework can shed new light on the issue. In particular, if water consumers react to a reference price, which may be that of the initial block or their actual block, the following block price can be interpreted as a loss or a discount, depending on whether the block tariff structure is increasing or decreasing, respectively.

A closely related topic is that of behavioural responses to price changes. We will investigate the implications of prospect theory (Kahneman and Tversky, 1979) on the optimal pricing policy and on the frequency of price updates, given that consumers seem to value losses more highly than gains, which should generate asymmetric price elasticities (*i.e.* higher price elasticities with price increases than with price reductions). This asymmetry was first corroborated by the pioneering study of Putler (1992). More recently this topic has been studied in the energy literature Adeyemi and Hunt (2007), but it is yet untested for water demand. The third topic deals with

the implications of the reference-transaction framework (Kahneman et al., 1986b) for water management. The concept of reference transaction is based on the dual entitlement principle, under which firms are entitled to a (positive) reference profit and individuals are entitled to reference terms (*i.e.* price, salary, rent). This concept was recently applied in a comparison of allocation rules for scarce resources (Raux et al., 2009) as well as in the marketing literature, which has analysed the issue of perceived price fairness (for recent reviews see Diller (2008) and Krishna (2009). In the case of water, since a reference transaction could imply fairness constraints, the utilities could be inhibited from proposing reference terms (*i.e.* prices) that would be perceived as unfair. This may indeed be the case in Portugal, where 71 per cent of water utilities are held by municipalities or associations of municipalities (INAG, 2011). Recent social protests against the rise of water bills highlight consumers' concerns and could lead to the maintenance of artificially low cost recovery levels by the municipalities due to fairness constraints. To illustrate, note that the revenues of Portuguese water utilities in 2009 covered only 80 per cent of the financial costs of providing the service[5], for water supply, and an even lower 46 per cent for waste water drainage and treatment (INAG, 2011). Given the characteristics of water as an essential good, indeed now a human right, perceived fairness could be one explanation for the insufficient cost-recovery levels attained by water utilities in many countries.

Finally, we will review the few existing papers on the impact of the information included in water bills, such as that on price, social norms, and resource saving campaigns, in particular the inclusion of reference consumption values that are used to frame consumers into social comparison. The water demand literature has emphasized the importance of incorporating information about the water price in water bills and its relevance to the effectiveness of water pricing policies (Frondel and Messner, 2008; Gaudin, 2006). Nevertheless, only recently has social comparison been tested as a water management tool (Ferraro and Price, 2011), and reference consumption information was the more effective tool of all the conservation strategies tested.

The remainder of the chapter can be summarized as follows. Section 2.2 contains a literature review of behavioural economics in water management. Section 2.3 describes the behavioural applications and their potential contribution to water policy and water resource economics. Section 2.4 concludes and examines potential paths for future research in water management shedding light on the behavioural applications suggested.

5. The financial costs of water services include the operation and maintenance costs, capital costs, administrative costs, and other direct costs (European Commission, 2003, p.118).

2.2 Literature Review of Behavioural Economics in Water Management

2.2.1 Behavioural Economics

Behavioural economics arguably started as early as the eighteenth century with Adam Smith's The Theory of Moral Sentiments, but economic theory gradually grew apart from psychology until the second half of the twentieth century with "researchers like George Katona, Harvey Leibenstein, Tibor Scitovsky, and Herbert Simon ... suggesting the importance of psychological measures and bounds on rationality" (Camerer, 2004a, p. 6).

In the mid-1970s Kahneman and Tversky (1974) identified some significant heuristics and biases of human behaviour, especially under uncertainty[6], but their major contributions to economics were published a few years later. In one of Econometrica's most cited papers the authors developed prospect theory as an alternative model to expected utility theory and the rational choice paradigm (Kahneman and Tversky, 1979). This article has had by far the most major influence in changing the conceptual framework of economics and establishing the growing field of behavioural economics[7].

The field of behavioural economics is focused on empirical validation and identification of behavioural departures from the standard model (*i.e.* the neoclassical model) as well as on the interpretation of behavioural deviations using alternative economic frameworks. Furthermore, these deviations can be organized into three areas where human nature strays from standard assumptions: there are limits to the pursuit of self-interest, to cognitive abilities, and to self-control (Mullainathan and Thaler, 2000)[8].

Despite the obvious rivalry between behavioural economic theory and standard rational choice theory, we want the reader to bear in mind that these two competing theories are not a dichotomy, in spite of past (and current) conflicts among practitioners. Future economic theory could (and we dare say should) be based on a hybrid approach, with the co-existence of neoclassical and behavioural approaches (MacFadyen, 2006; Rabin, 2002). For instance, Matthew Rabin states that behavioural findings should be integrated into economics and that his research programme "does not abandon the correct insights of neoclassical economics, but

6. For further information about departures from the standard economic theory see Kahneman et al. (1982).

7. Behavioural economics could be defined as "a commitment to empirical testing of neoclassic assumptions of human behaviour and to modifying economic theory on the basis of what is found in the testing process" (Simon, 2008, p. 221).

8. For a more recent analysis of the types of departures see (Zarri, 2010).

supplements these insights with the insights to be had from realistic new assumptions" (Rabin, 2002, p. 659).

The rivalry mentioned here is one barrier to the development of this field, but there is another one, related to the dissemination of behavioural economic findings. The recent literature has made several efforts to encourage use of behavioural economic models, either through analysis of field phenomena (Camerer, 2004b) or by pointing out potential applications of different behavioural models (Ho et al., 2006). Nonetheless, some subfields of economics have shown little evidence of the incorporation of behavioural economics. Water resource economics is one of these cases, as discussed in section 2.2.2.

2.2.2 State of the Art of Behavioural Economics in Water Resource Economics

Water resource economics deals with the efficient allocation of a scarce resource (water). It aims to develop water management policies and to study the decision-making process of economic agents that use water resources (Griffin, 2006). In surveying this literature we found there is almost no incorporation of concepts from behavioural economics.

The subfield of behavioural water economics should focus on the development of water resource economics through the application of the findings of behavioural economics, as well as insights from other related general fields (*e.g.* psychology, sociology, ecology, marketing) or more specific fields (e.g. behavioural environmental economics, experimental economics, environmental psychology, behavioural finance).

So far, there seem to be very few published papers in this subfield. The first paper to incorporate behavioural assumptions into water resource economics was Winkler and Winett (1982), which approaches resource conservation, namely residential energy and water, integrating the psychological (social-learning) and economic views. The authors discuss the importance of monetary rebates for conservation policies, emphasizing that those rebates[9] (*i.e.* economic approach) could allow changes in conservation behaviour, but also that they could be complemented by information technology that would influence consumer behaviour (*i.e.* psychological approach). Therefore, they argue for a combined approach in conservation policies, without overlooking the psychological framework in the policy-makers' agenda.

Additionally, the authors argue that changes in human behaviour are made through behavioural interventions which should be interpreted in the context of two systems of behaviours: an internal system (linked to the individual) and an external system (linking the individual and the society). Therefore, insofar we are

9. Nevertheless, the application of (monetary) rebates has since been criticized due to the low price elasticity of water demand (Foxall, 1995).

analysing behaviours of households (the typical individual level used in residential water demand literature) we should account for these two systems when designing water policies.

More recently, Jorgensen et al. (2009) contribute to the residential water demand literature with a new socio-economic model to understand household water consumption, emphasizing the importance of trust. Their work stresses the demand side and summarizes the main direct and indirect drivers which determine human behaviour towards water conservation. Their model also emphasizes other behavioural variables besides trust (*e.g.* past water use behaviour, outdoor-area interest and use, and pricing attitude), although the authors advise that there could be other variables to discover.

Finally, another issue within the framework of behavioural economics is the impact of social comparison as a water conservation strategy (Ferraro and Price, 2011). The authors analyse the influence on water consumption of three types of experimental treatments (*i.e.* technical recommendation, pro-social message, and social comparison). These authors conclude that non-pecuniary strategies (*i.e.* psychological strategies) do influence water conservation, with a higher effectiveness of social comparison in the group of high-use households, and a larger effect in the short-term rather than the long-term.

One of the major issues in water resource economics is the potential unsustainability of use (*i.e.* demand exceeding water supply in a consistent manner leading to the degradation of the resource). Strategies to improve water management can be centred on demand management or on supply enhancement (Griffin, 2006). Perhaps due to the prevalence of the latter throughout the twentieth century, the last few years have seen demand-side strategies became the dominant paradigm both in the water and energy sectors (Strengers, 2011; Barberán and Arbués, 2009)[10]. Naturally, demand analysis is also the purpose of the few published papers, described already, which incorporate behavioural insights into residential water consumption.

Further applications of behavioural economics in water management could also be developed for other sectors that contribute significantly to water demand, such as agriculture, industry, and tourism, although these are outside the scope of this chapter. Another possibility would be for supply-side analysis to take into account the biases of system managers within water utilities and understanding the behaviour of these utilities.[11]

10. This one-sided approach can be criticized, for instance Merrett states that "[w]ith outstream water we should always integrate in our thinking and our practice both demand-side and supply-side strategies" (Merrett, 2005, p. 92).

11. Recent literature discusses the importance of understanding the behaviour of firms. See the work of Bandiera et al. (2011) for a review of field experiments with firms.

At this point two questions could arise: (i) why is there so little work on behavioural economics in the water management literature? And (ii) why does behavioural economics matter in this context?

From our perspective, the underdevelopment of this subfield has some potential explanations:

Neoclassical hegemony

- Environmental economics models are underpinned by the hegemony of standard neoclassic economic theory (Shogren and Taylor, 2008; Venkatachalam, 2007), and water resource economics is not an exception, as will be described in section 2.2.3.

Dearth of household data

- Scarcity of social/psychological data about households (Jorgensen et al., 2009) and lack of "readily available data" in environmental data (Smith, 2008, p. 141).

- Difficulty in obtaining reliable (and real) variables (*e.g.* appropriate income per household) and in collecting information from several sources of household data.

Limited systematization and availability of detailed aggregate data

- There are significant limitations in the available aggregate statistics, even those related to fundamental aspects of water supply and waste water services at the country level (OECD, 2010).

Little application of experimental design to residential water demand

- Few water demand studies have used experimental data during the last decade (as discussed in section 2.2.3), possibly because many water utilities have not traditionally focused on demand management and so do not perceive the value of engaging in such activities.

Status quo bias

- Resistance to change of water resource economists to behavioural economic models[12], which is in a broader sense connected to status quo bias in human behaviour. Or as stated by MacFadyen "we are often reluctant to abandon the security of conventional construct systems, but there may be cascade effects as highly regarded practitioners adopt new ideas" (MacFadyen, 2006, p. 195).

12. Note that water resource economists may not be aware of the existence of behavioural economics models and therefore in this case the idea of resistance to change is not applicable.

In response to the second question, there are some arguments in favour of incorporation of psychological insights into water resource economics:

Development of residential water demand models, using a behavioural perspective

- A wider set of models to test would improve knowledge of demand determinants and contribute to water policy design.

Impact of psychological strategies in water policy

- Policy-makers have exhibited little understanding of psychological strategies, diminishing the potential role of demand management and leading to a lack of significant influence of resource management strategies on policy (Winkler and Winett, 1982).

In the expression "economic agents' behaviour", behaviour should stand first

- That "a major part of economics is concerned with the study of behaviour" (Winkler and Winett, 1982, p. 422) seems to be a trivial statement. However, the residential water demand literature is focused on the economic, leaving the behaviour on the sidelines.

If economics is about studying economic agents' behaviour (*e.g.* consumers, firms, and investors), there is indeed redundancy in "behavioural economics" (Simon, 2008; Thaler, 1999). We think data play a major role in this issue. Shogren and Taylor state that data are essential because they are "a necessary condition to fully understand the relevance of any behavio[u]ral bias to economic phenomena" (Shogren and Taylor, 2008, p. 34). Arguably this is one of the major constraints to the development of behavioural environmental economics in general and behavioural water economics in particular.

There have been some recent improvements in aggregate environmental data, such as the creation of the Water Information System for Europe in 2007 (WISE, 2007). However, there are still no globally available micro-level data.

The scarcity of individual household consumption data and of potential conditioning factors which are difficult to measure (*e.g.* past water use patterns, or attitude towards restrictions) is another important issue (Jorgensen et al., 2009). At the household level additional information (*i.e.* economic, financial, and behavioural indicators) is also essential to improve water demand studies. However, the quality of the information used influences the significance and robustness of both statistical and economics results in water demand literature (Arbués et al., 2010). To illustrate the difficulties, it is interesting to consider the experience we have had in the research

project we are currently developing.[13] We contacted many water utilities to ask for their cooperation, both in providing us with consumption data and customer telephone numbers so we could run a household survey. Some utilities could not provide organized information on household consumption levels, others did not have telephone numbers in their customer databases, and yet others did not agree to cooperate with the project because of data privacy concerns. In one case of a rural municipality with a small customer base, the utility was keen to participate and did give us the necessary data, but after we had collected a few surveys some of the customers complained to the utility that they thought we had asked for too much information on household characteristics (house size, garden, appliances, household income, number and age of household members, and so forth) and therefore they wondered whether the research team might possibly be running a scam! Naturally, the utility withdrew its cooperation.

Besides this household data problem, there is another scarcity problem (and we are not talking about water scarcity): the lack of information about water allocations and consumption levels. Some examples of lack of measurement can be found in all sectors (agriculture, households, and industrial water), as well as in water losses, not only the leakage but also the unmeasured waste and consumption of water (Brown, 2002).

After this overview of the state of the art of behavioural economics in water management and discussion of some problems that have negatively influenced the development of this subfield, we provide a brief literature review of residential water demand to highlight past contributions and bring out the absence of behavioural models. Then we discuss four behavioural applications that could contribute to water resource economics.

2.2.3 Literature Review Based on a Behavioural Perspective

There are a few recent literature reviews in the field of residential water demand (Schleich and Hillenbrand, 2009; Worthington and Hoffman, 2008; Arbués et al., 2003). We do not intend to provide another one. Instead, we will analyse the residential water demand literature in light of the potential applications of behavioural perspectives, to be developed in section 2.3.

Nonetheless, before starting that analysis we want to discuss the categorization of the type of data used in residential water demand studies. The literature reviews divide data between aggregate data and household data. In this literature review we will also take into account whether the data is experimental. Thus, the categorization

13. *Pricing and behavioural responses in the water sector* supported by Fundação para a Ciência e a Tecnologia (Portuguese Science and Technology Foundation), PTDC/EGE-ECO/114477/2009.

of the data used by the studies includes: aggregate data (AD); household data (HD); experimental household data (EHD), where the data is collected directly from households through experiments; and experimental aggregate data (EAD) where we have experimental data at the aggregate level related to one or more communities. These categories are summarized in Figure 2.1.

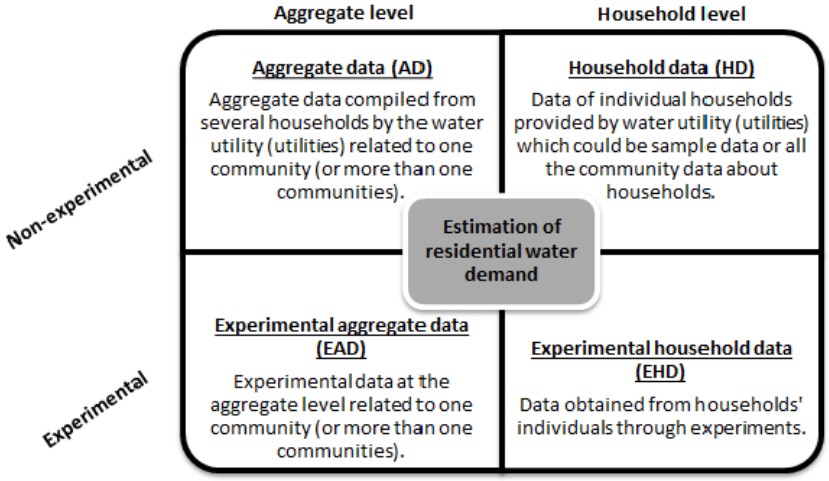

Fig. 2.1: Type of data used in residential water demand studies

Table 2.1 summarizes 25 papers that estimate residential water demand that have been published since 2000. The great majority used panel data and the periodicity of the data is mostly annual or monthly, with some exceptions. Typically the price elasticity of residential water demand in these studies is inelastic and negative, whereas income elasticity is positive but has a small magnitude in general terms, which is in line with the findings of the literature (Worthington and Hoffman, 2008).

The use of aggregate data is more common than household data, as expected. A more interesting finding is that experimental procedures have not been used often in this literature. Also, there are differences in the way data are obtained through experimental design or surveys. Two studies use surveys to obtain aggregate data from water utilities, namely Bell and Griffin (2008), which asked water providers about tariff structures, and Mazzanti and Montini (2006), which obtained information on water consumption, tariff structure, and water users from water utilities. Nonetheless, these studies are not experiments and should not be misinterpreted as EAD studies just because the researchers used surveys to obtain the data. In order to understand what would fit in the EAD category, suppose there is a government funding programme to enforce the use of water-saving technology in some communities of the country's richest regions in income per capita during a given period.

Tab. 2.1: Brief overview of residential water demand studies since 2000 to 2011

Author(s) (year)	Study area	Data set	Periodicity	Type of data	Price elasticity	Income elasticity
(Bell and Griffin, 2011)	USA	Panel	Monthly data [Jan-95; Dec-05]	AD	Residential: -0.15 Commercial: -0.12 Aggregated: -0.27	n.a.
(Martins and Moura e Sá, 2011)	Madeira (Portugal)	Cross-sectional	Data obtained from 1 survey	HD	n.a.	n.a.
(Monteiro and Roseta-Palma, 2011)	Portugal	Panel	Annual data [1998, 2000, 2002, 2005]	AD	[-0.13; -0.05]	[0.03;0.09]
(Arbués et al., 2010)	Zaragoza (Spain)	Panel	Quarterly data (10 meter readings) [1996–1998]	HD	Aggregated: -0.57	Wealth semielasticity(1): 0.29×10^{-3}
(Diakité et al., 2009)	Côte d'Ivoire	Panel	Annual data [1998–2002]	AD	-0.82	0.15
(Schleich and Hillenbrand, 2009)	Germany	Cross-sectional	Annual data [2003]	AD	-0.24	0.36
(Bell and Griffin, 2008)	Texas (USA)	Panel	Monthly data [Jan-99; Dec-03]	AD	-0.13	n.a.
(Frondel and Messner, 2008)	Leipzig (Germany)	Panel	Annual data [1998–2001]	HD	[-0.49; -0.27]	[0.30; 0.31]
(Kenney et al., 2008)(2)	Aurora (USA)	Panel	Monthly data [1997–2005]	HD	Pre-drought: -0.56 Drought: -1.11 Aggregated: -0.60	n.a.
(Ruijs et al., 2008)	São Paulo (Brazil)	Time series	Monthly data [1997–2002]	AD	[-0.50; -0.45]	[0.39; 0.42]
(Martínez-Espiñeira, 2007)	Seville (Spain)	Time series	Monthly data [1991–1999]	AD	Short-run: -0.10 Long-run: -0.50	n.a.
(Martins and Fortunato, 2007)	Portugal	Panel	Monthly data [1998–2003]	AD	-0.56	n.a.
(Musolesi and Nosvelli, 2007)	Cremona Province (Italy)	Panel	Annual data [1998–2001]	AD	Short-run: -0.27 Long-run: -0.47	0.18
(Olmstead et al., 2007)	USA and Canada	Panel	Daily data [four weeks]	HD	Full sample: -0.33 IBT only: [-0.61;-0.59]	Full sample: 0.13 IBT only: [0.18; 0.19]
(Arbués and Villanúa, 2006)	Zaragoza (Spain)	Panel	Quarterly data (10 meter readings) [1996–1998]	HD	-0.08	0.79

Continued

Tab. 2.2: Brief overview of residential water demand studies since 2000 to 2011 (continued)

Author(s) (year)	Study area	Data set	Periodicity	Type of data	Price elasticity	Income elasticity
(Gaudin, 2006)	USA	Cross-sectional	Annual data [1995]	AD	Base model: -0.37 Price info given: -0.51 Price info not given: -0.36	Mean: 0.30 Median: 0.24
(Hoffmann et al., 2006)	Brisbane (Australia)	Panel	Quarterly data [Sep-98; Jun-03]	AD	Short-run: -0.51 Long-run: -1.17	0.24
(Mazzanti and Montini, 2006)	Emilia-Romagna (Italy)	Panel	Annual data [1998–2001]	AD	[-1.33; -0.99]	[0.40; 0.71]
(Carter and Milon, 2005)	Florida (USA)	Panel	Monthly data [1997–1999]	HD	**Marginal price short-run** Know price: -0.58 Don't know price: -0.21	**Short-run** Know price: -0.01 (not significant) Don't know price: 0.06
(Garcia-Valiñas, 2005)	Seville (Spain)	Panel	Quarterly data [Dec-91; Sep-00]	HD	Average: -0.49 Peak period: -0.55 Offpeak period: -0.46	0.58
(Arbués et al., 2004)(3)	Zaragoza (Spain)	Panel	Quarterly data (10 time observations) [1996–1998]	HD	[-0.06; -0.03]	[0.07; 0.21]
(Martínez-Espiñeira and Nauges, 2004)	Seville (Spain)	Time series	Monthly data [1991–1999]	AD	-0.1	0.1
(Garcia and Reynaud, 2004)	Bourdeaux (France)	Panel	Annual data [1995–1998]	AD	-0.25	0.03 (not significant)
(Krause et al., 2003)	New Mexico (USA)	Panel	Data obtained from 6 experiments	EHD	[-0.10; -0.02]	n.a.
(Higgs and Worthington, 2001)	Brisbane (Australia)	Cross-sectional	Annual data [n.a.]	HD	n.a.	n.a.

Source: author's analysis of the papers. Notes: aggregated data (AD) are the data compiled from several households by water utilities related to one or more communities; household data (HD) are data of individual households provided by water utilities, which could be sample data or all the community data about households; experimental household data (EHD) is the information collected directly from households through experiments; experimental aggregated data (EAD) are experimental data at the aggregate level related to one or more communities. n.a.: not available or not applicable. (1) The wealth (income) semi-elasticity is the percentage change in water consumption when the income variable changes 1,000 €. (2) This study used community household data with all household data about single family homes available of the city of Aurora. (3) Almost all the data used in this study are household data, with the exception of the variable of availability of collective hot water facilities used in the water demand estimation that was obtained through a telephone survey.

A possible control group for this field experiment would be communities of the same regions, in which the use of the technology is not compulsory. Thus, analysing the aggregate data from each community the government can check whether the cost of the programme would compensate the water savings for a global implementation in all regions. In this case we would have EAD.

In the case of EHD and HD some experiments and household surveys have focused on residential water demand during the last decade (Martins and Moura e Sá, 2011; Frondel and Messner, 2008; Olmstead et al., 2007; Carter and Milon, 2005; Krause et al., 2003; Higgs and Worthington, 2001). A recent work from Martins and Moura e Sá (2011) argues that water bills fail to spread environmental education among water consumers because they are too complex. They recommend the redesign of the bills with more clarity and simplicity, because current bills could compromise price signals and consequently the effectiveness of price strategies.

Frondel and Messner (2008)'s work uses data from a household survey in Leipzig (Germany) to analyse price perceptions and their impact on residential water consumption. They conclude that water pricing policies will only have significant effects in sophisticated households (*i.e.* "price-conscious"). Naïve households (*i.e.* "price-ignorant"), the majority according to their sample, do not significantly diminish their water consumption with price increases. In a prior study, Carter and Milon (2005) also approached the issue of price knowledge, among other sources of heterogeneity. These authors used a 1997 survey of residential water consumers and monthly billing data of these households and found that water users' behaviour is sensitive to price awareness, with price-conscious households exhibiting more responsiveness to both average and marginal prices. Additionally, the authors obtained a counter-intuitive conclusion that price awareness increases water consumption which may be explained by price-overestimation, in line with the literature on electricity demand.

Olmstead et al. (2007) use household data from a previous study[14] and suggest that the difference between the price-elasticities under IBR and uniform rates could be explained by behavioural responses to price structures or city-level heterogeneity.

Krause et al. (2003) developed six laboratory experiments in New Mexico (United States) which combined experimental and survey data to analyse and estimate water demand. The authors found that consumer heterogeneity matters, since the heterogeneous responses of consumers are relevant to water policy effectiveness. Moreover, they criticized the limitations of studies that use aggregate data, which do not allow testing for this heterogeneity. Higgs and Worthington (2001) used a

14. Household level data obtained through mail surveys and historic billing data (Mayer et al., 1999).

household survey in the city of Brisbane (Australia) to study consumer preferences in a dual-pricing system (*i.e.* consumers can choose one of two systems). The authors conclude that consumers generally prefer a pricing system which minimizes the impact on payments of uncertain future demand, even if there are no clear reasons to do so considering only current consumption. This can explain the so-called "flat-rate bias".

To sum up, economists have not used experimental data very much in residential water demand studies. This could be explained by the resistance of social scientists to laboratory experiments[15], which are criticized because of their lack of realistic features and lack of generalization to the real world (Falk and Heckman, 2009). Non-experimental data (*i.e.* AD and HD) are used by most of the studies, with laboratory experiments and field experiments left on the sidelines.[16]

Furthermore, none of the studies accounts for asymmetric price and income elasticities or reference block pricing. The use of the reference-transaction framework has likewise never been proposed, whereas the use of social comparison (and reference consumption) has just begun with the pioneering work of Ferraro and Price (2011).

We proceed to discuss the four behavioural applications we propose - reference block pricing, asymmetric elasticities, reference transaction, and social comparison - highlighting their potential contribution to the enrichment of this literature.

2.3 Discussion of Behavioural Applications and Their Effects in Water Management

In this section we suggest four applications of behavioural economics to water demand studies based on four different behavioural frameworks, namely prospect theory, asymmetric price elasticity (APE), reference transaction, and social comparison. Table 2.3 summarizes the main features of different behavioural economic frameworks that can have implications for water management. We stress that these potential applications are not exhaustive. Our approach is to focus on the introduction of some new methods into the residential water demand literature.

2.3.1 Reference Block Pricing

Prospect theory proposes a model of decision-making under risk which accounts for some behavioural biases, namely the certainty effect, the reflection effect, and

15. Lab experiments are sometimes underestimated compared with field experiments due to the implicit assumption of the superiority of field data over lab data. However, Falk and Heckman argue that lab experiments should be done more often (see Falk and Heckman (2009) for further details).

16. The discussion about non-experimental data versus experimental data is outside the scope of this research, although further research should focus on the advantages and limitations of different type of experiments within water resource economics.

the isolation effect (Kahneman and Tversky, 1979)[17]. Prospect theory assumes an asymmetric value function with three characteristics: value depends on the deviation from the (neutral) reference point[18] (*e.g.* status quo or current asset position); the function is concave for gains and convex for losses; and it is steeper for losses than for gains (*i.e.* there is loss aversion). This means that individuals are more sensitive to changes seen as losses than to gains of the same magnitude with respect to a reference point. Supported by the existence of loss aversion, the potential application suggested for this concept is reference block pricing. Notice that most pricing research in both economics and marketing has been focused on intrinsic prices, although the "behavioural aspects of pricing", including reference-price effects, acquired some importance over the last three decades. For a categorization of these behavioural aspects see Krishna (2009).

As noted in the Introduction, the significant amount of literature on pricing structures in regulated water utilities does not explain the popularity of increasing block tariffs, given the theoretical efficiency of marginal-cost pricing in most situations. Some countries and regions do use decreasing block tariffs, predominantly for users with high consumption levels, due to their weight on the total revenues of water utilities. Since these large consumers ensure "substantial revenues" and "stable flows", the water utilities could be reluctant in such cases to apply tariff structures which promote water conservation (OECD, 2010, p. 11). On the other hand, Griffin and Mjelde (2011) have recently argued that low-consumption and low-income households are favoured with uniform block tariffs compared with increasing block tariffs.

Despite this extensive discussion of block-tariff settings in water, the impact of asymmetric value functions with loss aversion (Kahneman and Tversky, 1979) has never been proposed. We think that consumer responses could be based on a reference point which we call the consumer's reference block tariff. This may be the tariff of their actual block or, alternatively, the initial blocks of a tariff structure could be interpreted as reference points, so that framing effects would influence customers to view a change to the following block as a loss (increasing block tariffs) or discount (decreasing block tariffs).

17. The certainty effect is the bias to underweight outcomes that are probable in relation to sure outcomes. Reflection effect is the aversion to risk in the domain of gains accompanied by risk seeking in the domain of losses. Finally, the isolation effect means that people display inconsistent preferences in the presence of the same choice with a change of framework (*i.e.* framing effects). For additional information see Kahneman and Tversky (1979).

18. The reference point could shift and be different from the status quo. The location of the reference point and the form in which the choice is framed are essential determinants of decisions.

Tab. 2.3: Potential behavioural applications to water management

Seminal reference	Behaviour framework	Potential application	Policy implications	Current references in water management
Kahneman and Tversky (1979)	Prospect theory	Reference block pricing	• Redefinition of tariff structures • Revision of the effectiveness of pricing policy • Influence on price elasticities in terms of magnitude and persistence	-
Putler (1992)	Asymmetric price elasticity (APE)	Asymmetric price elasticity (APE)	• Redefinition of tariff structures • Revision of the effectiveness of pricing policy • Influence on price elasticities in terms of magnitude and persistence	-
Kahneman et al. (1986b)	Reference transaction	Reference transaction and tariff acceptability	• Understanding of the insufficient cost recovery achieved by water utilities through tariffs • Definition of economic criteria for equitable allocation • Implications in the definition of allocation rules for scarce resources • Redefinition of water policies	-
Festinger (1954)	Social comparison (and reference consumption)	Social comparison (and water reference consumption)	• Development of water conservation strategies • Redefinition of water policies • Influence on price elasticities in terms of magnitude and persistence	Ferraro and Price (2011)

Source: author's analysis.

Furthermore, loss aversion indicates that individuals are more sensitive to variations interpreted as losses and consequently IBR could lead water consumers to reduce consumption by more than higher flat rates. Therefore, the reduction on water consumption due to changing to a more expensive block tariff, which would be typically explained by the price effect, could also be explained by this loss aversion effect.

This behavioural application could have several implications to sectors with non-linear prices. The concept of reference block price could contribute to the redefinition of tariff structures, revision of the effectiveness of pricing policy, redefinition of water policies, and also influence the determination of price elasticities in terms of magnitude and persistence.

2.3.2 Asymmetric Elasticities of Residential Water Demand

APE can be defined as the asymmetric behaviour of consumers to price changes, according to the seminal work developed in the field of marketing (Putler, 1992). Typically if prices increase with respect to a reference price the price elasticities of demand will be higher, whereas we will have lower price elasticities with price reductions. The author argues that reference price influences consumer behaviour. Moreover, he corroborates the existence of loss aversion. We propose that both asymmetric price elasticity and the asymmetric income elasticity of demand are relevant issues in residential water demand.

Water pricing is one of the most important policy instruments to deal with scarcity and sustainability issues, allowing the implementation of demand management strategies (Griffin, 2006). Therefore, the study of the price elasticity of water demand is an essential measure for evaluation of the impact of pricing policies.

APE has been commonly applied in marketing studies according to Ho et al. (2006). More recently the study of APE has also been extended to the energy sector (Adeyemi and Hunt, 2007; Gately and Huntington, 2002), but it has not been approached so far in the domain of residential water demand, according to our previous literature review. Moreover, the study of asymmetric income elasticity (henceforth AIE) has not been analysed in this domain either. However, there is a piece of research in energy economics stating that income changes have asymmetric effects in the energy and oil demand in many non-OECD countries and these should be accounted for to mitigate biased estimations (Gately and Huntington, 2002).

The existence of APE could have several policy implications, of which we highlight the formation of reference prices, their effects on water consumption, implications for the design of tariff structures and impact on optimal water pricing policies.

Note that we argue that asymmetry in price and income elasticities should be tested, not assumed to exist. In this sense we believe that residential water demand studies should look into the issue instead of implicitly assuming that both price and income elasticities of water are symmetric.

2.3.3 Reference Transaction and Tariff Acceptability

The reference-transaction framework was first suggested by Kahneman, Knetsch, and Thaler during the 1980s. The concept is based on the dual entitlement principle under which firms are entitled to a (positive) reference profit and individuals are entitled to reference terms (*i.e.* price, salary, rent) (Kahneman et al., 1986b). The most puzzling finding of the authors was that consumers and employees consider it acceptable for a firm to increase price and/or cut wages in order to ensure a reference (positive) profit. Additionally, firms' behaviour seems to be influenced by fairness constraints which lead to inefficient decisions according to standard rational theory. Using a framework with fairness constraints could explain many market anomalies. In particular, we believe the reference-transaction framework could provide a better understanding of the low levels of cost recovery in the water sector.

Notably, one of the major aims in the development of water policies has been the cost recovery of the services provided by water utilities through water prices (OECD, 2010). According to this report it is often difficult to reach full cost recovery exclusively through tariffs in water sector, with this concern reflected in Article 9 of the Water Framework Directive (European Parliament and Council, 2000). Given this difficulty the core debate has changed from full cost recovery to sustainable cost recovery, which implies a mix of tariffs, taxes, and transfers (*i.e.* three types of revenues, also known as "3Ts") to achieve that aim.

According to our perspective, the use of the reference-transaction framework (Kahneman et al., 1986b) could be tested using an experiment to assess the attitudes of water users and managers of water utilities in at least two different ways. First, how does framing influence individual perceptions of fairness in water pricing? Second, why do water utilities so often seem to be financially unsustainable if they ought to be entitled to a positive reference profit? Both questions seem important in order to develop new approaches to cost recovery, at least for countries in which water services are a political issue for municipalities, such as Portugal. In the first question the underlying idea is to understand how different frameworks influence the application of water pricing policies, especially tariff increases aimed at ensuring full cost recovery. The second question is more puzzling. On the one hand, the concept of reference transaction implies the existence of fairness constrains which limit the water utilities' profit maximization and hence could explain (at least partially) the financial

unsustainability. On the other hand, water utilities, as firms, should be entitled to a positive reference profit, which would minimize the issue of insufficient cost recovery. The essential nature of the good in question and traditionally low prices may provide clues to answer these questions. The marketing literature provides one avenue for solving this puzzle by identifying price fairness as a multifaceted concept, with possibly conflicting components, such as firm reputation, inferred motive of firm and price comparison (Krishna, 2009) or price honesty and credibility (Diller, 2008).

The reference transaction framework has not been applied to water resource economics as far as we know, although it seems appealing to understand whether water utilities could be a counter-evidence of the reference profit entitlement. This topic has been explored in experimental research, with a recent application in the comparison of allocation rules related to two scarce resources, seats in a high-speed train and parking spaces Raux et al., 2009. The authors tested different allocation rules and conclude that they depend on the educational level of the individuals, the type of good, and the type of scarcity (exceptional or recurrent).

This framework could have some policy implications for water management, such as understanding why prices charged by water utilities are often insufficient to cover their costs, defining economic criteria for equitable allocation of scarce resources and general redefinition of water policies, in particular those related to public versus private ownership of utilities, since the reference transaction could be seen differently by consumers in each case.

2.3.4 Social Comparison (and Water Reference Consumption)

The theory of social comparison was developed in the seminal work of Festinger (1954). Typically, social comparisons are based on framing individuals with comparative information in order to promote a specific behaviour. Since Festinger's findings there have been several studies on this issue, but only recently has the theory been applied to residential water demand. In particular, the use of social comparison as well as pro-social information and technical advice given to the members of a household can influence their water consumption (Ferraro and Price, 2011). The authors show that social comparison has the strongest impact on consumer behaviour, using as reference consumption neighbours' consumption levels. Households in a randomized field experiment were provided with their own consumption along with two types of comparison: the median household consumption of their region and the percentile of that household considering all households of the region.

In this sense, the neighbours' consumption levels could be seen as the reference consumption, defined as a reference value of consumption (normally the average or median consumption) which frames the consumers into a social comparison framework.

Consequently, if consumers have household consumptions above average (or median) they will categorize their actual situation in the domain of losses (*i.e.* these consumers will try to save water in order to achieve the domain of gains) and vice versa. In the field of energy economics the reference consumption framework has also been applied recently in a field experiment with the aim of promoting energy conservation by consumers through two reference consumption set-ups: an average consumption level of neighbours and an efficient consumption level of neighbours (Allcott, 2011). The author concludes that non-pecuniary strategies of energy savings can change consumer behaviour in a significant and cost-effective manner. Moreover, there is also another avenue of research focused on environmental conservation in hotels. A recent study (Goldstein et al., 2008) concludes that guests of hotels react more to social-comparison frameworks (*e.g.* "the majority of quests reuse their towels"), than to the typical appeals to environmental protection.

Gaudin (2006) underpins the importance of the information provided to water consumers through the water bill and the relevance of this information in the effectiveness of water pricing policies. Frondel and Messner (2008) corroborate the importance of incorporating information in the water bill (*e.g.* price and cost perception) and argue that pricing policies need to be complemented by the availability of information to consumers in their bill, including price and cost information. More recently, Martins and Moura e Sá (2011) found that the clarity of water bills is a major issue in residential water sector. According to the authors the bills fail to have environmentally relevant impacts on consumers, namely in terms of fostering water conservation, thus their redesign to make them clearer and simpler could contribute to the effectiveness of price-based policies.

The social comparison measure could be tested in other ways. For example, the use of the typical average (or median) household consumption does not account for household size when framing the consumers. This fact could lead to biased conclusions if the household size has a significant impact on consumption. Arbués et al. (2010) recently argued that using household data which accounts for household size could matter in the estimation of residential water demand. Potential contributions of the social comparison framework to water management include the development of water conservation strategies, the redefinition of water policies, and influence over the price elasticities in terms of magnitude and persistence.

Framing effects are well-known to behavioural economists. Our aim in this section was to briefly explain some behaviour frameworks which we use to illustrate some of the applications and effects in water demand studies. In the section 2.4 we discuss further research of the suggested behavioural applications.

2.4 Conclusion and Future Research

At a basic level, water consumption cannot be considered sustainable until its costs are properly recovered. This issue has occupied many economists who have analysed customer demand, on the one hand, and service costs, on the other. However, financial cost recovery is not sufficient - truly sustainable use must respect ecosystem needs and be based on a good understanding of consumption patterns.

One of the aims of this chapter was to approach the scarcity issue. Surely, water scarcity is a topic dear to all water researchers; however our direct focus was on another type of scarcity: that of residential water demand studies that include behavioural economics, *i.e.* empirical testing of behavioural assumptions. Nowadays, the fields of behavioural economics and experimental economics, which arose from the collaboration between psychologists and economists, are an integral part of mainstream economics, as can be attested by many articles in top economic journals (Santos, 2011). However, the existing water demand literature exhibits a clear dominance standard neoclassic economic theory. We argue that further research on water demand should use behavioural economics frameworks and account for behavioural failures[19].

As argued by Thaler (1999) the logical evolution of economics as a field will be the incorporation of behavioural features into economic models. The challenge is to understand that the highway along which the herd of researchers is travelling could be the slowest way. Exploring alternative approaches and rethinking the frameworks could be the new alternative to that highway. New empirical results could promote discussion of new hypotheses and new lines of reasoning (Smith, 2008). Nevertheless, the development of environmental economics data along with social and psychological data (Jorgensen et al., 2009; Smith, 2008) is essential: without a proper vehicle, travelling will be a footslog.

In our view, this is one of the fundamental issues holding back the development of behavioural economics in the water domain. Information needs to be periodically collected, compiled, and organized, always respecting confidentiality constraints, especially in the case of household data. We believe that the development of more powerful databases and the growing importance of the sustainability issue will bring new researchers into water resource economics. The importance of data wealth has been proven by the developments of behavioural finance (Thaler, 1999). The challenge of development, collection, and systematization will be the first step in further research on behavioural applications in water management.

19. Behavioural failures refer to situations where "a person fails to behave as predicted by rational choice theory" as well as an "anomaly, paradox, bias, heuristic misperception, fallacy, illusion, or paradigm" (Shogren and Taylor, 2008, p. 27).

This chapter discussed some behavioural applications that could reshape the understanding of major issues in water management, through four different ideas: reference block pricing, asymmetric elasticities, reference transaction, and social comparison (and reference consumption). None of these lines of research have been analysed so far, with the exception of social comparison.

Reference block pricing could be empirically tested with the identification of reference blocks within different pricing structures (*e.g.* increasing and decreasing block rates) for each household and looking into their ex-post consumption behaviour after block shifts. Reference effects could help explain the stronger consumption reactions found by Olmstead et al. (2007) for IBR and thus provide a justification for the overwhelming use of such structures in Portugal, as well as in other countries.

Further research on asymmetric elasticities is essential due to the importance of price and income elasticities to evaluate pricing and affordability, which are core issues in water policy. If the typical assumption of symmetric elasticities does not hold this could reshape, to some extent, the pricing policies in the water sector.

The reference transaction framework could be an explanation for insufficient levels of cost recovery by emphasizing how perceived price fairness hinders tariff increases. Then again, limitations to profit maximization through fairness constraints contradict the idea that water utilities, as firms, are entitled to a positive reference profit. Although both ideas come from the reference transaction framework, they have antagonistic effects and the study of their combined impact is a further avenue of research.

Lastly, social comparison (and reference consumption) is a recent topic with several promising lines of research: the comparative study of different social comparison treatments (*e.g.* sending users the average household consumption in their neighbourhood, region, or country) and the application of findings from energy conservation literature, such as efficient consumption information, are two potential options for further research in this area. Furthermore, the use of different household sizes in experimental design could result in new findings.

There are other areas of water resource economics in which behavioural applications could also be applied, such as supply analysis, including investment decisions in water infrastructures, policy design, cost–benefit analysis, resource efficiency, water losses, and water markets, among others. For instance, in water markets, Garrido (2007) used a laboratory experiment to test specific market regulations of the water reform in Spain and concluded that eliminating the existing trading restrictions would imply welfare gains for senior users of water rights.

Simon (2008) argued that the development of behavioural research (and theory) is based on testing economic theories through empirical methods, namely survey

research and experiments based on direct observation, either in laboratory context or through observation of the decision-making process in natural environments (*e.g.* case studies based on individual decisions or decisions in business firms). These methods are not common tools for economists, who are challenged by the techniques of experimentation and individual data collection as well as by interpretation of survey data. Thus, economists who aim to implement empirical tests of economic theory will probably have to invest time to develop skills in at least one of the aforementioned methods. These additional skills give an edge to behavioural economists and contribute to the redesign of consumption theory in general and water resource economics in particular. Further research could focus on the advantages and limitations of different types of experiments (*e.g.* laboratory experiments and field experiments) in contrast with the typical use of nonexperimental data.

If water resource economists were to grasp the differences between the "rational consumer" and the "normal consumer"[20] through empirical behaviour analysis, that could improve water management practices and prevent scarcity, while possibly gaining insights that would be applicable to other natural resources. This conceptual framework could also be important to understand the supply side, with the analysis of existing water utilities as "rational" or "normal" in terms of corporate decisions (*e.g.* operational decisions, or investment decisions).

Although behavioural economics was originally based on empirical research it is not to be dismissed as some sort of "reverse engineering" field based only on empirical analysis. Since the seminal work of Kahneman and Tversky (1979), behavioural economics is based on both empirical and theoretical foundations. Therefore, the development of residential water demand argued for in this chapter is implicitly based on a dual approach which tries to incorporate both.

The behavioural applications proposed in this chapter are based on the seminal works of psychologists such as Daniel Kahneman, Amos Tversky, and Leon Festinger, as well as on the price fairness research in marketing literature. We believe this highlights the relevance of a multidisciplinary approach to provide new research ideas and improve our understanding of water consumption.

We would like to end the chapter by noting that one of its primary aims is to promote brainstorming, not necessarily to be exhaustive in our analysis of possible applications of behavioural economics in water management. To conclude, our timeless question is: are economists thinking outside the box in their fields?

20. This draws on the dichotomy rational investor and normal investor suggested by Statman (1999), which can be similarly applied to consumer behaviour.

3. DO YOU KNOW HOW MUCH YOU PAY FOR WATER?

3.1 Introduction

The Organisation for Economic Cooperation and Development stated the principles of water governance: effectiveness, efficiency, trust and engagement (OECD, 2015). This document highlights the importance of a holistic approach to build up public confidence and fairness, besides the conventional principles of effectiveness and efficiency. Water demand management is crucial to achieve a balance between uses and the availability of the resource. Water pricing, in particular, is broadly accepted as a tool for increasing economic efficiency in use as well as the financial sustainability of utilities and, if prices are properly set, even environmental sustainability. Water supply systems should therefore be managed taking into consideration consumer price reactions, and many studies have assessed these through the estimation of water demand functions as shown by several literature surveys (Correia and Roseta-Palma, 2014; Sebri, 2014; Nauges and Whittington, 2010; Worthington and Hoffman, 2008; Arbués et al., 2003; Dalhuisen et al., 2003). Most point to fairly low values of the price-elasticity of demand (range: -0.1 to -0.6). However, a few authors have noted two important factors on residential water demand. Firstly, residential consumers are not always fully informed of their water price (Frondel and Messner, 2008; Carter and Milon, 2005) nor tariff structures (Tralhão, 2011) and this naturally has an effect on the role prices can play in moderating consumption. Secondly, literature shows that there are clarity and informational issues regarding water bills as well as the transparency about water prices in these bills (Martins and Moura e Sá, 2011; Gaudin, 2006).

Household surveys have been widely used in issues related with residential water management literature (Binet et al., 2014; Nauges, 2014; Martins and Moura e Sá, 2011; OECD, 2011), although they mostly neglected the consumer perception about two essential pieces of information in demand function: the water price and the water quantity consumed. Exceptions are Frondel and Messner (2008) and Carter and Milon (2005). Studies have paid limited attention to the determinants of consumption perception bias (Beal et al., 2013), or in other words, why the perceived water use by the consumers does not match their actual water consumption. Nevertheless, perceived consumption versus effective consumption has been addressed by Tralhão

(2011), who found that lower consumptions imply greater accuracy. Followed by Barata et al. (2012), who shown that larger water consumption reduces the consumer accuracy about their actual consumptions. According to the authors, one potential explanation pointed out for this is that higher levels of water consumption and income levels are related, which could indicate that a higher consumption level reflects a lower concern with the water bill paid.

With our 2012 survey, we were able to collect detailed information about the characteristics of dwellings, households and respondents, consumer habits; price, bill and consumption perceptions; as well as on consumer attitudes towards environmental and financial sustainability of water utilities. The method chosen for primary data collection was the telephone survey applied during the summer of 2012 for a sample of residential water users in Portugal. With the collaboration of ERSAR (Water and Waste Services Regulation Authority), we gathered thirteen water utilities that were willing to participate. They are dispersed across mainland Portugal and have different characteristics (*e.g.* population size, urban-rural typology, management models).

The database contains information on households and dwellings obtained from the respondents, and on their actual water consumption and bill from the 12 months preceding the survey, provided by the water utilities. This enables us to create a unique data set to compare perceptions about water price, monthly consumption and total monthly water bill with their actual values. We collected data on average monthly household disposable income in each municipality from Portuguese Tax Authorities (PTA) (*Ministério das Finanças*). Our database also includes weather data from the Portuguese Sea and Atmosphere Institute (*IPMA*), namely were monthly minimum, maximum and average temperature in Celsius degrees and the total monthly precipitation in millimetres, *i.e.* the amount of rain that falls per square meter in one hour, collected from Portuguese weather stations. All climate variables are based on the year prior to the survey data collection (*i.e.* between July 2011 and June 2012).

This study is organized with the following structure. In section 3.2, we briefly discuss the current situation of the sector in Portugal. In section 3.3, we present a condensed review of the literature. In section 3.4, we describe the database and empirical results. In section 3.5, we discuss the limitations and potential avenues for future research.

3.2 Framework of the residential water sector in Portugal

The current market structure of the Portuguese mainland water sector is fairly complex, where the most common governance structures are the municipal departments

in retail water services (Pinto and Marques, 2015). On the other hand, bulk water services are mainly provided by multimunicipal concessionaires revealing a heterogeneous structure in terms of management in water supply (WS) and wastewater (WW) services that could have relevant financial shortcomings in water utilities.

WS and WW services in Portugal are characterized by a problem of cost recovery, in spite of a positive evolution after the approval and transposition of the Water Framework Directive (WFD) (European Parliament and Council, 2000). ERSAR data shows cost recovery ratios in 2005 of 0.87 and 0.57 (INAG, 2005) in water supply (WS) and waste water (WW), respectively, for mainland Portugal. In 2013, the cost recovery ratio in WW increased to 0.67 and the cost recovery ratio in WS remained steady (ERSAR, 2014c). Nevertheless, achieving this improvement of cost recovery ratios implied rising water tariffs, which has in same occasional cases stirred up opposition and protests from the population[21]. *A priori*, it looks like there is a communication failure between consumers and water utilities that influences consumer perception. The overall affordability of water utility services in Portugal was 0.84% of the average household disposable income in 2013 (ERSAR, 2014c), comparing with OECD countries with a range between 0.2% (*e.g.* Korea, Italy) to 1.2% (*e.g.* Poland, Hungary), in 2008 (OECD, 2010). Nevertheless, it is far below the affordability threshold which ranges from 3% to 5% in the literature (Barata et al., 2015; Martins et al., 2013; OECD, 2010; Komives et al., 2005). Portugal exhibits idiosyncrasies, the work of Barata et al. (2015) raises concerns about poor and numerous households, where the affordability threshold (3%) for these families is exceeded and heterogeneity of the municipalities should be accounted for. There are large disparities between municipalities and cases where the affordability threshold is exceeded for the poorest 20% households, with a significant number of municipalities above the burden limit Martins et al. (2013), and even when low-income households have low-water consumption levels Cruz et al. (2015). However, these authors also found that overall the water charges can be considered affordable and respecting the human right to safe water under affordable conditions[22].

Therefore, public policies, and water utilities could focus on the issue of consumer misperception of prices, consumption and total bill, and how this misperception affects total consumption expenditure. Media often presents cases where consumers pay high prices or focuses on announcements of price increases for utility services

21. For instance, during 2011 social protests about increasing water prices occurred in some Portuguese municipalities, such as Loures, Odivelas and Cartaxo (Henriques and Filipe, 2011; Mirante, 2011).

22. As a comparison, in electricity the charges represent 2.8% of the average household expenditure, both in European Union (Linden et al., 2014) and United States in 2009 (Delmas and Lessem, 2014). In European Union, the electricity household expenditure ranges from 1.2% (*e.g.* Greece) to 5.6% (*e.g.* Slovakia), with Portugal exceeding the 4% of consumption expenditure, according to an Eurostat household budget survey carried in 2012 (Linden et al., 2014).

(Jornal de Notícias, 2015; Castanho, 2014; Tomás, 2014; Henriques and Filipe, 2011), although the reality of water-expenditure statistics often denies the fact for the average consumption. ERSAR data for 2013 shows that in mainland Portugal the average monthly total water bill for 10 cubic meters was 21.9 € (WS 10.4 €, WW 7.0 €, solid waste 4.5 €)[23] and the average water price per cubic meter for WS and WW were 1.2 € and 0.7 €, respectively (ERSAR, 2014c).

As noted above, water as a utility represents a small percentage of the average Portuguese households' monthly expenses[24]. The existence of increasing block rate (IBR) structure in all Portuguese municipalities also introduces complexity and could affect consumer perception. Potential explanations for street protests could be consumer misperception and media as well as the way the information is presented. This puzzling evidence is not addressed on residential water demand literature, as far as we acknowledge.

3.3 Literature review

Prices are seen in several different frameworks depending on the field of study. For instance, conventional economic sciences have been mainly focused in the intrinsic value and exchange value of a good or service. Nevertheless, in the last three decades some other aspects attracted researcher's attention, such as behavioural pricing that frames price as a subjective price. This subjective price is created by the consumer based on their internal reference prices (*e.g.* past prices) and price presentation effects (*e.g.* 99-cent endings), as well as on the perceived price fairness (Krishna, 2009), *i.e.* consumer perception about how fair the price is to him or her. Consumers have internal norms which are constructed by themselves against which they compare observed prices (Cheng and Monroe, 2013). These are called (internal) reference prices[25]. This will be their perceived price, *e.g.* perceived average price of water. Thus, it is important to stress that residential water demand studies, in general, use price specifications and observed prices (Sebri, 2014; Arbués et al., 2003) and even a recent price-perception approach that uses a geometric average of marginal and average prices and improves Shin's model in the choice of the perceived-price

23. Numbers may not add up due to rounding.

24. Even taking into account that the average water bill includes the costs with WS, WW and municipal solid waste, but does not include water resource rate or VAT (Value Added Tax), components with smaller relative weight (ERSAR, 2014c).

25. Reference prices are internal and dynamic prices used by individuals to judge and evaluate a given price of a good or service, so "cannot be external" (Cheng and Monroe, 2013, p.113). Cheng and Monroe (2013, p.108) also state "Researchers have mistakenly dichotomized reference price as internal (in mind) or external (in the environment). All reference prices are internal meaning they are in the minds of the individual buyers." Moreover, it is a well-established stylized fact that "Consumers have individual reference prices for each product or service they consider for purchases" (Cheng and Monroe, 2013, p.110). For an alternative perspective, see Kőszegi and Rabin (2006) on external reference points.

functional form (Binet et al., 2014), still does not go further that the conventional dichotomy between consumer reactions to marginal and average prices in utilities (Nieswiadomy and Molina, 1991; Shin, 1985). This seems to be a narrow approach, when the use of alternative approaches, such as the reference prices and study of their implications was never developed (Correia and Roseta-Palma, 2014). Besides the price, the same reasoning could be also applied to other reference terms (*e.g.* perceived monthly water consumption and bill).

The quality of information, namely the way the price, consumption and total amount paid are presented on the water bill, *e.g.* different transparency levels of water prices, influence consumer perceptions and behaviour (Gaudin, 2006). Moreover the type of information, *e.g.* average price of last month or average price of last year, will be an external reference price to the consumers and influence their price perceptions, a phenomenon known as price presentation effects.

In several sectors, from water to energy sector, price increases can be difficult to implement (Delmas and Lessem, 2014), since they can create negative emotions on consumers (Homburg et al., 2005). Surveys are important to access this issue because they enable us to analyse attitudes and perceptions.

Recently, the residential water demand literature has used household surveys, and it has become common practice to obtain richer and more detailed information about water consumers (Binet et al., 2014; Nauges, 2014; Martins and Moura e Sá, 2011; OECD, 2011; Clark and Finley, 2008). Moreover, recent studies have also used surveys to analyse water utility managers' attitudes and perceptions towards strategic planning, water conservation and rate structure decisions (Boyer et al., 2014, 2012).

Surveys are developed with two main purposes: *i)* evaluate respondents' (*e.g.* consumers or water utility managers') attitudes, habits, and perceptions; *ii)* obtain latent variables, *i.e.* unobserved variables that only become observable to the researchers with a survey, and observable variables with personal information that sometimes are not available to the researchers, *e.g.* monthly net household income, household size, dwelling with a pool, number of taps, among other specific chairacteristics.

Overall, surveys in this field seems to be extremely focused on consumer habits (Binet et al., 2014; Nauges, 2014; OECD, 2011) and attitudes towards water management, environment, sustainability, fairness and efficiency (Zetland and Gasson, 2013; Martins and Moura e Sá, 2011; OECD, 2011; Clark and Finley, 2008). However, there is scant evidence of surveys focusing on consumer perceptions about what we considered relevant variables in demand analysis, *i.e.* perceived consumption (Barata et al., 2012; Tralhão, 2011; Martins and Moura e Sá, 2011) and perceived

price (Binet et al., 2014) assuming imperfectly informed households. This latter study takes the Shin (1985) approach, used in water demand studies and also known as Shin price (Sebri, 2014), one step further. Nevertheless, the perceived price parameter is typically an estimation (Binet et al., 2014; Nieswiadomy and Molina, 1991; Shin, 1985) or obtained through treatment in experimental economics dealing with water demand (Wichman, 2014), instead of real perceived prices elicited from water consumers, *i.e.* their reference prices. Binet et al. (2014) did not account this in their survey design, although they collected information on household characteristics and water-using appliances (phase one) and on the actual consumption levels on the last three water bills (phase two). The authors concluded that water consumers underestimate the price (more strongly in the case of marginal price rather than average price). Martins and Moura e Sá (2011) concludes that more than 90% of their sample had a perception of bill, but around 85% did not have a clue about their water consumption. Overall, the water bills seem to have low-value information about water pricing requiring better price information (Binet et al., 2014; Martins and Moura e Sá, 2011; Gaudin, 2006). Consumer seems to act using a "benckmark" value (Moura e Sá and Martins, 2014) (or internal reference point) only looking at the water bill when there is an abnormal situation (*e.g.* increase in total amount) or when they wish to know the amount they must pay (Martins and Moura e Sá, 2015). Therefore, the authors argue that besides enhancing the quality of invoices, since information within the invoices is sometimes undervalued, due to numeracy and literacy problems, consumer awareness and the effective informational role of water bills could be improved by informational and educational programs.

Although these are interesting findings, this literature did not take further steps to understand if consumers underestimate or overestimate price, consumption and total water bill, with the exception of Binet et al. (2014) for price perception. Moreover, it is also important to explain why this happens and how new approaches can cope with these issues of consumer perceptions and reference points (*e.g.* reference price, monthly reference consumption and monthly reference water bill).

3.4 Survey on the water consumption of Portuguese households

3.4.1 Description of survey and dataset

The database used was a household-level survey based on Portuguese residential water consumers. The Portuguese and English versions of the survey are provided in the appendices D and E. A telephone questionnaire, on a sample of Portuguese residential water consumers, which was performed during the summer of 2012. Thirteen Portuguese water utilities were selected to join the project based on their

willingness to participate and with the help of ERSAR (Economic Regulator for the Water and Waste Industry). Table 3.1 shows the response rates computed as the number of responses divided by the number of dwellings in each municipality, where dark blue is the higher value and light blue is the lower value. The response rates are slightly higher for water utilities with less number of dwellings.

Tab. 3.1: Total dwellings and response rates by water utility

Water utility	Total dwellings	Response rate
1 (Águas do Sado)	61.904	0,4
2 (CM Lagos)	24.810	0,8
3 (CM Montemor-o-Velho)	13.207	0,7
4 (CM Sines)	7.448	2,6
5 (CM Vila de Rei)	2.956	2,0
6 (CM Vouzela)	5.812	2,4
7 (EMARP, Portimão)	46.419	0,4
8 (EMAS Beja)	18.932	1,1
9 (SM Alcobaça)	34.578	0,2
10 (SMAS Caldas da Rainha)	30.909	0,6
11 (SMAS Sintra)	182.377	0,1
12 (SMAS Guarda)	26.494	0,8
13 (SMSB Viana do Castelo)	46.605	0,4

Source: author's analysis. Number of dwellings in 2012 based on ERSAR data.

The questions in the survey were chosen based on literature review, consultation with experts from water sector and pretests with water consumers[26].

The household data collected has a final sample size of 2,233 water consumers from Portuguese municipalities. It includes both primary data obtained from households through the phone survey and their actual consumption and billing data, provided by water utilities for the twelve previous months (July 2011 to June 2012), which allows us to compare actual consumer perceptions with real data[27].

The data set includes information from consumption habits to several dimensions of consumer perceptions on water price, monthly consumption, monthly total bill, sustainability and fairness concerns, containing around one hundred variables. The data set does not include consumer names, addresses or other type of private information.

The locations of the municipalities in mainland Portugal are provided in figure

26. Survey developed under the project PTDC/EGE-ECO/114477/2009, with financial support from FCT - Fundação para a Ciência e a Tecnologia (Science and Technology Foundation). Additional information can be provided upon request.

27. The water consumption provided by the water utilities is based on both monthly estimates and real values: we create a dummy variable to control for this potential issue, *estimated consumption bias*.

3.1 and the main characteristics by water utility are summarized in table 3.2. The number of blocks is four in almost all water utilities, with exceptions of the utilities 5 and 8 (CM Vila de Rei and EMAS Beja). The average monthly household disposable income (2011) ranges between 1.040 € in utility 5 (CM Vila de Rei) and 1.481 € in utility 1 (Águas do Sado), based in the Portuguese Tax Authorities. Overall, the actual average bill in the sample and the average bill based on ERSAR for an average consumption of 10 cubic meter (m^3), in 2012, have their minimum values in the utility 5 (CM Vila de Rei). The highest value for the reference of 10 m^3 is the utility 9 (SM Alcobaça), which is the second largest value in our sample.

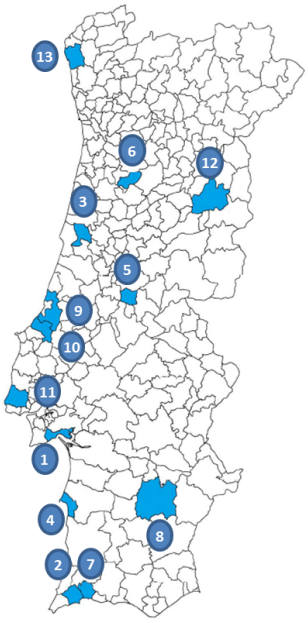

Fig. 3.1: Locations of the municipalities

3.4.2 Highlights from the survey responses

Household and respondent characteristics

In the sample collected, there are 51% detached or semi-detached houses (henceforth houses) and 49% apartments. The respondents are mainly owners of the houses (83%) and apartments (76%) and the majority of the responses regard their main residence (85% and 89%, respectively) (table A.1, in appendix A).

The monthly net household income is similar between houses and apartments in our sample, overall 55% of the households have an income between 501 and 1,500 €. Dwellings with two members represent 35% and 36% in house and apartments, respectively (table A.2).

Tab. 3.2: Summary statistics by water utility

Water Utility	Total dwellings	Number of blocks	Income (€)	Actual average consumption (m^3)	Actual average bill (€)	Average bill (consumption 10 m^3, €, ERSAR)
1 (Águas do Sado)	61.904	4	1.481,3	9,4	20,1	19,6
2 (CM Lagos)	24.810	4	1.144,2	8,2	18,8	22,9
3 (CM Montemor-o-Velho)	13.207	4	1.295,5	9,0	10,6	13,7
4 (CM Sines)	7.448	4	1.449,7	11,0	16,4	15,5
5 (CM Vila de Rei)	2.956	6	1.040,3	7,8	7,3	8,3
6 (CM Vouzela)	5.812	4	1.062,2	4,8	9,0	12,2
7 (EMARP, Portimão)	46.419	4	1.209,4	8,0	21,0	24,0
8 (EMAS Beja)	18.932	6	1.456,7	8,9	17,6	26,8
9 (SM Alcobaça)	34.578	4	1.174,3	11,1	23,2	27,7
10 (SMAS Caldas da Rainha)	30.909	4	1.219,6	9,4	18,0	20,1
11 (SMAS Sintra)	182.377	4	1.404,5	7,7	23,7	26,2
12 (SMAS Guarda)	26.494	4	1.413,5	8,3	19,2	26,7
13 (SMSB Viana do Castelo)	46.605	4	1.254,3	7,5	18,9	21,4

Source: author's analysis.

The average weighted household size is 2.7 inhabitants per dwelling (2.9 per house and 2.5 per apartment), taken into account sampling weights based on respondents per water utility. This value is similar to the national household size in Portugal (2.6), according to National Statistical Institute of Portugal[28].

In the sample, the respondents are 52.5% women and 47.5% men, and 93% have primary or secondary education (table A.3). Regarding the water bill, 92% of the sample are payers, and almost 70% state that they always look at the information of water bill. Considering awareness about the type of information in the water bill, 54% of consumers state that they analyse the detailed information, rather than only the total amount. Finally, we also question whether consumers look at it due to an increase or to a decrease in the total amount. As expected, respondents look mainly due to increases, 53%, rather than decreases, 2%. The remaining 45% state they didn't look. This empirical evidence is raw data that partially corroborates the idea from prospect theory that losses are more valued than gains (Kahneman and Tversky, 1979).

Consumer habits and decisions

This section describes the consumer habits and decisions made regarding the water billing process. In table A.4, we summarize some consumer habits and decisions. Around 90% of the total sample stated that they water the garden at the coolest period of the day to avoid evaporation ("Do you water your garden/backyard/vegetable garden in the morning or at night to avoid evaporation?", *evaporation*) and use the washing machine with full loads ("Do you normally wash full loads?", *full*). The concerns on watering the garden are stronger in houses (91%) rather than apartments (80%), as expected. For car washing, 66% stated that a hose is used for the subsample of houses (the overall percentage is 61%, *car_hose*). The existence of an alternative to publicly supplied water (*well*) is more common for houses (27%) and not apartments (1%). As for decisions related with the billing process, almost half use direct debit (*debit*), which could be an important factor in water bill perceptions. The electronic water bill (*ebill*) is not the primary method of receiving the water bill, since 95% of the sample still use the traditional method based on a letter in the mail.

Due to geographical differences between the municipalities involved, our sample comprises a diversity of family and household characteristics, thus providing an overall view of the Portuguese reality in the residential water sector. Additionally, we also found that a large majority of households from different municipalities follow other pro-environmental behaviours, including *i)* choosing the shower instead of baths (97%), *ii)* closing the tap while brushing the teeth (90%) and *iii)* closing the

28. Source: PORDATA, *https://www.pordata.pt/Portugal/*, accessed on 17 August 2015.

tap while soaping in the shower (77%). From our total sample, another important decision is that 81% of the respondents do not submit their meter reading to the water utility. Finally, a consumer habit that revealed a significant variation was the preference to drink tap water instead of other sources (*e.g.* bottled water or water from public fountains), since around 58% of respondents did not have a preference for drinking tap water (with a minimum of 35% and a maximum of 82% depending on the municipality). The analysis of the determinants of some of these decisions will be discussed in chapter 4. We proceed the analysis to understand consumer awareness and perceptions, especially about the water bill, consumption and price.

Consumer awareness and perceptions

Regarding the total monthly water bill, the majority of respondents (87%) try to come up with an estimate of the average level they pay for water each month, in line with previous findings for a Portuguese municipality that found a similar response rate (84%) (Tralhão, 2011). However, in our survey, we found that they tend to overestimate their water bill on average. The ratio of the estimated consumption and the actual average consumption is 1.3 *(number of observations, n=1924)*, while 70% estimates are between the minimum and maximum bill paid in the previous year. Nonetheless, there is a significant variation between water utilities in this last finding, 46% to 81%, which can be an indicator of differences in the quality of information provided to consumers.

With respect to the monthly water consumption, only a minority of respondents try to come up with an estimate of the level of water consumption (24%). From those who guessed their consumption they significantly overestimated it, on average: the ratio of the estimated consumption and the actual average consumption was 2.2 *(n=518)*, and only 57% come up with a guess between their minimum and maximum consumption of the previous year. As the previous case of the monthly water bill, there is a significant variation between water utilities in this last finding, 38% to 78%, which can be again an indicator of significant differences in the quality of information provided in the water bills as well as literacy levels in different parts of country.

As for prices, respondents are aware of the increasing block rate (54% respond to the question on tariff structure and 72% do it correctly). In our sample, the number of blocks perceived question only have a response rate of 27% and from those 79% underestimate the true number of block applied by their water utility. A potential explanatory factor is that consumption rarely hits the higher blocks and therefore consumers are not aware of them. On the other hand, the high non-response rate (73%) for number of blocks, can indicates a lack of information about this aspect.

Overall, these findings are in line with Martins and Moura e Sá (2011). Sur-

prisingly, 23% of our sample believe they have a uniform price, although block tariff structures with increasing prices are universal in Portugal. On the other hand, Tralhão (2011) highlights that less than 10% of the consumers know their tariff structure, and when the type of structure was presented to them only 15% guessed correctly the increasing block tariff structure.

In our survey, we also found that more than 90% of the sample do not know water prices, neither marginal prices nor average price. Thus, only 7% state they know an approximate average price for cubic meter of water consumed. Moreover, to the simple yes-no question *"Do you know the per cubic meter price associated with each block?"*, only 8% answered they know their marginal prices. This is in line with the previous water demand studies that found less than 15% of their sample were aware of the price paid for their water consumption (Frondel and Messner, 2008; Carter and Milon, 2005). Frondel and Messner (2008) found that only 12% of their sample is aware of their marginal prices and tariff structure and argue that price policy will impact only on households that are price aware (price-conscious). The study by Carter and Milon (2005) states that only 6% of households are aware of the marginal prices they pay, and that consumers typically react more to average prices than to marginal prices.

A puzzling fact in our study was that even after stating they do not know their water price, consumers still answer questions about their price fairness perceptions. "Processing price information begins with initial exposure to price information (...)" (Cheng and Monroe, 2013, p.120). In residential water demand estimation, this could be problematic since consumers seem to be adequately exposed to price information, perhaps due to lack of clarity in water bills (Martins and Moura e Sá, 2011; Gaudin, 2006). This could partially explain the low response rates and knowledge about water prices found in this literature[29]. If consumers have higher expense awareness rather than price awareness, consumers could be using expense awareness as a proxy for reference price, since in their mind expense be framed as the "value" of water. The ratio of the estimated average price and the actual average price is 0.5 *(n=146)*, which reflects an underestimation. Furthermore, looking deeper into this small sub-sample of consumers that try to guess their average price we found that all estimates are outside the actual price range[30]. Moreover, excluding the fixed charge to calculate the price range, 35% are within the minimum and maximum price of their tariff

29. Another potential factors are poor data quality (Moura e Sá and Martins, 2014), numeracy and literacy issues (Martins and Moura e Sá, 2015) and the fact that numerical information is not objective, as we might think, but rather abstract in nature (Cheng and Monroe, 2013). This research about different representations of prices in our minds could be relevant to understand this issue, although is outside our initial scope.

30. The maximum and minimum prices for each consumer were used. The prices are based on their water supply, waste water, municipal solid waste and value-added tax plus the fixed charge, according to the information provided by the water utility.

structure. This issue will be analysed in detail in chapter 5, where we propose a conceptual model of perceived price fairness.

To sum up, according to our survey consumers mistakenly believe that they are cognizant of their water bills (around 69% stated they always look at the water bill). Yet, responses show that residential consumers are not aware of the average price paid and the few who try to come up with estimates tend to underestimate it. The full tariff structure is generally unknown, while the values of monthly water consumption and bill tend to be overestimated.

3.5 Conclusion and Future Research

Our study confirms the view, common in the literature of residential water demand, that consumers have limited knowledge of the marginal price of water (Frondel and Messner, 2008; Carter and Milon, 2005), which can be explained by the different levels of price transparency in the water bill (Gaudin, 2006). A potential line of future research is the use of bills as an alternative to water price in the estimation of water demand.

Overall, the survey revealed that Portuguese consumers have a low awareness level about their reference points, such as their perceived price (92% and 93% of our sample do not know their marginal or average price, respectively) and perceived consumption (76% of our sample). Consumption and price, which are extremely important to economic analysis, seem to be unknown variables to the majority of water consumers, although the bill seems to be widely acknowledged (87% try to guess their bill).

In general, we found the existence of three effects, with respect to consumer awareness and perceptions: underestimation of the average price and overestimation of monthly water consumption and bill. Knowledge about the full pricing structure was limited (54% try to guess and from those 72% know they have a IBR structure) and consumers underestimated the true number of block tariffs applied by their water utility in 79% of the sample. A potential explanatory factor is that consumption rarely reaches higher blocks, although, the high non-response rate (73%) can also indicate lack of information. Nevertheless, 57% and 70% of responses on the values of the monthly water consumption and bill, respectively, are between the minimum and maximum values of the previous year. Regarding price, all consumer responses to the survey were outside their average price range paid in reality. Water resource economists should think how to cope with these issues, acknowledging and testing consumer awareness.

One of the aims of this article is to explore the puzzle that the majority of water consumers are unaware of their price, as traditionally shown in this literature,

and yet react to price according to same studies. This puzzle could be partially explained by the fact that people normally know (our believe to know) their water bill. Consumers could in fact use water bill as a proxy to water price, and can mix the two different values, an avenue of further research.

To successfully manage demand through prices, operators have to do a better job of providing information to customers. Stakeholder engagement is a crucial dimension for the development of trust and engagement in public policies (OECD, 2015). A holistic approach should be considered by the public authorities of water sector, the government and water utilities to improve consumer awareness, tackling these misperceptions as well as the general lack of information.

Additionally, pricing policies should address not only price perceptions, but also acknowledge that the timeless discussion about marginal and average water price seems to have low perceived relevance for water consumers in terms of influencing their consumption, probably because of biases affecting their decisions (Umpfenbach, 2014). The total monthly water bill could emerge as a key element in the development of future policy making in water sector. In chapter 4, we will discuss factors that could explain the formation of reference points, such as reference price, consumption and bill.

4. WATER CONSUMER BEHAVIOURS AND PERCEPTIONS

4.1 Introduction

Several studies have focused on water-saving behaviours based on indoor and outdoor water uses (Grafton, 2014; Nauges, 2014; Grafton et al., 2011), but only some accounted for the potentially different explanatory factors of indoor and outdoor water conservation choices (Dupont and Renzetti, 2013), according to our review of the literature (table B.1, in appendix). Two surveys by the OECD (Organisation for Economic Cooperation and Development) collected information about ten and twelve thousand households in ten and eleven countries, respectively, (OECD, 2014, 2011) and were the basis for a large part of the studies in the literature review conducted. Dupont and Renzetti (2013) were an exception using data at local level, namely the Households and the Environment Survey (HES) performed by Statistics Canada in 2006.

Typical indoor water-saving behaviours are closing the tap while brushing teeth, taking showers instead of baths, plugging the sink while washing dishes and washing full loads. Conventional outdoor water uses include rainwater collection or wastewater recycling, and watering the garden in the coolest parts of the day as pro-environmental and water conservation behaviours. The literature also focuses on water-efficient appliances and on the factors influencing the household's probability to invest in these equipments such as pro-environmental attitudes, dwelling ownership, and policy variables (Millock and Nauges, 2010). The importance of socio-demographic, economic, political and environmental attitudinal and behavioural factors to enhance pro-environmental consumption and purchase behaviours has also been recently highlighted (Sánchez et al., 2015). These authors found that environmental attitudes (opinion of respondents on statements about the environment), left-wing political ideology and the level of environmental information of the consumers have a positive effect on pro-environmental behaviours. Another factor that can impacts pro-environmental behaviours is Media, specifically news about water such as water scarcity or water-saving campaigns. Queiroz et al. (2012) consider this factor, but only for the household's decision whether to drink tap water, and not for water-saving behaviours. Overall, the main focus of studies has been either about pro-environmental consumption (*i.e.* general water-saving behaviours),

purchase behaviours (*i.e.* investment in water-efficient equipments) household and respondent determinants, as well as climate factors for outdoor water conservation choices. However, information about the water bill and consumer perceptions is underinvestigated. The literature on indoor water conservation choices focuses mainly on specific behaviours and uses data from OECD surveys in several cases. Our work is the first to explore the factors that may explain the household's likelihood to adopt modern billing methods, and we propose some new factors to explain water-saving behaviours, such as variables of consumer perceptions and attitudes. We also analysed the household's probability to adopt other indoor water conservation behaviours, such as closing the tap while soaping in the shower and washing full loads of laundry. Moreover, we study the household's probability to adopt outdoor water-saving habits, commonly covered in this field, namely whether the dwelling has a water deposit/tank or even a laundry tub to harvest rainwater and whether the garden/backyard/vegetable garden is watered in the morning or the evening to avoid evaporation. Furthermore, we also study the factors affecting the household's probability to submit meter readings to the water utility and to pay the water bill by direct debit.

As noted in chapter 3, a puzzling question within water demand studies is the high level of price unawareness (Frondel and Messner, 2008; Carter and Milon, 2005). These studies found that more than 85% of their samples were not aware of the marginal prices they paid which compares with 92% in our sample (see section 3.4.2 for details). Nevertheless, the bill is commonly known by water consumers (Martins and Moura e Sá, 2011; Tralhão, 2011). These authors pointed out values around 90% of their samples[31]. Overall, the total amount billed is generally known, but the unit water price, marginal or average, is not.

It would be interesting to understand the factors that influence consumers perceptions about the total amount of their bill, the average price and the consumption levels. These perceptions may also be seen as reference points, such as those commonly used in prospect theory to divide the space of outcomes of the value function into gains and losses (Kahneman and Tversky, 1979). These (neutral) reference points are consumer anchors for given outcomes, commonly assumed to be status quo values, but which can be also be formed in other ways[32]. Our main aim is not to cope with reference points, but to shed new light into the formation of such points for water costumers.

Martins et al. (2015) discuss the determinants of consumer awareness about

31. The majority of the sample in our database (87%) try to come up with an estimate of the average level paid for their bill.

32. Reference points may be an expected or desired level. Reference points may change and, consequently, be different from status quo, for instance the change in the monthly salary when an unexpected tax increase occurs(Kahneman and Tversky, 1979).

the water bill through an equal-weighted index with three components: i) total amount paid, ii) consumption and iii) tariff scheme. The latter, is based on the actual knowledge of the consumers about: i) services charged along with water supply, namely wastewater and solid waste, ii) presence of increasing block rates, and iii) the accuracy of the respondent about the about the average price. The authors found that income negatively impacts on awareness, and factors such as education, number of water-using appliances and looking more often to the water bill have a positive impact. Our study differs from the previous one, since it focus on the formation of reference points, rather than consumer awareness. Thus, our goal is to understand the determinants that influence people to have an internal reference for price, consumption and bill, a behavioural pricing issue, specially focused on the relation of perceived price fairness with reference points (Somervuori, 2014; Krishna, 2009).

In our database, the perceived price fairness, measured through the statement "The tariffs charged for an essential good such as water are unfair" was answered by 93% of the respondents, when only 7% know their average price. This is a puzzling fact, since even after failing to show they know the water prices, they still have fairness concerns. The mental processing of the price in the consumers mind is dependent upon exposure to price information (Cheng and Monroe, 2013), although residential water consumers do not seem to be exposed to it. There are many potential explanations for this finding, such as the lack of clarity and price information in water bills (Martins and Moura e Sá, 2011; Gaudin, 2006), weak data quality (Moura e Sá and Martins, 2014), numeracy and literacy issues (Martins and Moura e Sá, 2015) and the fact that numerical information processing is not objective, but rather abstract in nature (Cheng and Monroe, 2013)[33]. All these potential factors, as well as idiosyncratic explanations related with municipalities where consumers are located, can play a role. Nonetheless, if consumers have higher bill awareness rather than average price, it is possible to hypothesize that consumer price fairness perception has an impact on bill perception, as a proxy to the "value" of water. In the case of poorly-informed consumers, their minds may frame perceived bill as the reference price, while well-informed consumers would know both their reference bill and average price.

Overall, in this chapter, we specifically address the following questions: What factors influence the water consumer's probability to have reference points for price,

33. Firstly, the authors state that the internal reference price are not directly observable, but suppose two numbers equidistant from a reference point, in numerical terms, are perceived to be closer to this reference if they are larger rather than smaller (Kahneman and Tversky, 1979). One example of this asymmetric perception is if the reference price is 10 Euros, then between 15 and 5 Euros, the higher value is typically perceived as closer to 10 Euros, although the price difference is equal.

consumption, and bill? Is perceived price fairness a factor affecting the formation of reference points? If so, what are its effects on the formation of perceived average water price and bill? Besides the conventional determinants used in this literature, what perception factors affect the household's probability to adopt outdoor and indoor water conservation behaviours and opt for modern billing standards? Finally, why do some consumers prefer to drink tap water instead of using alternative sources?

In order to determine the household's probability to adopt outdoor and indoor water conservation choices and modern billing standards, we used a binary probit model, with and without sample selection and instrumental variables probit models, common methods in this literature (Nauges, 2014; Dupont and Renzetti, 2013; Grafton et al., 2011). Probit and special regressor models were applied to study the respondent's probability of being aware of the reference points. The modelling framework is described in section B.1.1. The distinction between household and respondent probabilities is mainly due to the fact that water conservation choices, as well as other choices within the dwelling reflect a common behaviour within the household. Nevertheless, perceived values, such as reference points, are less likely to have such general nature and be common knowledge within the household, since each household member will have idiosyncratic internal references.

Furthermore, in the preliminary analysis we included dummy variables for water losses or leakages, or any interruption in the water supply service, in the previous year. These factors were tested, since interruption in water supply, might influence water saving behaviour. For example, if you have a lot of interruptions you have a greater incentive to use a tank, if you can, to get alternative water. Losses or leakages could affect the probability of adopting the water-saving behaviour.

In section 4.2, we discuss the main factors influencing conservation choices of residential water consumers and choice to drink tap water through a brief literature review. In section 4.3, we describe the empirical results about the formation of reference points, the probability to adopt conservation behaviours and more modern billing methods, as well as drinking tap water, based on the analysis of the average marginal effects. Plus, we perform robustness tests of endogeneity. In section 4.4, we present the conclusions and discuss the potential avenues for future research.

4.2 Literature review

4.2.1 Determinants of water-saving behaviours

The brief literature review summarized in table 4.1 highlights four groups of variables of interest used in water-saving behaviour studies using: i) household and respondent variables, ii) attitudinal and behavioural factors, iii) political variables and iv) climate

variables (see table B.1, in appendices, for details). Consumption perception variables, have not typically been used to explain water-saving behaviours in this literature. Moreover, there is scant evidence of studies on billing practices. The respondent's probability of being aware of reference points, namely, reference price, monthly consumption and bill about tap water has also not been covered.

Tab. 4.1: Brief review of type of variables used in studies of water-saving behaviours

Studies	Household and respondent	Attitudinal and behavioural factors	Political factors	Climate factors
(Grafton, 2014)	✓	✓	✓	-
(Nauges, 2014)	✓	✓	✓	-
(Dupont and Renzetti, 2013)	✓	-	✓	✓
(Grafton et al., 2011)	✓	✓	✓	-

Source: author's analysis.

Household and respondent determinants

Explanatory variables applied in these models typically include: total monthly household income, a dummy variable for the existence of a volumetric charge, household size, dwellings with at least one children, house ownership, urban area, as well as individual characteristics such as age, education and gender (Grafton, 2014; Nauges, 2014; Dupont and Renzetti, 2013; Grafton et al., 2011). On the other hand, there are less usual specific regressors, such as the number of years in the current residence (Grafton, 2014; Nauges, 2014), the number of rooms in the dwelling and the type of dwelling, highlighting if it is a detached house or other type of house (Grafton et al., 2011). Dupont and Renzetti (2013) used additional factors, such as the marginal price of water as well as the price variation, although it is the only study in our review that does not include information about attitudinal and behavioural factors.

Attitudinal and behavioural determinants

There are different ways to account for attitudes and behaviours. Some studies assess attitudes on environmental issues and the "environmental concern" index (Grafton, 2014; Nauges, 2014; Grafton et al., 2011). We accounted for household pro-environmental opinions, namely whether the respondent agrees or disagrees with the statement "Water should be more expensive where it is scarcer". Following the literature on perceived price fairness (Diller, 2008), we tested in the preliminary analysis fairness concerns about water price, namely whether the consumer is in agreement or disagreement with the statements: i) "The water price should be

increased if the water utility incurs in a loss", ii) "The price you pay for water is fair" and iii) "the tariffs charged for an essential good such as water are unfair".

Policy and Political determinants

Several articles have used policy and political variables, such as the non-price water policies (Dupont and Renzetti, 2013), the fact that the respondent is a voter in the last elections and an environmental organization supporter (Grafton, 2014; Nauges, 2014; Grafton et al., 2011), as well as an environmental organization member (Grafton et al., 2011). Overall, the political determinants such as election participation or collaboration within environmental organization, either as a supporter or a member, typically have a significant positive impact on the household's probability to adopt water-saving behaviours. However, database does not include such variables, therefore these effects were not tested in this research.

Climate determinants

Climate variables are not common in studies of the probability to adopt indoor and outdoor water-saving behaviours. In indoor water uses, the explanatory power of climate factors is questionable, although outdoor water conservation choices are expected to be affected by precipitation (rainfall) and temperature. Dupont and Renzetti (2013) used total precipitation (rainfall) in the household area, number of days with average daytime temperature above 18 Celsius degrees (degree days), and average daytime temperature, all variables calculated for summer months (June, July and August). The authors found that rainfall and degree days have, respectively, a negative and positive statistically significant impact on the frequency of lawn and garden watering during the summer months, based on a bivariate ordered probit model with instrumental variables. Nevertheless, the average daytime temperature was not significant.

Consumption perception determinants

This topic is novelty in the literature. Some studies discuss the low level of knowledge about key elements of the water bill (Martins and Moura e Sá, 2011; Tralhão, 2011), but so far no attempt has been made to analyse their potential impacts in water-saving behaviours. We hypothesized and tested consumer perception variables in the preliminary tests to understand their impact on water conservation choices. One of the variables selected was dummy perception variable on whether consumers know that their tariff structure is an increasing block rate (IBR), in order to test whether those who know it behave differently. Moreover, factors that make the

information and knowledge about the water bill salient were studied. We also tested dummy variables based on whether consumers answered survey questions about their perceived values of average price (*referenceprice*), monthly water consumption (*referencecons*) and monthly bill paid (*referencebill*), *i.e.* whether they have reference values for these. Furthermore, we check if consumers are aware of their average perceived water bill total (*percbillt*).

4.2.2 Determinants of the decision to drink tap water

A question that has been puzzling to water resource economists is why consumers buy bottled water instead of drinking tap water. Indeed, the bottled water market continues to growth rapidly (Jakus et al., 2009; Doria, 2006), although some articles argue that it is environmental unsustainable due to the waste and the fossil fuel pollution related with packaging and transportation (Arnold and Larsen, 2006; Wilk, 2006). The global average consumption per capita of bottled water increased from 17.8 to 33.3 litres, with Portuguese bottled water consumption per capita increasing from 71.5 litres in 2000 to 90.5 litres in 2011[34]. Bottled water can cost hundreds or thousands of times more than tap water, while tap water could have superior quality, see for example the literature reviews from Johnstone and Serret (2012), Jakus et al. (2009), and Doria (2006). Yet, bottled water is perceived as having higher quality and being more healthy than tap water (Ferrier, 2001), possibly due to Media reports on the perceived quality of tap water (Queiroz et al., 2012). Overall, the risk perception related to adverse health concerns (Zivin et al., 2011; Jakus et al., 2009) and quality perception have been the major topics in this literature, although there is a complex set of factors affecting consumer perception of water quality, including demographics and cultural background, trust in the water utilities, prior experiences, sensorial information (organoleptics) and impersonal and interpersonal information, just to point out a few (Doria, 2010). Nevertheless, no study has yet approached the impact of perceived tap water price and consumption perception variables on the discrete choice between tap and bottled water consumption. Our contribution to this subject differs slightly from the aforementioned studies by looking at the choice of drinking water from the tap versus other sources (including bottled water).

The typical models used to perform such studies are binary probit (Francisco, 2014; Johnstone and Serret, 2012; Um et al., 2002) or multi-nominal probit models (Johnstone and Serret, 2012), if the dependent variable is categorical, *e.g.* the use of bottled water, use of filtered water or both is one example. According to the literature review, we categorize the explanatory variables in groups and test their

34. Source: Authors calculation based on the industry statistics of Beverage Marketing Corporation, *http://www.bottledwater.org*, accessed on 17 August 2015.

statistical significance in our database.

The brief literature review highlighted in table 4.2 shows three groups of variables of interest in these studies: i) household and respondent characteristics, ii) water quality and iii) trust variables, in which the checkmarks denote the type of variables used in each study to estimate the probability of drinking tap water or purchasing bottled water (see table B.2 for details). The variables will be detailed in the next sections.

Tab. 4.2: Brief review of the type of variables used in studies about the decision between drinking tap water or alternative sources

Studies	Household and respondents	Water quality	Trust
(Bontemps and Nauges, 2015)	✓	✓	-
(Francisco, 2014)	✓	✓	✓
(Nauges, 2014)	✓	✓	✓
(Johnstone and Serret, 2012)	✓	✓	✓
(Um et al., 2002)	✓	✓	-

Source: author's analysis.

Household and respondent variables

A common group of regressors or explanatory variables used in these models include: monthly household total income or logarithmic income, household size and dummy variables for administrative areas and to distinguish urban from rural regions, as well as individual characteristics such as age, education, gender and children (Francisco, 2014; Nauges, 2014; Johnstone and Serret, 2012; Um et al., 2002). Interestingly, there are other specific variables: the price of bottled water and the presence of children between 0 and 5 years and 6 and 18 years (Francisco, 2014). An environmental concern index (Nauges, 2014) has been used, but with mixed results in terms of statistical significance; and car ownership due to the time costs of buying and transporting bottled water (Johnstone and Serret, 2012), and the influence they have on the consumer's decision. Finally, Um et al. (2002) consider monthly average water bill, type of house, the use of a water tank or water shortages.

Water quality variables

Water quality variables are typically important determinants of the choice between tap and bottled water. Variables about the satisfaction with the quality of tap water, concerning both the taste and the impact on health are common (Nauges, 2014; Johnstone and Serret, 2012). Other studies include a dummy if water is safe to

drink without treatment (Francisco, 2014), expectations about the water quality and quantity, the perceived relevance of tap water or previous unpleasant experiences when drinking tap water (Um et al., 2002). We use ERSAR water-quality data by municipality to collect a time-series from 1993 to 2012 in order to create one variable based on the percentage of tests not complying with the limits imposed in the quantity of chemicals in the water. The water quality variable related to violation in chemical parameter values is expected to be relevant, since, drinking water quality violations are more common than other form of pollution (Zivin et al., 2011), or at least more common detected because tests are mandatory.

Trust variables

Several studies used trust variables in their research, such as the trust level about the environmental impacts of products (Nauges, 2014); the trustworthiness of government entities in terms of environmental concerns, when compared with alternative information sources, like NGOs (non-governmental organisations) and consumer associations (Johnstone and Serret, 2012); and the perceived trust based on government information about safe water (Francisco, 2014). Such trust variables are used to analyse how trust effects affect the decision to drink tap water. Nevertheless, in general, these variables have turned out to be statistically insignificant, with the exception of the environmental impacts of products (Nauges, 2014). Although our survey did not include trust specifically, the questions included fairness concerns. We included in the preliminary analysis two questions about perceived price fairness that account for salience to fair and unfair tariffs: "The price you pay for water is fair" and "The tariffs charged for an essential good such as water are unfair". The consumers' responses to these questions ranged from totally disagree to totally agree (based on the widely known Likert scale, from 1 to 5). Analysis of the determinants of perceived price fairness on residential water sector is scarce and we will discuss this topic in chapter 5.

Consumption perception variables

Water consumption variables related with information about the bill, information clarity and consumer perception, such as perceived water price, consumption and bill, are not typical in this literature (see table B.2, in appendix). Based on our data, we used consumer perception variables to understand their impact in the decision to drink tap water. For instance, the unit charge is often used in probit models as a dummy variable to reflect whether water consumption is charged on a volumetric basis (Nauges, 2014; Johnstone and Serret, 2012). In Portugal, on the other hand, all water utilities charge on a volumetric basis. We also created dummy variables based

on whether or not the consumer answered survey questions about reference values of average price (*referenceprice*) and monthly water consumption (*referencecons*); this is equivalent to checking whether consumers have reference values for their average water price and monthly consumption.

4.3 Results

4.3.1 Analysis of the probability of formation of reference points by residential water consumers

The following results used the database previously described in section 3.4 of chapter 3. In this study, we are also interested in factors that influence whether consumers have perceptions about their relevant reference points, such as perceived bill, average price or consumption level. The total amount paid seems to be more salient to consumers than water price, according to chapter 3. Despite low consumer awareness about the average water price, the majority of consumers have an opinion on perceived price fairness, *i.e.* the question "The tariffs charged for an essential good such as water are unfair" was answered by 93% of the respondents. Surprisingly, and coincidentally, 93% do not know their average prices. Our work also tries to address this puzzling question, *i.e.* how can consumers that do not know their average prices have price fairness concerns? Does this fact have consequences on the formation of a price reference does it also impact other reference points?

Kahneman's work (Kahneman and Tversky, 1979) on prospect theory, had other extensions, one of which concerns perceived price fairness (PPF), which evolved from his work on the reference transaction (Kahneman et al., 1986b). PPF has been used in several approaches, from its genesis in the evaluation of justice standards on price, income and earnings (Kahneman et al., 1986b) to comparison of several rules for allocation of scarce resources (Raux et al., 2009), as well as the analysis of the PPF antecedents, *i.e.* determinants that lead consumers to construct a perception on price fairness. The has been analysed from the point of view of marketing and management sciences (Krishna, 2009; Diller, 2008). To address the subject, we use two of the fairness questions about PPF included in the survey[35]. The chosen questions were "The price you pay for water is fair" and "The tariffs charged for an essential good such as water are unfair". We create a dummy variable that aims to make salient the most extreme answers about price fairness (*fairprice* variable), *i.e.* consumers who answered "totally agree" to the former question and and "totally disagree" to the latter. We used probit models to assess the impact on the existence of internal consumer references about the average price, the volume consumed and

35. See appendix E, table E.4 for additional information

the total amount billed (the *referenceprice*, *referencecons* and *referencebill* variables), which are discrete variables. We also used special regressor models to account for potential endogeneity in two explanatory variables, the price fairness perception (*fairprice*) and whether consumers know they are facing an IBR tariff structure (*knowIBR*).

The summary statistics of the explanatory variables used in these models are shown in table B.12, in the appendix B. We used the special regressor model of (Lewbel, 2014) to account for the potential endogeneity problem. We also took into account possible multicollinearity issues. The special regressor modelling framework is described in section B.1.2. This model has some advantages (Dong and Lewbel, 2015), such as allowing for endogenous binary variables, as well as other discrete choices such as ordered and multinomial as well as accounting for heteroskedasticity of unknown form (Lewbel, 2000). Covariates can be continuous, limited, censored or discrete (Dong and Lewbel, 2015). In our case, we have two discrete binary variables that we suspect about endogeneity (the case of *fairprice* and *knowIBR* variable).

The use of the special regressor method requires the use of a special regressor V satisfying some assumptions. We selected as special regressor the fitted values of an auxiliary regression explaining household income from other covariates in our sample (*incfitted*)[36], which were then normalized to explain the formation of three reference points under study. We found support for the continuous distribution of the original variable *incfitted* (ranging from 0.5 to 8.1) (see table B.9, in appendix). These special regressors can be considered to be exogenous, since the linear prediction of income in our sample is not likely to be influenced by the three reference points proposed, and are expected to have a monotonic and increasing relationship with the reference variables of interest (*i.e. referenceprice*, *referencebill* and *referencecons*). As describe in section B.1.2, the expected value of the dummy reference variables (D) conditional on the covariates X of the model ($E(D \mid X, V)$) should increase with special regressor V. For prove the monotonic relation we used the Kernel-weighted local polynomial regression following Bontemps and Nauges (2015).

On figures B.1 and B.3 in appendix B.7, we used the demeaned value of *incfitted* as the special regressor for reference price and consumption, respectively, defined as *incfittedd*). Since we expected the probability of having a reference of the water bill to decrease with the income level, the special regressor in this case was defined as *mincfittedd*, describe as minus *incfitted* demeaned (see figure B.2 in appendix B.7).

36. We used an OLS regression of the income variable explained by the variables level of schooling, male, household size, percentage of employed and retired members by household size, owner of the house, having a pool, and the number of tap and dishwashers. We used heteroskedasticity-robust standard errors (henceforth robust standard errors) and sampling weights based on the percentage of the dwellings divided by the sample percentage of questionnaires. For additional information see the list of variables descriptions B.3 and the regression in table B.7 (in the appendix).

We provide graphical evidence supporting the increasing monotonic relationship for the three cases, with 95% confidence interval (CI) bands.

The weak-instrument-robust test (Anderson-Rubin Wald test) and the Hansen J statistic of overidentification test are not rejected for the three different reference points[37]. After performing these tests the following instruments were selected: if the respondents agree or disagree with the statements "The water price should be increased if the water utility incurs a loss" (loss) and "Water tariffs should be equal in all the country" (uniform), the numbers of years of schooling of the respondent (school), the percentage of actual average monthly bill in the income fitted (afford) and the number of payers of the water bill in the household (payers).

The average index values[38] (marginal effects at means) and the probit models[39] are presented, respectively, in tables B.10 and B.11, in the appendix, and the null hypothesis of exogenous variables was never rejected in post-estimation tests of the special regressor method. This provides us evidence of no endogeneity of *fairprice* and *knowIBR*[40].

The average marginal effects of the relevant regressors are shown in table 4.3 (see table B.14 in the appendix B.8 for probit model results).

Overall the most robust variables to explain the probability of having reference points are whether the consumer is often or always aware of the detail in the water bill (*freqdet*), whether he knows his tariff structure is IBR (*knowIBR*), and

37. The results of the tests were i) Reference price: no evidence of weak instruments ($F(5, 1615) = 1.05$, with $Prob > \chi^2(1) = 0.384$) and no overidentification ($\chi^2(3) = 2.21$, with $Prob > \chi^2(3) = 0.530$), ii) Reference bill: no evidence of weak instruments ($F(5, 1615) = 1.04$, with $Prob > \chi^2(1) = 0.391$) and no overidentification ($\chi^2(3) = 3.69$, with $Prob > \chi^2(1) = 0.30$), and iii) Reference consumption: no evidence of weak instruments ($F(5, 1615) = 0.83$, with $Prob > \chi^2(1) = 0.527$) and no overidentification ($\chi^2(3) = 1.7$, with $Prob > \chi^2(3) = 0.637$).

38. The marginal effects for the special regressor methods were calculated using the average index function (AIF), given its main advantage over average structural function (ASF), the easy of estimation (Lewbel et al., 2012). For recent critic and detailed explanation about AIF and ASF see Lin and Wooldridge (2015).

39. In the case of special regressor the Stata command *sspecialreg* was used. The models used standard kernel density approach, the Silverman's rule of thumb for automated bandwidths, instead of manual selection of bandwidths. We used trimming, *i.e.* ignored extreme values, since our assumption was that outliers do not represent the distribution under analysis. Thus, to deal with outliers we use the *trim* option at 5% level, so we trimmed using a common level of the ninety-fifth percentile (Ghosh and Vogt, 2012).

40. The results of the relevant tests reveal that *fairprice* and *knowIBR* are endogenous regressors. The null hypothesis of Wald test of exogeneity is not rejected for *referenceprice* ($Prob > chi2 = 0.221$), *referencebill* ($Prob > chi2 = 0.282$) and *referencecons* ($Prob > chi2 = 0.798$). The results of other relevant tests for *referenceprice* were Durbin (score) tests $chi2(2) = -6228.14$ with $p - value = 1.00$ and Wu-Hausman test $F(2, 1536) = -614.482$ with $p - value = 1.00$, for *referencebill* were Durbin (score) tests $chi2(2) = -5852.51$ with $p - value = 1.00$ and Wu-Hausman F test $(2, 1536) = -606.698$ with $p - value = 1.00$ and finally for *referencecons* were Durbin (score) tests $chi2(2) = -2944.32$ with $p - value = 1.00$ and Wu-Hausman test $F(2, 1536) = -502.461$ with $p - value = 1.00$. All the tests point to no endogeneity in any reference-point specification. Although, in the reference price the model is only globally significant at 5% level (see table B.11, in appendix). One potential reason to explain this is that *referenceprice* is a rare event, representing only 7% of the sample (chapter 3).

Tab. 4.3: Average marginal effects of the probability to have consumer perception awareness based on reference points

Variables	referenceprice	referencebill	referencecons
incfitted	0.025***	-0.019**	0.024*
	(0.008)	(0.009)	(0.014)
freqdet	0.055***	0.059***	0.121***
	(0.016)	(0.016)	(0.025)
knowIBR	0.060***	0.035**	0.188***
	(0.017)	(0.017)	(0.026)
fairprice	-0.085**	0.082	0.072
	(0.040)	(0.062)	(0.106)
urban	-0.052***	0.011	-0.055*
	(0.017)	(0.020)	(0.030)
meter	0.017	0.028	0.171***
	(0.017)	(0.020)	(0.030)
Observations	1,660	1,700	1,700

Standard errors in parentheses. Average marginal effects for probit models were calculated using Stata command *margins*.
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' computations using Stata 12.1

the linear prediction of income (*incfitted*). Since higher-income households have more purchasing power, their total water expenses could represent a small share of their household disposable income. In a country characterized by an acceptable affordability (Barata et al., 2015; Martins et al., 2013) having a reference bill seems to be neglected, because expenditures with water utility services represent less than 1% percentage of the household disposable income, on average (ERSAR, 2014c).

The other two variables seem to reflect that a well-informed consumer has a higher probability of forming a reference price, consumption or bill, at 1% significance level (SL) in almost all cases. The probability of having a reference consumption increases by 0.19 (19 percentage points), if the respondent knows he's facing an IBR, at 1% SL. The magnitude of the impact of *knowIBR* is smaller for reference bill and price representing an increase in the probability to the formation of this reference, between 0.04 and 0.06, respectively. Thus, people that know their price structure are more likely to have reference points. People who only look to the total amount paid may probably have less information than others, which could be related with the creation of references in their minds. Moreover, consumers that look often or always for the water bill, including the detail are more likely to have reference points by 6 to 12 percentage points.

The variable about the consumer opinion whether the water price is fair

(*fairprice*) has a negative impact on the probability of formation of a reference price, at 5%, and is insignificant in explaining the probability of having a reference consumption or bill. This may reflect, that people only create references when there is a negative evaluation in fairness judgement, as suggested by behavioural pricing literature (Rutte and Messick, 1995; Somervuori, 2014). In fact, Xia et al. (2004) suggest that fairness and unfairness may be represented by distinct variables of interest, since they could be different constructs. Although in marketing theory consumers are assumed to maximize utility, when fairness is incorporated there is evidence that social preferences may also play a role in consumer behaviour (Krishna, 2009; Ho et al., 2006). Moreover, consumers are not constantly concerned about fairness (Somervuori, 2014) and have uncertainty about the fair price (Cheng and Monroe, 2013). People only search for a price comparison, using a reference when there a negative evaluation or a surprising situation (Bechwati et al., 2009). This topic will be explored in more detail on the chapter about PPF (chapter 5).

The *urban* variable seems to positively affect the formation of reference price, since for people leaving in urban areas the probability to create a reference price is 5 percentage points lower in comparison with consumers from rural and semi-urban areas. As expected, the probability of formation of a reference-consumption value increases by 0.17 (17 percentage points) for consumers that submit the meter readings. Naturally, people who report their water consumption to the water utility are trivially more likely to have a reference value for consumption.

The mental processing of the price, as well as monthly water consumption and bill, in the consumer's mind is dependent upon consumer exposure to price information (Cheng and Monroe, 2013). But other factors such as submitting the meter readings and water bill information could also influence this process. These evidences could be an important issue for residential water consumers because they do not seem to be exposed to enough water price and monthly consumption information, according to our sample (chapter 3). The lack of clarity and price information in water bills (Martins and Moura e Sá, 2011; Gaudin, 2006), as well as numeracy and literacy issues (Martins and Moura e Sá, 2015) may contribute to this phenomenon. Overall, more well-informed consumers seem to be more likely to have the reference points analysed in this section and PPF appears to be significant to explain reference price, after accounting for endogeneity bias.

4.3.2 Analysis of the probability to adopt outdoor water-saving behaviours

We had two dummy dependent variables summarizing concerns about avoiding evaporation when watering any type of garden (*wswatgarden*) and using a laundry tub or water deposit/tank to collect/harvest rainwater (*wstank*). The use of a water

deposit/tank is a water-saving equipment used by the consumers, but we considered the question a behaviour in the sense that they collect water from that equipment, therefore contributing to water conservation in their dwellings. Around 7% of the sample had a tank (non-response rate of 0.2%) and 85% watered the garden in the coolest parts of the day to avoid evaporation from those who have a garden (non-response rate of 6%). In the latter case, we hypothesized the existence of sample selection because 64% of the sample stated that do not have any kind of garden. The first study to address sample selection within this context was Nauges (2014)) which recalls that if a dependent variable is observed only for a limited and non-random sample there might be a sample selection bias. In residential water-saving behaviour studies, only respondents with a garden could answer this question, so the sample selection problem should be accounted for. We use a probit model that accounts for this selectivity issue[41]. The modelling framework is described in section B.1.1.

The summary statistics of the final determinants used in the probit models are in table B.12, (see table B.3 for probit model results). The marginal effects of the variables with impact on the probability of the outdoor water-saving behaviours are shown in table 4.4 (see the appendix B for probit model results, table B.15). The results are based on the estimated average marginal effects of the regressors of the probit model of table 4.4. We account for sampling weights differences, using weighted probit models by municipality[42] and robust standard errors.

The probability of collecting rainwater in a laundry tub or water deposit/tank (*wstank*) is positively influenced by 9 percentage points by the fact that type of dwelling is a detached or semi-detached house instead of an apartment (*dwetype*), in line with this literature (Grafton et al., 2011). The increase of the number of taps in the dwelling (*tap*) has a positive impact in *wstank*, but not on *wswatgarden* reflecting concerns to control water consumptions. Moreover, we found that *well*, has a positive impact on *wstank*. Consumers which have an alternative to publicly supplied water are more likely to collect rainwater by 0.05 (5 percentage points) compared with people who do not. Collecting water from alternative sources may be reflects money saving concerns, and individuals which are more likely to use a method to collect rainwater. Finally, *avcons6m* has a significant negative impact on the probability to adopt this outdoor water-conservation behaviour. This may suggest that water consumption is steady, and normally constant over time, and this regressor could represent a proxy for this. Overall, we get the expected signs although the low level of people with tanks (7% of the sample) in the sample limits the generalization of the

41. Stata command *heckprob*, also known as *heckprobit*, fits maximum-probability probit models accounting for sample selection bias.

42. Sampling weights by municipality are defined as the percentage of the dwellings (dwellings by municipality / total number of dwellings) divided by the sample percentage of questionnaires (questionnaires by municipality / total number of questionnaires).

Tab. 4.4: Average marginal effects of the probability to adopt outdoor water-saving behaviours

Variables	wstank	wsgarden
dwetype	0.086***	
	(0.018)	
tap	0.004**	0.005
	(0.002)	(0.003)
well	0.048***	0.014
	(0.013)	(0.028)
children	0.000	-0.070**
	(0.014)	(0.030)
elder	0.003	-0.048**
	(0.009)	(0.021)
inactive	0.020	0.041*
	(0.013)	(0.024)
percbillt	-0.000	0.003***
	(0.001)	(0.001)
unfairprice	-0.008	-0.109***
	(0.018)	(0.034)
avcons6m	-0.004***	
	(0.001)	
watsummer		0.025***
		(0.007)
Observations	1,609	502

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

results and the estimates about the other explanatory variables, which was expected given the low number of observations of this behaviour within the sample.

The decision to water in a way that reduces evaporation (*wswatgarden*) could be conditional on sample selection (Nauges, 2014). We used the Heckman probit model to account for potential sample selection, in our simple probit model presented. The null hypothesis of the Wald test (or probability-ratio test) of independence between the main equation and selection equation is not rejected ($\chi^2(1) = 0.37$, with $Prob > \chi^2(1) = 0.543$), as described in the appendix, table B.17. The chosen instruments were number of washing machines (*washmach*), dwelling with a pool (*pool*), and income fitted (*incfitted*)[43].

The regressors with significant influence have the expected signs: negative impact of the number of household members with 65 or more years of age (*elder*) (Grafton et al. (2011) used a similar variable, *i.e.* number of adults in the household), as well as *children* (not significant in the case of Grafton et al. (2011) for this particular behaviour). More elders in the household decreases the probability by 0.05 (5 percentage points), at 1% SL. The presence of children also has a negative impact of 7 percentage points and the number of inactive members in the household has a barely significant positive impact of 4 percentage points. Inactive people may have more free time, and thus more flexibility to watering the garden in periods that reduces evaporation.

Perception variables *unfairprice* and *percbillt* seem to be strongly significant, at 1% SL. The fact that tariffs are perceived as unfair by water consumers has a negative impact of 0.11 (or 11 percentage points) on the probability to adopt this conservation behaviour, comparing with people that do not totally agree with the statement about price unfairness. This reveals that people who perceive tariffs as unfair have lower concerns in watering during the morning or evening to avoid evaporation to save water. The perceived bill (in €) had a positive impact increasing the household's probability by the instantaneous rate of change of 0.0034[44]. So for an 1% increase in the perceived bill, the probability of the decision to water in a way that reduces evaporation increases by 0.34 percentage points. The perceived bill effect may reflect money-saving concerns, since water consumers are normally aware that watering

43. The validity of instruments was confirmed using the Hansen test to control for overidentification and the C-statistic test for orthogonality (exogeneity) of the selected instruments (Baum, 2006). According to the literature some of the instruments used in selection equation were dummy variables related with urban area, ownership status, employee status and household recycling of glass containers or bottles (Nauges, 2014)

44. We calculate this value by changing the *percbillt* by a very small amount (*delta*), *i.e.* the standard deviation of the variable divided by 1,000. Afterwards, we computed the predicted value for the original case (*prediction*1), and for the case with the small variation (*prediction*2). Finally, we compute the $(prediction2 - prediction1)/delta$ to get the average marginal effect of the continuous variable. For a detailed explanation on how to compute average marginal effects of continuous variable see Cameron and Trivedi (2010).

during the coolest periods is a high-water demanding behaviour, that could reduce their water consumption. This finding may have potential implication for public policies directed at increasing perceptions of water bills.

Finally, the number of times a week people water the garden during the Spring or Summer are evidentially important regressors to explain *wswatgarden*. Additional tests including other relevant variables in the literature revealed to be robust in our probit models provided in the table B.19, as well as in the respective average marginal effects B.18 (in appendix). The average marginal effects (table B.21) and probit models (table B.22) without sampling weights are also provided in the appendix.

4.3.3 Analysis of the probability to adopt indoor water-saving behaviours

The three indoor water-saving behaviours analysed were the choices to wash full loads of laundry (*wsfullload*), close the tap while soaping in the shower (*wssoap*) and make use of the water that flows while waiting for it to get warm (*runwat*). The proportion of respondents adopting these behaviours in our sample are 84%, 74% and 32%, respectively, with the non-response rates below 1%, except for *wsfullload* with a non-response rate of 8%. The analysis performed was similar to the previous section. The summary statistics of the variables of interest used in the models about indoor water-saving behaviours are shown in table B.12 (in the appendix).

The marginal effects of the variables with impact on the probability of the indoor water-saving behaviours are shown in table 4.5 (see table B.23 in the appendix for probit model results). The results are based on the estimated average marginal effects of the regressors of the probit model with sampling weights and robust standard errors.

The proportion of household members who are either inactive or student (*inastudent*) and the actual average water price paid during the last twelve months (July 2011 and June 2012) (*aavprice*), prior to the survey, significantly increase and decrease, respectively, the probability of wash full loads of laundry *wsfullload*, at 1% SL. The former probably shows that typically those who do not have a job try to achieve money-savings through the water saving behaviour in question. People that experience water shortages (*wshortage*) are more likely to adopt behaviour, since they have more confidence in a continuous service without interruptions. Overall the perception variables about price and bill, as well as being aware about the IBR structure positively influence the probability of adopting this behaviour. The perception about price unfairness has a negative significant effect, at 1% SL, which could reflect that fairness judgements could lead to emotional responses and negative actions (Rutte and Messick, 1995), in this case the attempt to reduce consumption. This topic will be explored in chapter 5.

Tab. 4.5: Average marginal effects of the probability to adopt indoor water-saving behaviours

Variables	wsfullload	wssoap	runwat
inastudent	0.104***		
	(0.031)		
aavprice	-0.002***		
	(0.001)		
wshortage	0.049**		
	(0.022)		
unfairprice	-0.057***		
	(0.019)		
expenscarce	-0.019***		
	(0.007)		
loss	-0.018***		
	(0.007)		
referenceprice	0.083**		
	(0.039)		
referencebill	0.051**		
	(0.020)		
knowIBR	0.036**	0.075***	
	(0.016)	(0.027)	
employed		-0.044***	
		(0.014)	
p56education		-0.216***	
		(0.045)	
heducation		-0.105***	
		(0.028)	
dettot		0.076***	
		(0.026)	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' computations using Stata 12.1

Tab. 4.6: Average marginal effects of the probability to adopt indoor water-saving behaviours (continued)

Variables	wsfullload	wssoap	runwat
dishwach			-0.088***
			(0.028)
hpayers			-0.094***
			(0.034)
male			-0.098***
			(0.027)
p16education			0.117***
			(0.030)
meter			0.131***
			(0.033)
refblockprice			0.166***
			(0.044)
aavcons			-0.005**
			(0.002)
Observations	1,761	1,927	2,037

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

Moreover, the behaviour of closing the tap while soaping in the shower is negatively affected by the number of household members who are employed (*employed*) and have a primary education (5-6 years) (*p56education*) or an higher education (*heducation*), which could be potentially explained that closing the tap while soaping is in more likely to occur in people with a less busy life, probably without a job. Higher education and primary education have both negative signs, probably because income was excluded, since it was insignificant for this behaviour. On the other hand, the perception variables seems to positively impact the probability of closing the tap while soaping. Consumers that look for the details in the water bill (*dettot*) or that know they have an increasing block rate (IBR) structure (*knowIBR*), could indicate consumers with greater awareness.

Overall, the main variables of interest have a negative impact in the probability of adopting the behaviour of using water that flows while waiting to get warmer. The number of dishwashers in the dwelling (*dishwash*) can be a indicator of the income level. The respondents that are *male* appear to be less likely to adopt this behaviour. The fact that at least 50% of the household members are payers (*hpayers*) is negatively influencing the probability to reuse the water while waiting to get warmer, maybe indicating that a small proportion of payers implies higher concerns about water-savings. The negative effect for *male* could be a country-specific effect and Grafton (2014) shows that the gender effect can be either positive or negative, related with idiosyncrasies of each water-saving behaviour. Submitting the meter readings (*meter*) and having a reference about the marginal price (*refblockprice*) of water have positive impacts in *runwat*, probably because these factors with more informed consumers that have knowledge about price and consumption, thus a type of more informed consumer that adopt water-saving behaviour in a indoor habit that is one of the most water-demanding habits in the dwellings. Finally, with a negative impact we have the actual average consumption, since people that have higher water consumption is less likely to reuse the water of the shower.

Overall the results appear to be in line with the previous studies about indoor water conservation choices (Grafton, 2014; Nauges, 2014; Grafton et al., 2011). Additional tests including other relevant variables in the literature for both marginal effects and probit models and are provided with two different specifications: without sampling weights in tables B.28 and B.29, and with sampling weights in tables B.25 and B.26. Overall, the results appears to be robust to the different specifications and regressors used.

4.3.4 Analysis of the probability to adopt modern billing standards

Water utilities have improved reporting and paying systems since these practices provide better information and potentially motivate well-informed water consumers. In a recent study, several stakeholders' perceptions were accessed (Adeyeye, 2014), through stakeholder interviews, from water utilities and NGO (Non-Governmental Organisations) to policy makers and regulatory authority. Some of the points raised in this study were that: i) meter reading requires providing information, but can help in mitigation of household water bills, and concerning water utilities, ii) more transparency is needed on water bills and iii) incentives to direct debit systems, such as the offer of a discount, are seen as improvements to customer service. There is scant literature on these behaviours in the water sector, although a recent field study for the electricity sector (Barnicoat and Danson, 2015), based on interviews to older people in rural Scotland, found that the majority of these consumers are aware of their monthly energy payments, even when using direct debit. This seems to be related with elderly households placing more importance on money savings, although they have lower levels of energy-saving behaviours and lower knowledge about energy use (Mills and Schleich, 2012). In spite of the recognition of the importance of service innovation (such as payments through direct debit) and improvement of customer involvement and knowledge in water sector (through the use of a water meter reading app, an application or software with a specific purpose, for example) (Hoffjan et al., 2014), these services have received little attention in water-saving related studies. The adoption of behaviours such as having an electronic water bill or paying the water bill through direct debit, is fairly neglected in the literature, probably because they are relatively new technologies. Our study provides empirical evidence on two such behaviours: the voluntary registration to pay the water bill by direct debit (*ddebit*), and wether the respondent receives an electronic bill, only for municipalities offering this service in 2012 (*ebill2012*). The adoption rates of these behaviours in the sample were 48% and 3%, respectively, with the non-response rates below 2%. Overall, the electronic bill seems to be an information method that is not preferred by the majority of the respondents in our sample. The summary statistics of the variables of interest used in the models about modern billing standards are shown in table B.12, in appendix B.

The average marginal effects of the variables with impact on the probability of adopting modern paying procedures are shown in table 4.7 (see the appendix B for probit model results, table B.31). The results are based on the estimated average marginal effects of the regressors from the probit models, and the previous procedures used in the previous section were applied.

The probability to adopt modern billing standards is affected by a group of

Tab. 4.7: Average marginal effects of the probability to adopt modern billing standards

Variables	ddebit	ebill2012
p19education	-0.171***	-0.071***
	(0.026)	(0.018)
owner	0.322***	0.047**
	(0.031)	(0.021)
hsize	-0.029***	
	(0.010)	
urban	0.107***	
	(0.034)	
aavprice	0.004***	
	(0.001)	
unfairprice	-0.071*	
	(0.038)	
meter	-0.082**	0.030*
	(0.033)	(0.017)
Observations	1,989	1,306

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

common factors. These factors are the low schooling level (until the 9th year of school) (*p19education*), house ownership (*owner*) and submission of the meter readings to the water utility (*meter*).

House ownership has a significant positive effect maybe reflecting that owners may remain in a dwelling longer time periods than households with no ownership, who can change house more frequently. Therefore, non-owners might be less likely to have these modern billing standards using more traditional methods of payment and billing. The respondents with few or no years of schooling (*p19education*) are less likely to adopt direct debit or an electronic billing method, an effect that could reflect household members without qualifications and less aware about modern methods provided by their water utility and also less able to handle them (example computer literacy). The submission of the meter readings, have opposite signs in (*ddebit*) and (*ebill2012*), since probably consumers that submit their readings are interesting in controlling and prefer to declare their actual consumption, instead of using estimated values. This may indicate people with concerns about the monthly amount paid and therefore less likely to use a method like direct debit which is automatic. On the other hand, consumers submitting the readings seems to value accurate information. It may be the case that these consumers prefer methods that provide information more quickly than the traditional ones. Nonetheless, this an interesting topic for

further research, since the adoption of more modern methods for submitting the meter readings, such as software applications are being developed (Hoffjan et al., 2014).

The household size (*hsize*) and believing the water tariffs are unfair (*unfairprice*) have negative impacts on the probability to adopt a direct debit payment, at 1% and 10% SL. A potential explanation is that more members may indicate that the head of a large household may want to control the monthly amount paid. The *unfairprice* has a barely significant effect, although this can mean that when price is perceived as unfair, consumer may not feel comfortable with an automatic payment method.

In general the results appear to be robust according to the analysis of the probit model encompassing all the variables selected, without and with sampling weights which are shown, respectively, in tables B.33 and B.36, and the respective marginal effects in tables B.32 and B.35 (in appendix). In the case of *ebill2012* the variable owner is significant in the encompassing version with sampling weights, but insignificant without them. Since less than 5% in our sample represents respondents using electronic billing, this may be a rare event whose determinants are harder to grasp.

4.3.5 Analysis of the probability of drinking tap water

In this section, we analyse the decision to prefer to drink tap water instead of using alternative sources, as for example bottled water or public fountains. The marginal effects of the variables with impact on the probability to drink tap water are show in table 4.8 (see the appendix for probit model results, table B.38). The analysis of correlation and multicollinearity for this behaviour does not present no systematically strong correlation between the variables and all VIF (Variance Inflation Factors). Once again, sampling weights differences were accounted for.

The first column is shown for comparison purpose of the data without weights, the analysis will take as reference the model corrected with sampling weights. The variable *avpmun* has a negative sign as expected (Bontemps and Nauges, 2015). Water price is expected to have a negative effect in the probability to drink tap water (Bontemps and Nauges, 2015).

The average percentage of tests not complying with the limits imposed in the quantity of chemicals in the water (1993-2012) has a relevant negative impact, as expected. We found that an increase of 1% in the violation of water quality chemical standards had an expected impact of decreasing the probability to drink tap water by 0.10 (10 percentage points), at a 1% SL. This finding may reflect water quality concerns and health issues.

Tab. 4.8: Average marginal effects on the probability to drink tap water - Comparison without and with sampling weights

Variables	drinktap (without sampling weights)	drinktap (with sampling weights)
avpmun	-0.053***	-0.055***
	(0.020)	(0.021)
avvioqual	-0.096***	-0.099***
	(0.018)	(0.019)
unemployed	0.088***	0.086***
	(0.020)	(0.028)
mainresidence	-0.096***	-0.081*
	(0.032)	(0.044)
fair	0.017*	0.022*
	(0.009)	(0.012)
urban	0.056*	0.055
	(0.029)	(0.035)
Observations	2,044	2,044

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

The number of household members who are unemployed has a positive sign. The average marginal effect reflects that for each additional unemployed person in the household the probability to drink tap water increases by 0.08. Although this seems unstudied so far, it appears reasonable that unemployed household members who have low income level will adopt behaviours to obtain cost savings, preferring tap water rather than other sources, like for example bottled water or public fountains. Consumers with concerns about money savings are more likely, in our view, to know that tap water price can cost hundreds or thousands of times less than bottled water (Johnstone and Serret, 2012; Jakus et al., 2009; Doria, 2006). Moreover, the costs to access to water from fountains or other sources are also relevant, such as time and transportation costs. In fact, nontap sources outside the dwellings have collection costs, an important issue to understand household behaviour in an accurate manner (Nauges and Whittington, 2010).

People who responded to the survey concerning their main residence have a lower probability of drinking tap water, barely significant at 10% SL. There is a potential limitation since the respondents when answering if they usually prefer to drink tap water may not recall which residence is being associated with their answers. Nevertheless, since no clear explanation seem to justify why people in main residence are less likely to drink tap water this may seems a relevant line for further research.

People that considered the price they pay for water is fair (*fair*) is not commonly used in this literature. Our model reveals a barely significant effect of price fairness, at 10% SL. The increase in one level in the Likert scale (1 to 5), about the statement "The price you pay for water is fair" raises the probability to drink tap water by 0.02. This positive effect could suggest that water consumers are more likely to use tap water for drinking when they feel the price charge by the water utility is fair. This price fairness issue seems to be a novelty in the literature. We will return to this issue in chapter 5, and may be an important topic for further research.

Finally, the household being located in an urban area has a positive impact on the probability to drink tap water from the public supply network, but only without sampling weights, and at 10% SL. The variable *urban* aims to reflect differences between water consumers that live in urban areas versus semi-rural and rural areas. We expected that this could be related with higher satisfaction with taste and healthy impacts, as a previous study in this literature highlights (Nauges, 2014). On the other hand, rural and semi-urban areas may have lower levels of satisfaction in terms of taste and may be more like to people get water from alternative sources, such as drinking fountains. Nevertheless, this effect does not hold after applying sampling weights.

We provide additional tests to this final model in appendix with the probit models in table B.40 and the average marginal effects in table B.39 were we show the results including other variables based on the literature review made in table B.2 (in appendix).

These results include our control for omitted variables, multicollinearity and correlation issues, sampling weights and robust standard errors. We provide the probit models on the probability to drink tap water with and without sampling weights in tables B.38 (in appendix) as a control to the robustness of the results.

4.4 Conclusion and Future Research

This research approached the formation of reference points or perceived values for average water price, monthly water consumption and bill and analysed two different types of water-saving behaviours in dwellings, the outdoor and indoor water uses. Besides, it also performed detailed analysis of billing standards, such as the use of direct debit payment and electronic billing. Finally, we analysed the determinants to explain consumer preference for drinking tap water instead of using alternative sources.

First, in outdoor water conservation choices, the main results presented the expected effects, although the results are limited low sample representativeness (7% of the total sample) on the case of collecting rainwater. The case of watering the

garden during the coolest period of the day to avoid evaporation is also limited to the "all-or-nothing" approach (*i.e.* variable is either 1 or 0), although dealing with information about how frequent consumers water the garden, with an ordered probit model, is sometimes an alternative choice recommended (Dupont and Renzetti, 2013). We accounted for potential effects of climate variables and tested different specifications using data from *INE* (Portuguese National Statistics Office) and *IPMA* (Portuguese Sea and Atmosphere Institute), but we found no significant effects (see table B.18 in appendix). Secondly, we used the special regressor method to study reference points (section 4.3.1), but this method is also applicable to outdoor and indoor water conservation choices, and was never been studied, as far as we know. The use of the special regressor methodology allows for several types of endogenous regressors, but surprisingly the impact of endogeneity on perceptions have been understudied in the literature (Bontemps and Nauges, 2015).

We provide the first analysis of billing standards in residential water sector and a future line of research could try to measure to which extend the indoor and outdoor water conservations choices influence behaviours like using electronic billing or direct debit systems, a topic outside the scope of this work.

The formation of consumer perceptions and the probability of forming these internal reference points in water consumers' minds was analysed for the first time, in this literature. We used a special regressor method to account for potential endogeneity bias, specially recommended for the case of binary endogenous regressor. The endogeneity tests reveal that *fairprice* and *knowIBR* are exogenous, and therefore we used the standard probit. Nevertheless, the method specifications and manual choice of the bandwidth for the kernel density method (Bontemps and Nauges, 2015) (we used Silverman's rule of thumb, an automated method), sensibility tests and more detailed analysis of bootstrapping assumptions (*i.e.* number of bootstrapping samples) should be developed in further research. Moreover, we only analysed the impact of *fairprice*, but *unfairprice* variable could be further explored, since in marketing literature fairness and unfairness are considered to be different variables of interest (Xia et al., 2004). The development of a perceived price fairness index and the development of potential determinants is an avenue to be explored (Diller, 2008). We analyse this topic in chapter 5. This index may be included as a partial effect of a behavioural framework to explain observed consumer behaviours (Krishna, 2009), in order to develop a general model in water demand studies that incorporates consumer perceptions.

Another potential line of future research is the use of the water bill as an alternative to the water price since perception variables about bill and price are significant to explain indoor and outdoor water-saving behaviours. We will approach

this issue in chapter 6. Moreover, the issue of perceived fairness in terms of total amount of water paid, rather than perceived price may also be addressed, since it is more likely that water consumers (especially the bill payers) know the amount they pay, but not necessarily the tariff structure, as discussed in chapter 3. Price fairness concerns seems to be relevant to water consumers, as stated in Media, where the news gave importance to price raises and social protests. However public policies seem not to attach a lot of importance to fairness either about the average water price and bill. A set of studies has focused on understanding water bill and clarity issues (Martins et al., 2015; Martins and Moura e Sá, 2015; Moura e Sá and Martins, 2014; Martins and Moura e Sá, 2011; Gaudin, 2006), but further development of water bill fairness indicators, could lead to a better understanding of PPF and clarification of potential misperception of water consumers between water bill and price.

One of the starting points of this research was to identify factors that influence the household's probability to adopt outdoor and indoor water-saving behaviours as well as modern billing standards behaviours. Our main findings corroborate most of the literature, although we provide evidence for the first time that consumer perceptions, namely people knowing they have an IBR structure, a reference about the bill, the average and marginal price, and price unfairness are relevant determinants of both water-saving behaviours and modern billing choices in the residential water sector.

We also provided answers to two main questions: is price fairness a factor in the formation of reference points? If so, how does it affect average price and bill perceptions? The empirical evidence indicated that PPF has a significant positive effect in the probability of people to have a reference perceived value of price, but not on perceived bill and consumption.

Further empirical evidence about these findings in other countries, as well as in other sectors, such as electricity or gas, may lead to a reshape of pricing and non-pricing policies, since other determinants, like firm reputation may play a role (Krishna, 2009). In this context, a future avenue of research is also the improvement of water literacy and the promotion of transparency (Martins and Moura e Sá, 2015). Overall, our study provides evidence that a new set of perception variables may contribute to better understand water-saving behaviours and consumer references and choices.

5. PERCEIVED PRICE FAIRNESS - DETERMINANTS IN THE RESIDENTIAL WATER SECTOR IN PORTUGAL

5.1 Introduction

Water pricing has been focused on two major challenges: i) there is an increasing competition for resource use, and ii) sustainable access to water supply and sanitation must be ensured (OECD, 2010). In this paper, we add a discussion on the determinants of Perceived Price Fairness (hereafter PPF) at the level of water tariff policies, considering the case of residential water use in Portuguese households.

Research on PPF seems to be a relevant issue, although studies on this topic are scant (Bolton et al., 2003) and broadly comprehensive models sparse (Bechwati et al., 2009). PPF links consumer perceptions and emotions to achieve an outcome considered acceptable, reasonable and just, when comparing the seller's price with a reference price (Somervuori, 2014; Xia et al., 2004).

This literature uses several approaches to explain how and when price fairness judgements occur (Xia et al., 2004), although it has been largely influenced by the dual entitlement principle from Kahneman et al. (1986b). This principle emphasizes that firms are entitled to a reference profit and consumers to reference terms, such as a reference price. The main factors influencing consumer perceptions of unfair price in the marketplace are therefore prices, profits and costs (Bolton et al., 2003).

Moreover, people tend to prefer simple prices rather than complex ones, even when the former are more expensive, since complexity has a negative impact on customer fairness perceptions (Homburg et al., 2014). As nonlinear pricing is common in the residential water sector, this could be an additional factor affecting the perception of water consumers. Price judgements are complex processes that include reference prices and the notion of fair price, as noted by Cheng and Monroe (2013). PPF is a notion that pops up in the consumer's mind during the purchase decision process.

PPF is not in the main research agenda in water supply (WS) and wastewater (WW) services, although the recent article of Martínez-Espiñeira et al. (2012) discusses the fairness of an approach focused on the access to water residential use and the application of Spanish water tariffs. The results show considerable differences in both

water prices and tariff structures that can potentially explain the negative views about the different accessibility conditions between municipalities. The authors' recommendation to avoid unfairness in the access to water is the development of guidelines establishing the number of blocks, the block-consumption levels, and price harmonisation for the acceptable minimum to meet water-consumption needs.

Given the European Commission's priority to develop new economic instruments in the water sector and the current economic situation in Portugal, there has been a widespread debate around the sector's sustainability (mostly economic-financial). Since residential WS and WW services are local monopolies, consumer decisions are limited. Each household faces a single tariff structure of one water utility. To this extent, the PPF appears as a relevant measure of consumer perceptions on the impact of pricing policies (*e.g.* seasonal policies to conserve water during droughts).

Nevertheless, there is not much evidence of price fairness studies in water. As a comparison, in the electricity sector Fiorio and Florio (2011) used Eurobarometer surveys and found higher consumer satisfaction about prices in countries where utilities are mainly publicly owned.

According to the Eurobarometer, most Europeans agree with the principles of user-pays and polluter-pays[45] (European Commission, 2012). The European Customer Satisfaction Index (ECSI) can also provide relevant customer data for some determinants of price fairness. Considering all the sectors and subsectors studied in Portugal, customer satisfaction in the water sector substantially improved from the second to last position in 2008 to the third position in the 2014/2015 report (ECSI Portugal, 2015, 2013, 2012, 2011, 2010, 2009). The basic ECSI model that explains the latent variables used to determine customer satisfaction is presented in figure 5.1.

Each latent variable or component in the model is determined through manifested variables as described in Kristensen et al. (2000). Recently, Yeung et al. (2013) found a relationship between customer satisfaction and consumer expenditures in European Countries. Price is viewed as a signal of quality, but not consumer expenditures (Freitas and Wagner, 2009). As discussed in chapter 3, consumers in the residential water sector have more awareness about total monthly bill rather than price, although the price fairness variable used in chapter 4 seems to affect only the reference price, fairness and unfairness may be different constructs (Xia et al., 2004). Therefore, the measurement of unfairness rather than fairness, may be

45. Although the Eurobarometer does not mention these principles directly, it notes that more than 8 in 10 Europeans agree that water users should pay for the amount of water used, while about 6 in 10 Europeans agree that the price of water should reflect the environmental impact related to its use.

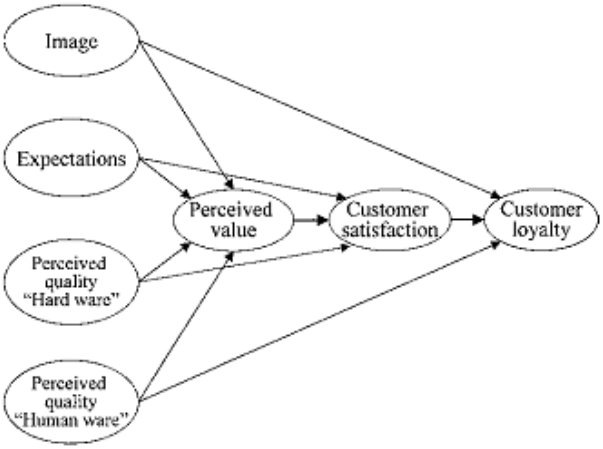

Fig. 5.1: The ECSI model
Source: Kristensen et al. (2000, p.50).

a further research avenue. We hypothesize a conceptual model where bill perception and price perception, can both play role on fairness evaluation. This model is based on the empirical evidence from chapter 3, where only 7% of the consumer have a reference price, with response rate above 90% for the price unfairness question "The tariffs charged for an essential good such as water are unfair". In this sense, customer satisfaction and price fairness models using price-related variables should allow to be tested the potential hidden impact of water expenditures. Notice that Customer Satisfaction Index and PPF are not alike, since there are several differences in latent and measurement variables, as well as in the conceptual model that we will propose in section 5.3. The ECSI model is a tool for firms to better understand the major factors that influence customer satisfaction and loyalty. On the other hand, the price fairness model that our study proposes is focused on a consumer perspective, which has been neglected in this literature (Chung and Petrick, 2015). Nevertheless, some measurement variables used in the construction of Customer Satisfaction Index are also relevant for PPF, as we will discuss in detail in section 5.4.

Greater bill clarity has been promoted in Portugal through Recommendation number 1 of 2010 (ERSAR, 2012a) of the Water and Waste Services Regulation Authority (hereafter ERSAR), and the Decree Law 114/2014 (Assembleia da República, 2014), which entered into force on the 1st of March, 2015. This trend to more clarity to water users may contribute to the customer satisfaction increase observed in the Portuguese water sector.

As for reference price, since there is a history of transactions between water utilities and water users, expressed on the water bill, the idea of Kahneman et al. (1986b) that the reference term will be the latest price known could be extended to

account for the total amount of the water bill as an alternative to the water price, since it is more likely that the consumer knows the former. Moreover, reference price is a dynamic internal price based on consumer perception and used as a comparative price (Somervuori, 2014; Cheng and Monroe, 2013), thus consumers react relative to this reference rather than to prices. Other factors that could affect fairness judgements are framing effects, in particular money illusion (Kahneman et al., 1986b). In section 5.2, we discuss cost recovery ratios in mainland Portugal and potential framing effects of water price increases in media.

The conceptual model of PPF based on Maxwell (2008) and Rutte and Messick (1995) (as cited in Somervuori (2014)) is divided in three parts: fairness antecedents, evaluation process and consequences. The novelty in our conceptual model is the segmentation into price-conscious and *naïve* consumers. The analysis of antecedents or determinants of PPF and subsets of potential indicators for each one will be discussed in section 5.4. The determinants that will be analysed are price clarity, distributive fairness, consistent behaviour, price reliability, price honesty and respect and regard for the partner and fair dealing. The study of Diller (2008) states price clarity and price honesty as a common determinant of PPF. In our view, price clarity addresses the question: is information clear? On the other hand, price honesty addresses whether information is always completely available. Therefore, price clarity is based on potential indicators from the water bill. Price honesty is focused on the completeness and implies that water utilities will not take advantage of the consumers, in spite of their monopolistic position.

The aim of this study is to suggest a potential conceptual model to measure the PPF incorporating price awareness and the relevant consumer knowledge about bill in the residential water sector. The chapter is organized with the following structure. In section 5.2, we discuss the current situation of the sector in terms of cost recovery and household affordability. In section 5.3, we propose a conceptual model of price fairness influenced by price awareness. In section 5.4, we present a review of the literature on PPF and explain the potential PPF determinants in the residential sector water. Finally, in section 5.5 we conclude and discuss the topics for future research.

5.2 Cost recovery in the residential water sector in Portugal

The Water Framework Directive (WFD) (European Parliament and Council, 2000) highlights the need for cost recovery, considering financial costs and environmental scarcity. Both prices and taxes can be used to achieve this goal. In Portugal, a water resource charge was created as a mean to begin tackling environmental and resource costs, while financial costs recovery was mostly left to water tariffs.

According to ERSAR, cost recovery ratios in water utilities present an increasing tendency between 2005 and 2013. In 2005, the cost recovery ratios for water supply (WS) and wastewater (WW) were 0.87 and 0.57 (INAG, 2005), for mainland Portugal. In 2013, the last available year, the cost recovery for WS remained steady and for WW increased to 0.67 (ERSAR, 2014c).

However, this increase was made exclusively by price increases, which often do not seem to be well perceived by consumers as portrayed by the stirred up opposition and social protests against price increases by Portuguese consumers of several municipalities[46]. A socially fair price is a price that is equal to everyone. The personal unfairness has minor importance when compared with the social unfairness, since the "amount of distress caused by personal unfairness appears to be relatively mild compared with reactions to social unfairness (Maxwell and Comer, 2010)" (as cited in Somervuori (2014, p.469)). Moreover, media coverage could also have contributed to grounding of consumer perceptions, in particular on water price. News could be a potential source of framing effects, since media often exhibit information on consumers generally paying high prices or announce price increases for water utility services (Jornal de Notícias, 2015; Castanho, 2014; Tomás, 2014; Henriques and Filipe, 2011).

These negative media highlights fail to account for the good level of affordability of water utility services, considering the typical Portuguese household. Recent data corroborate that overall the services paid are 0.84% of the average household disposable income in 2013 (ERSAR, 2014c). As a comparison, OECD (Organization for Economic Cooperation and Development) countries in 2008 had affordability levels of water utility services ranging between 0.2% (*e.g.* Italy and Korea) and 1.2% (*e.g.* Hungary and Poland) (OECD, 2010). Additionally, the average affordability level for Portugal is far below the affordability thresholds of 3% and 5% which are used in the literature (Martins et al., 2013; OECD, 2010; Komives et al., 2005) as references, allowing an acceptable subsistence level of water consumption. Martins et al. (2013) does highlight that Portugal exhibits some idiosyncrasies. Average values of affordability may hide specific situations of each municipality, and the authors' findings suggest that there could be large disparities. Additionally, the affordability threshold, previously mentioned, is sometimes exceeded, with a significant group of municipalities where the poorest 20% households are above the affordability threshold calculated by the authors based on the weight of essential minimum quantity charges in the household income.

Commonly the news about residential water prices present information in terms

46. As an example, it is possible to mention the social protest on the price increases by consumers of Loures, Odivelas and Cartaxo during the year 2011, published in the media (Henriques and Filipe, 2011; Mirante, 2011).

of variations, or percentages, instead of absolute values. Although there are some exceptions (Mirante, 2011), this bias is observed even in news with very detailed information (Suspiro, 2015). Plus, news often mix presentation of price and total monthly bill, which may reinforce consumer misperception. At first glance, there seems to be a communication failure between water utilities and consumers that limits consumer perception. Therefore, insights about consumer perceptions, namely the PPF, could be important to reduce this informational gap and social criticism about water price increases.

Although the water bill represents a small percentage of the average monthly expenses of Portuguese households, consumers can disagree, at times noisily, with increases in their water tariff. This contradiction can be justified by the perceived unfairness associated with price increases. The next section analyses the factors that may contribute to improve the perceived fairness of water price.

5.3 Conceptual model of price fairness

The conceptual model of PPF that we suggest in figure 5.2 is an adaptation of works of Maxwell (2008) and Rutte and Messick (1995) (as cited in Somervuori (2014)). Rutte and Messick (1995) suggest a three-part conceptual model with antecedents, evaluation and consequences. The outcome evaluation process precedes the fairness evaluation process. This first stage assesses whether the outcome is positive, neutral or negative, and only the latter evokes a fairness evaluation. At this stage, a price comparison process between the suggested price and the consumer's reference price level occurs (Somervuori, 2014).

The fairness dimension is active when there is a negative evaluation in the price or bill comparison, and invokes feelings of distress and thoughts of unfairness in the individuals, leading to the second stage. When outcomes, in this case price or bill comparison, are neutral or positive, the consumer usually does not perform a fairness evaluation (Rutte and Messick, 1995; Somervuori, 2014); this is expressed in figure 5.2 by the positive signs near price and bill comparison boxes. Individuals do not have fairness concerns all the time, the positive signs represent situations with positive outcome evaluation and without distress and fairness judgements (Somervuori, 2014).

The determinants of fairness judgements suggested by Kahneman et al. (1986b) are the outcomes, the reference transaction, and the context. The second part of the model focuses on the fairness evaluation process which determines if the outcome is unfair. This process is influenced by the distress dimension that could be reference (Rutte and Messick, 1995) and context dependent (Xia et al., 2004). The fairness evaluation is focused on the identification of the fairness rule that has been violated. According to Kahneman et al. (1986a) a fairness rule is, for example, that it is

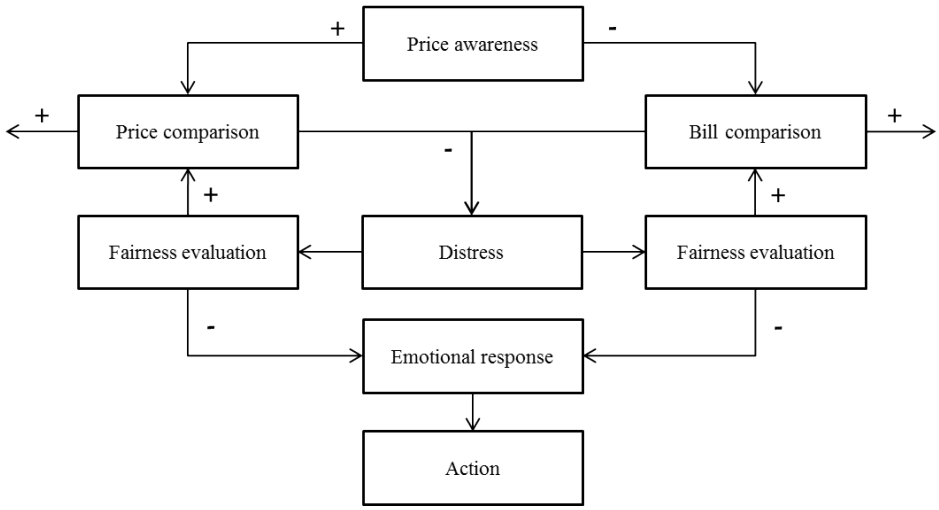

Fig. 5.2: Conceptual model of price fairness

Source: Author's adaptation from Somervuori (2014), Maxwell (2008), and Rutte and Messick (1995).

"fair" for a firm to maintain its reference profit, if necessary, by increasing prices or cutting prices[47]. A judgement considered unfair leads to the third stage of emotional reaction.

Following the conceptual model, when fairness judgement is considered fair (positive sign) the outcome is evaluated as positive. For instance, when firms hike prices to reflect higher costs, which would not be perceived by consumers as unfair (Somervuori, 2014), as when a tax rise implies a price increase in WS and WW services. Since consumers use fairness rules firms are allowed to fully recover cost increases (Kahneman et al., 1986a), reflecting these increases in final prices. The model contemplates cases where the initial outcome evaluation was negative, but if the fairness judgement is positive and leads to the conclusion that the outcome is fair. Therefore, the individuals may experience feelings of disappointment, but not unfairness (Rutte and Messick, 1995).

Finally, part three describes the reaction or emotional response, which are the consequences of PPF. This process leads to an action, such as the observed consumer behaviour. When the fairness judgements are negative the consumer may have potential cognitive or behavioural reactions[48]. One example of a behavioural reaction is the adoption of non pro-environmental behaviours. Consumers that believe the tariffs are unfair are less likely to water the garden during the coolest parts of the day, as described in 4. Thus, the fairness evaluation can lead to two conclusions: i) the outcome was fair and, consequently, the outcome revaluated is positively influenced

47. See (Rutte and Messick, 1995) for a detailed discussion of fairness rules.

48. For example, cognitive reactions are cognitive distortions of price or changing the reference, and behavioural reactions are changes in behaviour or, in a extreme case, leave the situation. See (Rutte and Messick, 1995) for a details.

ii) the outcome was unfair and consumer reacts. In the latter, negative attitudes or hostile behaviours are common.

The proposed model is an extension of this conceptual model of price fairness including as novelties price awareness, since consumer are not always aware of their price, as discussed in chapter 3, and bill comparison that can be influenced by price fairness evaluation, according to chapter 4.

The figure shows the inclusion of the price awareness process which influences the consumer choice of price or bill comparison. In this process, consumer are price-conscious or *naïve*, as in Frondel and Messner (2008). After the awareness process takes place the consumer makes the price comparison, or uses heuristics to simplify the decision process and chooses alternatives to price, in our model this will be the bill comparison process. Bill comparison will be similar to the outcome evaluation process (Rutte and Messick, 1995) described above.

Consumers will not have fairness concerns all the time. An outcome evaluated in a negative manner will become salient and trigger the fairness judgement process (Somervuori, 2014). Any information related with water price can trigger this process. Bill comparison as an outcome evaluation process will be based on social, historical and context information (Rutte and Messick, 1995), such as information received by mail or in the website of the water utility, news in the media about water prices, and the consumer's water bill history. When there is a negatively evaluated price the consumer will feel distress and the next phase of the fairness evaluation process occurs. If fairness is negatively valued there will be an emotional response process, which leads to an action.

This conceptual model presents two novelties: i) it incorporates the fact that consumers unaware of prices can still make consumption decisions and ii) it hypothesizes that consumers can use heuristics or simplification mechanisms to make decisions in reality, due to bounded rationality with limited knowledge and ability (Simon, 1955).

Unfortunately, the available data on the survey (table E.4 in section E) seems limited to analyse the potential determinants of PPF (Diller, 2008)[49]. Therefore, we propose a set of determinants and respective variables that can explain PPF in the next section.

49. We performed additional tests on a potential PPF index, based on fairness questions in the survey, but found low level for the Kaiser-Meyer-Olkin measure of sampling adequacy (0.62), a measure of partial correlation of variables in the factor analysis. Moreover the Cronbach's alpha was at the "poor" level (0.49), revealing weak internal consistency between the variables used in the components of the factor analysis, according to the reliability of summative rating scale presented by George and Mallery (2003).

5.4 Determinants of PPF for water

Researchers in economics and marketing have been mainly confined to the study of the intrinsic price, although in the last three decades the research in behavioural pricing or price effects arise (Krishna, 2009). Krisna's conceptual model to explain the observed consumer behaviour is influenced by two type of price effects: i) the price presentation effects that impacts on consumer perceived savings (a measurement of subjective price) (Krishna et al., 2002) and ii) antecedents that influence PPF (Krishna, 2009). Therefore, two multi-dimensional constructs or intermediate variables explain the observed consumer behaviour, the "price framing"[50] and the "fair price". The antecendents on PPF that allow to explain how consumers perceive fairness standards are extensively reported in the literature (Campbell, 1999, 2007; Bechwati et al., 2009; Diller, 2008; Krishna, 2009), although this seems to be an issue addressed in marketing literature but rather neglected by mainstream economics.

The PPF arises as an extension of the seminal work on the reference transaction developed by Kahneman et al. (1986b), based on the principle of dual entitlement, which rules fairness standards and entitles reference price to consumers and reference profit to firms, as well as establishing sellers' profit orientation. Within this framework the water utilities should, in theory, be entitled to a (positive) profit of reference while consumers have a right to a term of reference, *i.e.* the reference price. However, in Portugal, as in other countries, increasing block rates are common and water utilities have tariff structures with different number and size of blocks (OECD, 2010). These non linear prices introduce greater complexity and may contribute to the lack of clarity of the water price. Recent studies note the existence of a gap between consumer expectations on total monthly water bills and the informational contents of water bills (Martins and Moura e Sá, 2015). These authors stress that there are low awareness levels regarding key elements of their bills, a fact that jeopardises the effectiveness of these bills in communicating prices. Additionally, water consumers appear to have a "benchmark" reference (Moura e Sá and Martins, 2014) about the water bill (or internal reference point). Moura e Sá and Martins (2014) developed a set of fifty-seven consumers' requirements based in interviews to three focus groups and found that the high majority of their sample only look at bills when there is an odd situation (*e.g.* an unexpected increase in total amount paid) or for comparison (*e.g.* monthly comparisons between the amount to be paid in the current month and the previous one). So water consumers seem to look mainly for odd or abnormal patterns and to get information about total water expenses, using a kind of heuristic, or shortcut, to evaluate their bill. Thus, they take a practical and quick decision, in a behavioural economic perspective: if nothing "abnormal" happens they check the

50. See Krishna et al. (2002) for a detailed meta-analysis of price presentation effects.

total amount and pay.

PPF may be a significant factor in household decisions on water consumption. The analysis of PPF shows a range of approaches to evaluate the standards of justice on price, income and earnings in the seminal work of Kahneman et al. (1986b). A recent approach found that consumer attitudes towards allocation rules, such as highspeed train seats and parking spaces, are framed by the context (Raux et al., 2009). Krishna (2009) provides an analysis of the PPF antecedents as is performed in the marketing literature. In this study, we attempt to define what could be the main PPF determinants (*i.e.* antecedents) in the Portuguese residential water sector. We point towards a line of future research to assess consumer perceptions about water policies and discuss economic criteria to make PPF measurable in a way that will contribute to the water demand literature.

The consumer assessment of PPF is based on several antecedents or determinants. Some of the antecedents of PPF highlighted in the literature are (Campbell, 1999, 2007; Bechwati et al., 2009; Krishna, 2009):

- Firm reputation.
- Firm with excessive profits.
- Inferred motive of firm, such as immoral or unethical behaviour.
- Consumer inability to understand pricing structures.
- Direction of price change.
- Human or inhuman communication of price change (*e.g.* price tags).
- Price for self versus price for others.

In order to identify determinants of PPF in WS and WW services we propose the following components based on Diller (2008):

The major changes from the original approach were the inclusion of price clarity as a determinant and the exclusion of the right of influence and co-determination,(Diller, 2008). The clarity and simplicity of the water bill, as well as the poor consumer knowledge about their water price are important issues as previously discussed in chapter 3. On the other hand, the water supply (WS) and wastewater (WW) services involve business relationships between water utilities and water consumers involving

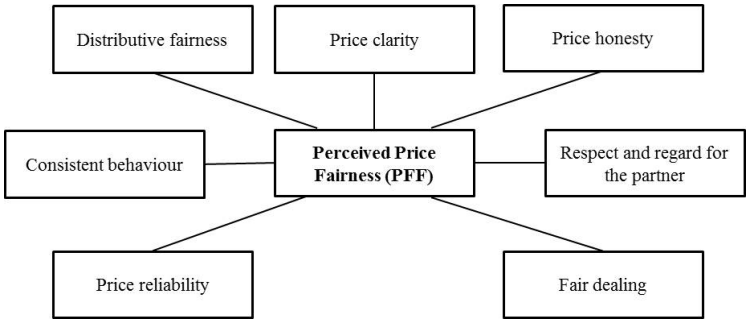

Fig. 5.3: Components of PPF in WS and WW services
Source: Author's analysis adapted from Diller (2008, p.354).

asymmetric information and market power. PPF is particularly important in transactions in which there is a power imbalance, being essential to promote consumer acceptability regarding the conditions imposed by the utility. Consumer acceptability could foster an improvement in the implementation of public policies. Currently, we do not see the right to co-determination of the price, as applicable in the water sector at least explicitly. However, it is important to emphasize that the adoption of such a strategy could foster the acceptance of price increases as fair (Diller, 2008).

The potential indicators that can allow to explain these components are discussed below.

5.4.1 Price clarity

Price clarity reflect concerns about if the information provided is clear and understandable. In this sense, this determinant addresses the question of clarity as a crucial issue for providing better and comprehensive information, specially about price, in the water bill.

The clarity of the price charged for WS and WW services has emerged as a relevant topic in the literature on residential water demand. Some recent studies using samples of consumers found that less than 15% of their sample were aware of the price paid for their water consumption (Frondel and Messner, 2008; Carter and Milon, 2005), as well as the findings about consumer awareness about marginal and average prices in chapter 3. These evidences reveals that more attention is needed to this neglect issue. Furthermore, there seems to be a lack of a systematic approach by water entities that provide information about water sector. Recently, an analysis of the existence of explicit information related with price in the monthly water bill was performed by Machado (2015). This study reveals that the compliance level of the water bills is unsatisfactory, thus recommending the implementation of an invoice template issued by ERSAR. Along with documentation with additional information to explain procedures to water utilities (ERSAR, 2015). This could be an important

process to improve clarity.

Additionally, the clarity of the water bill is a privileged instrument through which the consumer gains (or should gain) knowledge of the prices for each tariff block. Potential indicators of the clarity of the information available in the bill are provided by one latent variable presented in Consumer Satisfaction Index, namely the analysis of the clarity and simplicity of the water tariffs (ECSI Portugal, 2015), as well as in ERSAR (2014c) and APDA (2014) reports. These factors that could summarize the complexity of pricing structures are describe in table 5.1, as well as the available data sources and the type of data available.

Tab. 5.1: Price clarity - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Analysis of the clarity and simplicity of the water tariffs	ECSI Portugal (2015, p.8) (by municipality)
Existence of explicit information on the invoice price in the monthly water bill (Gaudin, 2006)	*n.a.*
Type of tariff	APDA (2014, pp.51-54) (by management model)
Number of tariff blocks	*n.a.*
Dimension / consumption intervals of the tariff blocks	*n.a.*
Number of charged components by service (*e.g.* water supply, wastewater, solid waste)	*n.a.*
Type of charged components by service (fixed access charge and variable charge)	ERSAR (2014c, pp.173-182) (by municipality)

Source: Author's analysis. Note: *n.a.* not available.

5.4.2 Distributive fairness

The fairness of prices implies that prices should be based on costs, a rule that is considered honest in general. A surprising finding from Kahneman et al. (1986b) is that fairness judgements allows for firms not to share a loss imposed to transactors, and in the domain of gains firms are permitted not to share their gains with transactors. Another unexpected finding is that fairness rules imply that a firm may incorporate opportunity costs related to excess demand, because it is unfair to use its monopolistic influence. The authors also found that is offensive/unfair to exploit the special dependence of an individual and the location of scarce goods (such as water) in an explicit auction. Kahneman et al. (1986a) identify two rules of fairness: (i) a firm is "unfair" when it exploits an increase in market power which affects the reference transaction through losses to the other part, and (ii) a firm is "fair" even when it

cuts salaries or increases prices or rents, if these actions are done to maintain its reference profit. WS and WW services are a different case from other sectors, and do not follow this pattern, given the low cost recovery levels in mainland Portugal. Some potential explanations could be that water is an essential good and the sector is a natural monopoly, which can imply that different rules of fairness apply.

As natural monopoly, water utilities are constrained by regulations and generally not expected to be entitled to a positive reference profit. Currently, Portuguese utilities still have insufficient recovery cost levels, on average, especially in the case of WW, as previously mentioned in section 5.2. Distributive fairness implies that the water utility (WU) should not have profit, so that consumers do not have a loss.

Another important issue is that consumers consider that lower water prices for specific groups are fair if adequate reasons exists, such as low-income or numerous households, as long as these different conditions are clearly specified. This sector appears to have idiosyncratic features that lead us to question: will consumers consider it fair for a WU to incorporate losses in order to keep the final price steady for consumers, even when exogenous events, such as reduced availability or quality issues indicate that a price increase is in order? If yes, in which kind of events? And additionally will reference price (Kahneman et al., 1986b) influence the PPF?

Summarizing up, distributive fairness can be assessed taking into account the dimensions or type of indicators in table 5.2.

5.4.3 Consistent behaviour

Water utilities are not expected to make changes without prior notice to the consumers. It is essential that the WU follows a consistent behaviour, based on a proper legal and institutional framework, respecting regulatory measures and procedures in the water sector. The existence of a public regulator for the water sector, ERSAR, and the extension of its regulation powers to all utilities (ERSAR, 2010a) was a major breakthrough. ERSAR promotes the standardization of policies and tariffs, collect and publish information, and pushes towards a better implementation of legislation on WS and WW services, as well as monitoring water quality for human consumption.

It is important to note that only a few years ago was ERSAR's scope of action extended to the regulation of service quality and economic regulation for WU with direct management and delegations. ERSAR was established in 2006 and became operational in 2009, with the entry into force of the Decree-Law 277/2009 (as cited in ERSAR (2014a)). The latter piece of legislation approved ERSAR's organic statute, mission, and redefined and enlarged its regulatory power, in addition to the concessions to water utilities already in their "umbrella supervisor". The strengthening of this regulation power of ERSAR has consequences that may impact

Tab. 5.2: Distributive fairness - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Indicators of consumer perceptions about distributive fairness (*e.g.* collected through surveys or experiments)	*n.a.*
Affordability of water utility services	ERSAR (2014c, p.183-189) (by municipality)
Tariff charges (*i.e.* monthly water bill) for 10 cubic meters by service	ERSAR (2014c, pp.165-172) (by municipality)
Indicators of economic and financial performance reflecting whether the WU had a profit or loss (*e.g.* operating results, net income) as well as indicators of efficiency and water loss	ERSAR (2014c, pp.193-202) (by municipality)
Comparative analysis of asymmetric price charged between urban and rural regions and water use purposes	APDA (2014, pp.55-69) (partial information by region, management model and municipality size)
Existence of tariff for numerous households, available in the WU, in order to foster social equity	APDA (2014, pp.51-54) (by management model)
Existence of a social tariff for households with low incomes provided by the WU in order to foster social equity	APDA (2014, pp.51-54) (by management model)

Source: Author's analysis. Note: *n.a.* not available.

on consumer perceptions about the consistent behaviour of water utilities. In this respect, it is interesting to assess whether the regulations in this context, and the recommendations suggested by ERSAR, influence consumer perceptions about the behaviour of WU as service providers, and therefore the PPF. This could be achieved through the development of a PPF index, performed on an annual basis, in line with ECSI.

The WFD already states that water prices should encourage efficient use of water resources, whatever their use, through the cost allocation to users. As noted earlier, WFD defends adequate cost recovery level, including financial costs and environmental and resource costs. It also requires this cost allocation to different uses to be clear. However, for this allocation to be valid, WU have to provide reliable accounting data.

Ultimately, by securing a better balance between the satisfaction of consumer needs and the environmental sustainability of water resources, as well as encouraging consistent reporting by WU, the WFD fosters a positive perception about PPF. Some potential indicators for assessing the consistent behaviour of WU in terms of tariff structures are described in table 5.3.

Tab. 5.3: Consistent behaviour -Relevant factors of measurement and available sources

Factors	Sources (type of data)
Evaluation from ERSAR to determine if WU implements the mandatory legislation	ERSAR (2014d, pp.91-105, 149-171) (by municipality)
Determine if WU implements the cost-recovery principle according to WFD	ERSAR (2014c, pp.122-159) (by municipality)
Comparative analysis of annual variation of fees and charges	APDA (2014, pp.130-138) (partial information by municipality)
Financing capacity and financial self-sustainability of the WU	ERSAR (2014c, pp.193-202) (by municipality)
Investments and subsidies received by the WU (Government budget, Program Contracts and EU Funds) and monitoring that these subsidies are being reflected in the final tariffs paid by water consumers	ERSAR (2014c, p.60-64) (partial information by water utility companies)

Source: Author's analysis. Note: *n.a.* not available.

5.4.4 Price reliability

In the analysis of price reliability, we highlight that the effective price paid by the household is only available retrospectively because the water bill is only available after consumption has been made (*i.e.* in the following month). Furthermore, not only is there a variable component of the price dependent on the consumption level, but the actual water consumption is not always measured on a monthly basis, but rather estimated. Besides, there are several other components (*e.g.* water resources charge, VAT, solid waste and wastewater fees) in the water bill, many of which depend on the water consumption level.

Price reliability implies that water utilities will not undertake unexpected changes on prices. In order to increase PPF, this determinant can be fostered by transparency in reporting the individual costs charged on the final consumer price. Despite the limitations, some of the potential indicators that may be used to parse this determinant are shown in table 5.4.

5.4.5 Price honesty

This determinant reflects whether the price can be considered true and transparent (Diller, 2008). However, water prices do not appear to be transparent to consumers (Martins and Moura e Sá, 2011). While determining price clarity is key to improve consumer understanding of what they are paying, price honesty addresses the trust in the pricing information and the various components of the amount paid on the water bill. This component reflects the accuracy and completeness of information

Tab. 5.4: Price reliability - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Consumer assessment of reliability of WS and WW services	ECSI Portugal (2015, p.8) (by municipality)
Reliability of the data provided by the water utilities to ERSAR	ERSAR (2014c, pp.122-159) (by municipality)
Identification of explicit information in the water bill about cost recovery ratios, since is expected that this information will increase the perceived price reliability	*n.a.*
Infrastructure sustainability of the services in the water sector	ERSAR (2014d, pp.75-86,133-144) (by municipality)
Comparative analysis of improvements in the level of information and awareness of consumers about the tariff blocks applicable for its WU and operating costs by services	*n.a.*
Analysis of minimum and maximum price charged and price variations	APDA (2014, pp.139-146) (by region)
Analysis of price-quality relationship based on perceived quality and value of the WS and WW services	ECSI Portugal (2015, p.8) (by municipality)

Source: Author's analysis. Note: *n.a.* not available.

about prices, conditions and services. Consumers are entitled to information about price and payment of the service through the water bill.

Given the importance of price elasticity of demand as a central variable for water management and public policy analysis, pricing honesty emerges as a prominent issue. Price honesty in the context of a relationship between two agents, buyer and seller, is based on the fair and proper way the price is perceived by the economic agents involved in the transaction. The information provided to consumers must be complete, since this could influence their judgements about price honesty. For an honest relationship water utilities could disclose to consumers the costs by type of services. This could be an issue, since clearly established cost accounting system is need in WS and WW services[51]. As an essential good, water typically has an inelastic demand, causing consumers to have small reactions to price variations. Additionally, this sector is a natural monopoly where price is not competitive, which makes price honesty a particularly relevant determinant.

Showing the levels of cost recovery by component, *i.e.* charged by type of service (*e.g.* water supply, wastewater, solid waste) may allow consumers to have

51. In fact, there are Portuguese municipalities that are not possible to determine the cost recovery level, see ERSAR (2014c, pp.122-159) for details.

a better price fairness judgement which will consequently influence their reliability perception and increased acceptability.

Table 5.5 presents indicators to explain price honesty of residential water demand.

Tab. 5.5: Price honesty - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Analysis of complete information in the water bills	*n.a.*
Analysis of contract conditions provided by the water utilities	*n.a.*
Compliance of the WU to the right to inform consumers through their websites, preferentially using complete information	ERSAR (2014b, pp.97-98) (by municipality)
Level of consumer awareness about the purpose of each component charged in the water bill	*n.a.*
Level of awareness among consumers about the ability of the water utility to achieve cost recovery in water supply and sanitation of their county or municipality	*n.a.*

Source: Author's analysis. Note: *n.a.* not available.

5.4.6 Respect and regard for the partner

This determinant is quite relevant to long-term relationships, a situation that occurs in water sector, since residential water consumers in a given location can only get water from one WU. A relationship of respect with consumers should be created given the lack of alternative choices. The principle of solidarity must be taken into consideration, and the monopolist should not exert undue pressure on consumers, understanding that it is not supposed to take advantage of its monopolistic position.

There is evidence that sellers (*i.e.* water utilities), although they are in a position of greater power, seem to reject using their position to benefit themselves. Kahneman et al. (1986b) argue that when exist budget and legal constraints only, firms are profit maximizers, but in reality the existence of fairness restrictions affects their operational decisions. This may actually be one of the potential explanatory factors for difficulties in cost recovery in the water sector, discussed in section 5.2. Although the WU has a monopolistic position in the market, with many of these water utilities being managed directly or indirectly by municipalities the expected impact of fairness restrictions, and, consequently, impact on political reputation may potentially affect the operational decisions. Plus, the absence of correct pricing and the procrastination of price (increasing) decisions by the WU could have significant

impacts on cost recovery ratios.

Some of the potential indicators that show relevance to measure the respect and regard for the partner are described in table 5.6.

Tab. 5.6: Respect and regard for the partner - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Opinion survey on the respect and regard of water utility by their customers	ECSI Portugal (2015, p.8) (by municipality)
Clarity of information provided sent to the consumer either in the water bill (Martins and Moura e Sá, 2011) or in other information provided by mail or other communication channels	ECSI Portugal (2015, p.8) (by municipality)
Percentage of consumers who understand the calculation of water price by their water utilities	*n.a.*
Number of customer complaints	ERSAR (2014d, pp.59-62,121-124) (by municipality)
Evaluation of grounds for complaints	ERSAR (2014b, pp.93-97) (by municipality)
Indicators of service quality provided to water users	ERSAR (2014d, p.33-287) (by municipality)

Source: Author's analysis. Note: *n.a.* not available.

5.4.7 Fair dealing

Fair dealing involves a consistent, non-discriminatory and ethical treatment defending the interests of all parties, based on the use of careful and accurate information. This dimension of PPF refers to the concept of procedural fairness (Diller, 2008), including generosity in case of doubt and flexibility against unforeseen situations. In the water sector, this would involve, for example, WU ensuring free repairs when there have been deficiencies in supply or service, even if no such legal obligation exists. This flexibility in understanding a business relationship may lead, for example, to an increase in perceived fairness, positively contributing to a good WU-consumer relationship.

On this determinant, ERSAR has an important role. This authority aims to protect the interests of consumers by promoting the service quality provided by the WU and ensuring socially acceptable tariffs, without neglecting the economic, financial and environmental sustainability. The ERSAR still has regulatory responsibilities monitoring the WS and WW services and regulates the water quality for human consumption. Thus, ERSAR is in a position to ensure fair treatment. This can be achieved either by controlling that WUs are in compliance with legislation and public

policies, and by protecting consumers' interests and fostering good communication among water customers and utilities.

Next, in table 5.7 we present some dimensions which are considered relevant to approach this determinant:

Tab. 5.7: Fair dealing - Relevant factors of measurement and available sources

Factors	Sources (type of data)
Consumer perception survey about the fair treatment carried out by the WU	*n.a.*
Operating performance indicators of faults and system malfunctions	ERSAR (2014d, p.79-86) (by municipality)
Degree of compliance of the water sector legislation by the WU in terms of water quality tests	ERSAR (2014d, p.55-58,161-168) (by municipality)
Guarantees of free replacements and repairs in situations of shortages and deficiencies	*n.a.*

Source: Author's analysis. Note: *n.a.* not available.

5.5 Conclusion and Future Research

This study developed a conceptual model of price fairness, and defines the potential items that can explain the components of PPF, identifying measures of the PPF in the Portuguese residential water sector.

Recently, Chung and Petrick (2015) developed a multidimensional scale to measure price fairness in tourism and their results highlight two dimensions: cognitive and affective fairness, and stressing a lack of studies about PPF from a consumer perspective, since the literature is mainly focused on pricing strategy from a managerial perspective. When consumers do not know price, our conceptual model highlights that price fairness judgements can be influenced by heuristics that lead to consumer decisions based on alternatives to prices, such as the monthly water bill. Although the creation of a scale to measure PPF adapted to a specific context or field of research is fairly common, is still a thoughtful process in which the researcher needs to select several factors to explain each component. In most cases data is collected through surveys, experiments or scenario-based fairness judgements (Xia et al., 2004). This chapter tried to go beyond this typical creation of a construct, and also the traditional approach in economic research, using an interdisciplinary approach from various fields.

The analysis of PPF components suggests measurement variables to perform a fairness evaluation, which as highlighted in the conceptual model, can come about via either price or bill comparison. The organism's simplifications of the real world

creates discrepancies that explain behaviour, as noted by Simon (1955); one of these discrepancies is level of price awareness. The novelty in our conceptual model is proposing that residential water consumers have limited knowledge of water price. Thus, the level of price awareness determines whether price or bill comparison will occur. Thereafter, these comparison processes will follow the conventional path where a negative evaluation of an outcome triggers a fairness judgement, as presented in the literature (Somervuori, 2014; Maxwell, 2008; Rutte and Messick, 1995).

In this sense, potential lines of future research are to test the validity and reliability of the proposed items for each component of PPF and the use of the monthly water bill as an alternative to price in fairness assessments. The issue of perceived bill fairness, is exclusive to WS and WW services, since other services like communication and subscription services *e.g.* Internet access, online music download, online newspapers also present complex pricing schemes (Lambrecht et al., 2007).

According to the analysis of PPF components performed in section 5.4, there are important available sources for data collection, but there is lack of information in some components, in particular in the case of factors to measure consumer perception. As noted in chapter 2 the quality and availability of the data in the water sector is still limited, although ERSAR has made an effort to present more complete and reliable information every year, and on a more regular basis (ERSAR, 2014a, 2013, 2012b, 2010b, 2009, 2008). Improvement of data quality is crucial to improve water consumer fairness judgements and actions. More attention should be paid to consumer perceptions, for the improvement of consumer awareness indicators discussed in chapter 3. Once more, ERSAR could play a central role in the development of the relationship between water utilities and water users, promoting a deeper understanding of water consumer insights, and establish a contribution to the sustainability in the water sector, since PPF could be a relevant tool to improve the assessment and monitoring of the effects of public policies. The proposed approach can be applied to other sectors and countries, taking into account positive geographic and cultural idiosyncrasies. These issues are fruitful avenues of research that could be explored in future studies.

6. NONLINEAR PRICING WITH REFERENCE DEPENDENCE

6.1 Introduction

For most goods, consumers pay a single unit price which is easy to know and understand. Utility bills and other service bills, on the other hand, are commonly based on nonlinear price schedules with many confounding elements, such as access charges (or fixed fees) and unit prices that vary along several blocks. In these circumstances price becomes endogenous, because it depends on the block the consumer is on, and studying consumer reactions to price changes is more difficult. In particular, average prices are different from marginal prices and demand analysis requires appropriate techniques to isolate price elasticities and ensure that these are properly interpreted. As noted in Olmstead et al. (2007, p.194), with varying block rates "how price affects demand is, itself, somewhat elusive". The same authors find that the price elasticity of water demand is higher when the tariff structure is increasing block rates (IBR) and suggest that this could be due to an as yet unidentified behavioural response to price structure, as opposed to price. This matches a common perception among water managers that having IBR sends the consumer a stronger message about resource scarcity, which explains at least partly the growing popularity of IBR schemes (OECD, 2010). Monteiro and Roseta-Palma (2011) discuss the possibility that IBR are an efficient way for utilities to achieve cost-recovery when weather affects water demand and costs, but the behavioural implications of the price structure are not considered. In this paper, we analyse how the multiple unit prices associated with a nonlinear schedule, as well as the total amount the consumer pays (*i.e.* expense), can induce a behavioural response if consumer choices are altered because they are anchoring the price or expense on a given reference point and then treating deviations from this reference as losses or gains.

Reference-price models are based on the general theory of reference-dependent preferences, first proposed in the seminal paper by Kahneman and Tversky (1979), which emphasizes that people attribute value to changes in relevant variables, such as wealth, and not their absolute magnitudes. Moreover, loss aversion, defined as a larger sensitivity to changes that are seen as losses than to gains of similar size, appears to be a widespread trait of consumer preferences. Ho et al. (2006) provide

an overview of the evidence on loss aversion and reference dependence in a significant range of economic domains. Once the concept of reference dependence is introduced, it is crucial to understand how the reference point is defined. Kamenica (2008) notes that "context can influence decisions" and discusses how the range of products a firm offers can lead to contextual inference by consumers. Kőszegi and Rabin (2006) introduce a utility function with two separable components, consumption utility and gain-loss utility, where the former is akin to the classical utility formulation and the latter includes the reference point. The most common assumption is that people compare outcomes to their *status quo*, but Kőszegi and Rabin (2006) propose, more generally, that the reference point comes from expectations, which may not coincide with the *status quo*. This idea was also previously developed in a paper on asymmetric price elasticities (Putler, 1992), which suggests an expectations model to define the reference point, differing from previous literature that typically modeled reference prices exclusively using past prices.

While our discussion of reference expense seems to be a novelty, there are quite a few references in the marketing literature discussing reference-price models. Putler (1992) develops a theoretical setting of consumer choice and estimates asymmetric price elasticities for the (homogeneous) wholesale egg market. This type of price-elasticity asymmetry is also considered in Greenleaf (1995), which considers the implications for the profitability of promotions, and in Fibich et al. (2005) which discuss the difference between short-term and long-term effects. Krishna (2009) reviews the evidence on behavioural aspects of pricing, distinguishing between price presentation effects (which are typically analysed in lab experiments and include external factors, *e.g.* external reference prices) and internal reference prices (mostly based on scanner data on consumer purchases). In the economics literature, Heidhues and Kőszegi (2008) use a differentiated-product setting to study the impact on equilibrium prices of consumer loss aversion when there is strategic competition among firms. Finally, Simonson and Drolet (2004) ascribe possible differences between willingness-to-pay and willingness-to-accept to the different alternatives available to buyers and sellers, while concluding that the same principles guide anchoring behaviour in both cases. Our main contribution is to explore the potential role of price schedules in consumer expectations about price, in the first model, but we also explore the higher awareness of consumer to expense rather than price.

Nonlinear pricing has been the object of growing interest, "becoming increasingly popular for communication services (wireless phone service, Internet access) and subscription services (online music download, online newspapers)" (Lambrecht et al., 2007, p.698). Recent experimental economics applications with energy and water utilities (Allcott, 2011; Ferraro et al., 2011) are focused on social comparison through reference points, typically "reference consumption", and the potential roles of price

and expense information are not considered. Moreover, for many natural resources there is currently a focus on demand management, especially in developed countries where supply management was paramount in the past and where current resource use is frequently unsustainable (Griffin, 2006). One of the essential elements of demand management is an understanding of consumer reactions to price, but little (if anything) has been written on such reactions when consumers have gain-loss utility and price schedules are complex, or in situations where there is higher awareness to expense than to unit prices.

Furthermore, there are not many examples of behavioural economics insights in the environmental economics literature, with the exception of environmental valuation studies, in spite of the potential importance of behavioural failures in the environmental policy arena (Shogren and Taylor, 2008). In the case of water demand, Correia and Roseta-Palma (2014) discuss the handful of articles which attempt to incorporate behavioural effects. Behavioural economics is also (slowly) emerging in energy economics (Pollitt and Shaorshadze, 2011), climate change literature (Brekke and Johansson-Stenman, 2008) and sustainable forest management (Knetsch, 2005). The latter points out that "it is becoming increasingly clear that most economic analyses of resource issues (...) could be markedly improved by including the insights from the findings of behaviour economics" (Knetsch, 2005, p.101).

To contribute to such improvement, this paper is organized as follows: Section 6.2 presents our two models: i) a reference-price model with block rates and ii) a reference-expense model, describing theoretical results under different reference-price possibilities and a reference-expense framework. Section 6.3 concludes the paper by briefly examining implications for utilities or other firms, as well as pointing avenues for further research.

6.2 Modelling different types of reference effects with block rates

6.2.1 Modelling reference-price effects

Most price analyses in economics as well as in marketing focus on intrinsic price, although over the last three decades the "behavioural aspects of pricing" (henceforth behavioural pricing) emerge as an ineluctable topic (Krishna, 2009). In this section, we assume that consumers make rational choices and know their rate structure, yet have subjective reference prices which are affected by available block rates. Demand analysis under block-rate prices requires the use of a model that distinguishes the choice of block, which is discrete in nature, from the choice of consumption within the block, which is continuous (see Moffitt (1986) for the two-good model and an explanation of the econometric approach to demand estimation, and Hewitt and

Hanemann (1995) for an extension to the N-good case and an application to water demand). To find consumer demand, essentially requires three steps: i) definition of the budget subsets for the discrete choice; ii) maximization of utility in each budget subset to find demand conditional on location in that subset; iii) given conditional demands from the previous step, build the unconditional demand. The novelty in this paper is the incorporation of a gain-loss component based on the existence of a reference price in the utility function within step ii).

Definition of budget subsets

Suppose there are N goods, x_1 to x_N, one of which, x_1, is characterized by a nonlinear price schedule with a fixed fee or fixed access charge, FC, and K rate blocks, which imply $K-1$ switching points (or kink points). Let x_{11} to x_{1K-1} and p_{11} to p_{1K} denote the block-switching points and the block prices, respectively. Also, the first block starts at $x_{10}=0$. We assume that once the consumer changes to a higher block, only the additional units are charged at the new price, so that several marginal prices can co-exist in the consumer bill. Figure 6.1 illustrates the two-block budget set when there are only two goods and rates are increasing, $p_{11} < p_{12}$.

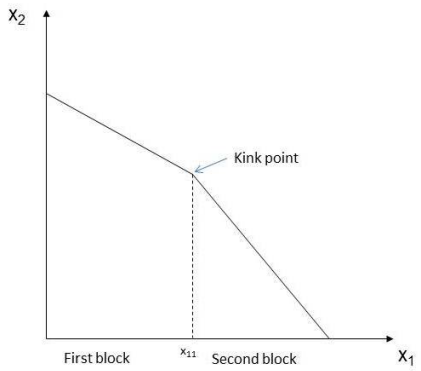

Fig. 6.1: Budget set with two blocks for x_1, with increasing block rates

The budget set B will be kinked but continuous and it will have $2K-1$ subsets, denoted by B_b, where $B = \bigcup_{b=1}^{2K-1} B_b$. All budget subsets are convex even if the full budget set is not, as will be the case for decreasing block rates. There are two type of subsets: i) kink points, which occur when $x_1 = x_{1k}$ and ii) line segments defined as $\left[(x_1,...,x_N) \mid x_{1k} \leq x_1 \leq x_{1k+1},\ p(x_1) + \sum_{j=2}^{N} p_j x_j \leq M\right]$ (Hewitt and Hanemann, 1995). The complete budget set can be written using the K budget segments defined by:

$$p(x_1) + \sum_{j=2}^{N} p_j x_j \leq M \tag{6.1}$$

where M is consumer income and $p(x_1)$ is the payment function for a customer's quantity purchased for a good or service with a K-rate block structure, namely:

$$p(x_1) = \begin{cases} p_{11}x_1 + FC & \text{if } 0 \leq x_1 \leq x_{11} \\ p_{12}\left(x_1 - x_{11}\right) + p_{11}x_{11} + FC & \text{if } x_{11} < x_1 \leq x_{12} \\ \ldots & \\ p_{1K}\left(x_1 - x_{1K-1}\right) + \sum_{k=1}^{K-1} p_{1k}\left(x_{1k} - x_{1k-1}\right) + FC & \text{if } x_{1k-1} < x_1 \end{cases} \tag{6.2}$$

Alternatively, the budget set can also be written using a difference term, d_k, which is the difference between the payment incurred for quantity x_1 (in the k^{th} block) and what it would have cost to purchase the same quantity at that block's price p_{1k}, and which is very common in the literature:

$$\begin{gathered} p_{1k}x_1 + \sum_{j=2}^{N} p_j x_j \leq M + d_k \qquad \forall k = 1, ..., K \\ \text{where} \qquad d_k = -FC - \sum_{i=1}^{k-1} \left(p_{1i} - p_{1i+1}\right) x_{1i} \end{gathered} \tag{6.3}$$

The sum of M and d_k is also known as virtual income. Thus defined, the difference term will be negative for decreasing block rates and it may be positive or negative for IBR, depending on the size of the fixed access charge [52]. Naturally, the case without such charges is a special case of this general formulation.

Reference points - reference prices

As noted in the Introduction, the conventional reference point is the status quo, based on the implicit assumption that the consumer's expectation about this status quo remains unchanged (Kőszegi and Rabin, 2006; Putler, 1992). Krishna (2009) presents a conceptual framework suggesting that the subjective price perceived by consumers has two types of determinants: internal reference prices (i.e. reference points created by consumers themselves) and external factors affecting reference prices (i.e. price presentation effects). Consumer behaviour, normally expressed by the quantity purchased (consumption level), is assumed to be determined by subjective price. According to conventional theory, the consumer is a price taker and in this sense, the reference point is exogenous, because "references prices are formed before the consumer chooses what to purchase, and are viewed as being exogenous at the time of choice" (Putler, 1992, p.289). The neoclassical perspective states that the consumption level will depend on two determinants: price and income. In this sense the existence of a reference consumption level (Kőszegi and Rabin, 2006) may

52. See appendix C.1 for details.

be influenced by reference prices and a reference consumer income[53]. In order to check the impact on consumer choices, we suggest three different reference-price possibilities, in a two-block setting: i) price of the first block, ii) price of the second block, and iii) the average of the two block prices. Case i) would apply if in the recent past the consumer paid the price of the first block. Case ii) is similar, for a consumer that has a higher consumption level so that he expects the second-block price. Case iii) would be applicable to situations where the typical consumption level is close to the block limit, sometimes falling on the first block and others on the second.

Utility maximization with gain-loss component based on reference prices

For the consumption choice within each budget subset, there are two alternatives: either the consumer is on a kink point ($x_1^* = x_{1k}$ for some k) or he is on a line segment k where the (constant) marginal price is p_{1k}. Either way, the decision will be the outcome of a utility-maximization problem with piecewise-linear budget constraints, where the utility conditional on being located on a specific budget subset is:

$$\begin{array}{cc} \max\limits_{x_1,...,x_N} & U(x_1,...,x_N,L_k,G_k,\theta) \\ s.t. & x \in B_b \end{array} \tag{6.4}$$

G_k and L_k are gain and loss terms, respectively, and θ represents other parameters of the utility function. This general formulation is compatible with Kőszegi and Rabin (2006)'s assumption of separability between consumption utility and gain-loss utility. Moreover, the model is reduced to the conventional economic model if there are no reference-dependence effects[54]. We now describe the role of G_k and L_k, following Putler (1992) but considering, for simplicity, that good 1 (x_1) is the only good where these terms exist, while taking into account multiple block prices. The idea is that having a price schedule (*i.e.* external reference prices) for this good provides the consumer with exogenous information that affects (internal) reference prices, and this may influence his perception of the price he is paying. Define the unit loss as $l_k = I(p_{1k} - p_{1r})$, where p_{1r} is the reference price, and the unit gain as $g_k = (1 - I)(p_{1r} - p_{1k})$. Naturally, the consumer cannot simultaneously feel an

53. The existence of a reference income or wealth is, however, outside the scope of this work.

54. Note, however, that Köszegi and Rabin's model is based on the expectations-formation literature, in contrast with our model which is based on adaptation-level formation. Adaptation-level theory suggests that reference-price formation by consumers can be grounded on the path of past prices and other factors, such as suggested prices (Putler, 1992). Pricing strategies could, in principle, be designed to highlight the price which firm managers intend to be the reference price.

(overall) gain and an (overall) loss, so:

$$I = \begin{cases} 1 & p_{1k} > p_{1r} \\ 0 & \text{otherwise} \end{cases}$$

To allow for the possibility that the gains or losses experienced by the consumer may not be linear, we define effective per unit gain or loss as:

$$E(l_k, g_k) = \begin{cases} E_l(l_k) & p_{1k} > p_{1r} \\ 0 & p_{1k} = p_{1r} \\ E_g(g_k) & p_{1k} < p_{1r} \end{cases}$$

where $E_l(l_k) > 0$, $E_g(g_k) > 0$, and each one approaches zero when l_k and g_k, respectively, approach zero. Now we can define the total loss or gain affecting the consumer, $L_k = E_l(l_k)x_1$ or $G_k = E_g(g_k)x_1$.[55] We assume that consumption marginal utilities are positive and decreasing, while $\frac{\partial U}{\partial L_k} < 0$, $\frac{\partial^2 U}{\partial L_k^2} > 0$, $\frac{\partial U}{\partial G_k} > 0$ and $\frac{\partial^2 U}{\partial G_k^2} < 0$. Thus the utility function has the expected properties, i.e. strict concavity in consumption and gains and convexity in losses. The existence of loss aversion would be reflected in a presumably stronger reaction of $E_l(l_k)$ to price "losses" than that embodied in $E_g(g_k)$ for price "gains".

The third step, as described in detail in Hewitt and Hanemann (1995), is to take the conditional demands for all budget subsets, verify which achieve indirect utility maximization taking all blocks into account and build the unconditional demand functions (if the whole budget set B is convex and there is a unique optimum) or correspondences (if the budget set is not convex, in which case there may be more than one solution). Note however, that demand functions will now depend not only on prices and income but also on the gain and loss effects.

Theoretical results using alternative reference prices

In this section, we analyse the impact of the gain-loss formulation on consumer choices for different reference-price possibilities. Starting with an interior solution on segment k, the first-order conditions associated with utility-maximization problem

55. For the loss term, it would be possible to consider only the units paid at the higher price, e.g. $x_1 - x_{1k-1}$ but this adjustment would not change the first-order condition.

(6.4) are:

$$\begin{aligned} \frac{\partial U}{\partial x_1} + E_l \frac{\partial U}{\partial L_k} + E_g \frac{\partial U}{\partial G_k} - \lambda p_{1k} &= 0 \qquad \forall k = 1, ..., K \\ \frac{\partial U}{\partial x_j} - \lambda p_j &= 0 \qquad \forall j = 2, ..., N \\ p_{1k} x_1 + \sum_{j=2}^{N} p_j x_j &= M + d_k \end{aligned} \tag{6.5}$$

Assuming that an interior solution exists, the solution of first-order conditions (6.5) is represented by the conditional demand functions (i.e. conditional on the quantity consumed being in the kth block), in particular for good 1:

$$x_1 = x_1(p_{1k}, l_k, g_k, M + d_k, \theta)$$

This general conditional demand function includes the standard components (i.e. price and (virtual) income) plus the marginal gain and marginal loss terms and consumer parameters.

As noted in the literature (Olmstead et al., 2007; Hewitt and Hanemann, 1995; Moffitt, 1986), the consumption choice could be either within each budget subset (*i.e.* line segment k) or at the kink point between two segments (for example, at $x_{1k-1} = x_{11}$ for $k = 2$). Therefore, the unconditional demand (x_1) in the more general case for k blocks and taking into account the unit gain and unit loss of each conditional demand function, we have:

$$x_1 = \begin{cases} x_{11}^*(p_{11}, l_1, g_1, M + d_1, \theta) & \text{if } x_{11}^*(p_{11}, l_1, g_1, M + d_1, \theta) < x_{11} \\ x_{11} & \text{if } x_{11}^*(p_{11}, l_1, g_1, M + d_1, \theta) \geq x_{11} \\ & \text{and } x_{12}^*(p_{12}, l_2, g_2, M + d_2, \theta) \leq x_{11} \\ x_{12}^*(p_{12}, l_2, g_2, M + d_2, \theta) & \text{if } x_{12}^*(.) > x_{11} \\ \quad ... & \\ x_{1k-1} & \text{if } x_{1k-1}^*(p_{1k-1}, l_{k-1}, g_{k-1}, M + d_{k-1}, \theta) \geq x_{1k-1} \\ & \text{and } x_{1k}^*(p_{1k}, l_k, g_k, M + d_k, \theta) \leq x_{1k-1} \\ x_{1k}^*(p_{1k}, l_k, g_k, M + d_k, \theta) & \text{if } x_{1k}^*(p_{1k}, l_k, g_k, M + d_k, \theta) > x_{1k-1} \end{cases} \tag{6.6}$$

Notice that the utility maximization only occurs at the kink point if utility maxima along each segment are found in the unfeasible range (Moffitt, 1986). Under IBR, the budget set will be strictly convex, therefore any interior solution will be

unique as long as indifference curves are continuous, even if they are no longer expected to be differentiable at the (block-switching) kink point: although the following figures only show the relevant section of each indifference curve, it is clear that the marginal rate of substitution will be higher where the slope of the budget constraint is lower, invalidating the existence of an alternative solution on the other block.

Whenever the price for good 1 is the same as the reference price, the gain and loss terms disappear and the problem reverts to the traditional consumer maximization problem. Otherwise, the impact of the new components can be intuitively gathered from an analysis of the marginal rate of substitution between good 1 and any other good j at a given consumption point $x^*(x_1^*, x_j^*)$:

$$\frac{\frac{\partial U}{\partial x_1} + E_l \frac{\partial U}{\partial L_k}}{\frac{\partial U}{\partial x_j}} < \frac{\frac{\partial U}{\partial x_1}}{\frac{\partial U}{\partial x_j}} < \frac{\frac{\partial U}{\partial x_1} + E_g \frac{\partial U}{\partial G_k}}{\frac{\partial U}{\partial x_j}} \tag{6.7}$$

Recall that $x_j, \forall j = 2, ...N$, does not have gain and loss terms [56]. Inequality (6.7) indicates that indifference curves will be steeper for losses ($p_{1k} > p_{1r}$) than when there is no gain-loss effect ($p_{1k} = p_{1r}$), while less steep indifference curves will occur in the domain of gains ($p_{1k} < p_{1r}$). A graphical analysis in two-good space can be used to show how the resulting change in the slope of indifference curves yields a different consumption choice. We will consider only two blocks and no fixed charge, to simplify. To apply the gain-loss framework, however, requires us to make assumptions about the reference price. We check the impact on consumer choices in three different cases: i) $p_{1r} = p_{11}$, ii) $p_{1r} = p_{12}$, and iii) $p_{1r} = \frac{p_{11}+p_{12}}{2}$.

If the reference price is the price of the first block (p_{11}), then consumers on the second block will be affected by a sense of loss, since their price is higher than the reference price, as shown on Figure 6.2. On the other hand, consumers on the first block or the kink will react no differently than in traditional models. Using equation (6.7), it is clear that if the consumer's choice without gain-loss components was on the second block, at that point, x^*_{1trad}, the new indifference curve will have a lower slope. Thus, the new choice will be a point to the left of x^*_{1trad}, such as x^*_{1new}.

In this case, the consumer will therefore choose less of the good x_1. Furthermore, if there is an increase of the second-block price (p_{12}), the loss term increases so the consumption response will be stronger than we would expect in a traditional utility-maximization setting. [57] This is a potential theoretical justification for the finding that consumers with IBR show higher consumption elasticities, as noted in section 6.1. It could also explain why water managers defend increasing blocks as a way to signal

56. See Putler (1992) for the case where all goods have gain and loss terms but prices are uniform.
57. See appendix C.2 for the Generalized Slutsky Equation.

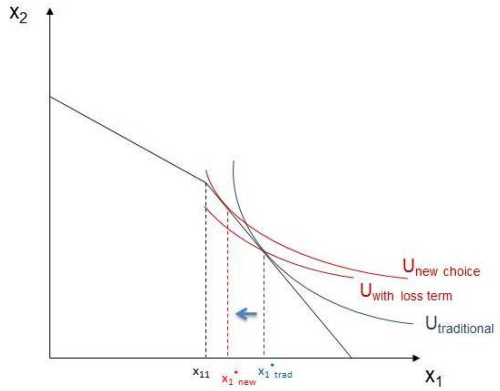

Fig. 6.2: Decrease in consumption due to the loss effect (with $p_{1r} = p_{11}$)

scarcity and decrease consumption, over and beyond what could be expected from a higher uniform price. Despite the coexistence of a wide range of rate structures in OECD countries (OECD, 2010), IBR are the most common choice for water (for example, in Portugal, Spain and Italy)[58].

There is no a priori reason, however, for consumers to set p_{11} as their reference price. It would also be possible for p_{12} to be the reference. In that case, consumers on the second block will have no gain/loss term, and those on the first block or at the kink will feel a gain because they see their price as a discount. Using similar reasoning to that developed in the previous paragraph, this will lead to an increase in consumption, as depicted in Figure 6.3.

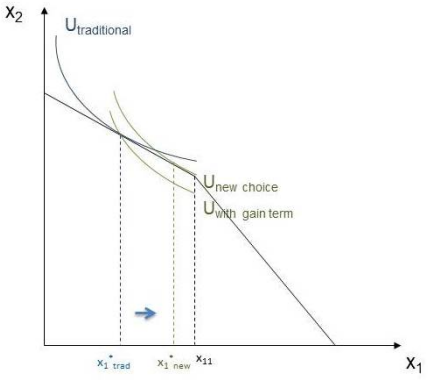

Fig. 6.3: Increase in consumption due to the gain effect (with $p_{1r} = p_{12}$)

Finally, if the reference price is the average of the two block prices, $p_{1r} = \frac{p_{11}+p_{12}}{2}$, indifference curves will shift on both segments, yielding a rise in consumption for those on the first block and a decrease for those on the second. This case is shown in Figure 6.4, which highlights that we would expect to see more "bunching" around

58. Although of course alternative tariff structures also have advantages, for instance decreasing block rates benefit large customers while providing stable cash flows to the seller (OECD, 2010).

the kink point.

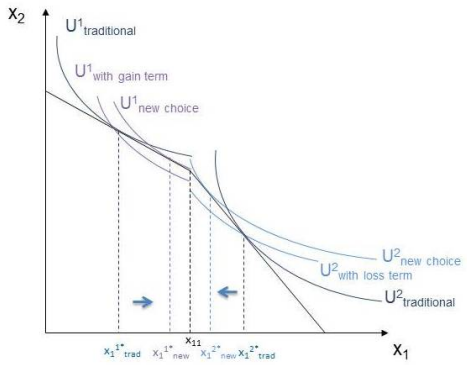

Fig. 6.4: Increase (decrease) in consumption in the first (second) block (with average price as the reference)

6.2.2 Modelling reference-expense effects

The previous model assumes that consumers have a reference price for the good which, along with the actual price paid, influences their consumption decisions. However, it would also be possible for a reference point to be related with the total amount paid for the service. In other words, consumers could have a reference expense, which seems more realistic in the residential water sector. As noted in Chapter 3, in a survey of Portuguese residential water users only 8% stated that they knew their marginal price, while 87% claimed familiarity with their total monthly water bill. Consumers thus show higher awareness with respect to their water bill expenses than to prices. A model which includes reference-expense effects seems to be in order.

Definition of budget subset

Suppose there are N goods, x_1 to x_N, with x_1, as in section 6.2.1. However, assume in this case that the consumer does not have salient information about block rates and will react only to the total amount paid for each good.

To simplify, we will assume in this section that unit prices are constant (or seen by consumers to be constant [59]) for all goods, so that the budget set B is no longer kinked:

$$\sum_{i=1}^{N} e_i \leq M, \quad \forall i = 1, ..., N \tag{6.8}$$

59. In our survey we found knowledge about the full pricing structure to be limited. Only 54% of households tried to guess their tariff structure.

where M is consumer income and $e_i = p_i x_i$ is the expense made for purchasing i. The expense is composed of x_i, an $n-$vector of purchased amounts, and p_i, an $n-$vector of prices.

Reference points - reference expense

In section 6.2.1, we suggested different prices that could be used as reference points. When dealing with expense, we acknowledge that people will typically have only one bill to pay in each period. There could still be different ways of modeling reference expense, *e.g.* using a lagged reference expense (such as the bill paid in the immediately preceding month or in the same month a year before if seasonality is an issue) or an average value. A further alternative would be for utilities to highlight a representative value for expense, as is commonly done for consumption in studies of social comparison. The relevant point in this section is to start from the premise that a reference expense exists, so a higher expense will be felt as a loss while a lower expense would be seen as a discount.

Utility maximization with gain-loss component based on reference expense

The consumer choice decision will be the outcome of the utility-maximization problem:

$$\begin{array}{cc} \max\limits_{x_1,...,x_N} & U(x_1,...,x_N, L_i, G_i, \theta) \\ s.t. & \sum\limits_{i=1}^{N} e_i = M \end{array} \tag{6.9}$$

where G_i, L_i and θ represent gain term, loss term and parameters of the utility function, respectively. The loss is defined as $l_i = I_i(e_i - e_{ir})$, where e_{ir} is the reference expense of good or service i, and the gain as $g_i = (1 - I_i)(e_{ir} - e_i)$. As in the previous model, the consumer cannot simultaneously feel gain and loss, thus we use a binary variable:

$$I = \begin{cases} 1 & e_i > e_{ir} \\ 0 & \text{otherwise} \end{cases}$$

Likewise, we define effective gain or loss as:

$$E_i(l_i, g_i) = \begin{cases} E_{li}(l_i) & e_i > e_{ir} \\ 0 & e_i = e_{ir} \\ E_{gi}(g_i) & e_i < e_{ir} \end{cases}$$

where $E_{li}(l_i) > 0$, $E_{gi}(g_i) > 0$, and each one approaches zero when l_i and g_i, respectively, approach zero. Now, we can define the total loss or gain affecting the consumer, $L_i = E_{li}(l_i)e_i$ or $G_i = E_{gi}(g_i)e_i$, respectively. We assume that consumption

marginal utilities are positive and decreasing, while $\frac{\partial U}{\partial L_i} < 0$, $\frac{\partial^2 U}{\partial L_i^2} > 0$, $\frac{\partial U}{\partial G_i} > 0$ and $\frac{\partial^2 U}{\partial G_i^2} < 0$. Thus, the utility function has the expected properties, *i.e.* strict concavity in consumption and gains and convexity in losses.

Theoretical results using reference expense

The impact of the gain-loss component on consumer choices for reference-expense effects is given by the first-order conditions associated with utility-maximization problem (6.9):

$$\begin{aligned} \frac{\partial U}{\partial x_i} + \left[E_{li} \frac{\partial U}{\partial L_i} + E_{gi} \frac{\partial U}{\partial G_i} - \lambda \right] p_i &= 0 \\ \sum_{i=1}^{N} e_i &= M, \qquad \forall i = 1, ..., N \end{aligned} \tag{6.10}$$

The results will be similar to Putler (1992), with the difference that p_i will now influence the gain and loss terms. The solution of first-order conditions (6.10) is represented by the conditional demand function:

$$x_i = x_i(p_i, l_i, g_i, M, \theta) \tag{6.11}$$

.

The impact of the new components can be intuitively gathered from an analysis of the marginal rate of substitution between good 1 and any other good j at a given consumption point $x^*(x_1^*, x_j^*)$:

$$\begin{gathered} \frac{\frac{\partial U}{\partial x_1} + E_{l1} p_1 \frac{\partial U}{\partial L_1}}{\nu_j} < \frac{\frac{\partial U}{\partial x_1}}{\nu_j} < \frac{\frac{\partial U}{\partial x_1} + E_{g1} p_1 \frac{\partial U}{\partial G_1}}{\nu_j}, \\ \text{where } \nu_j = \frac{\partial U}{\partial x_j} + \left[E_{lj} \frac{\partial U}{\partial L_j} + E_{gj} \frac{\partial U}{\partial G_j} \right] p_j \end{gathered} \tag{6.12}$$

This inequality allows us to perform an indifference curve analysis in two-good space (good 1 and good j) in which the utility maximization bundle x_g will occur where the indifference curve U_g is tangent to the budget constraint, when expense is lower than the reference expense ($e_i < e_{ir}$). When the expense is higher than the reference expense ($e_i > e_{ir}$), the utility maximization bundle x_l will occur in the tangent between the indifference curve U_l and the budget constraint, as shown in Figure 6.5.

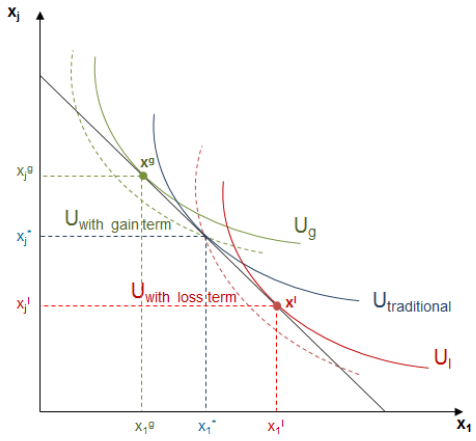

Fig. 6.5: Increase (decrease) in consumption with expense lower (higher) than reference expense

6.3 Conclusion and Future Research

First of all, it is important to note that nonlinear pricing analysis "(...) is a more realistic and thus more complex view of reality" (May, 1999, p.3). In this chapter, we have seen that the inclusion of a behavioural reaction to a reference price arising from a schedule with more than one unit price can generate different effects on consumption, depending on which price is seen by the consumer as the reference point. Because results are ambiguous, and considering that there is no reason to suppose a certain unit price will catch the consumer's attention more than any other, firms could advertise the price that best suits strategic objectives. For example, utilities who are dealing with capacity constraints or natural resource scarcity can focus specifically on advertising the first block price, or even the second, if there are more than two and the first is a heavily subsidized block meant only to ensure affordability for poorer households. Higher-block prices would then be framed as losses, to induce conservation behaviour even without raising prices. Furthermore, if those prices were to be raised, for example to reflect marginal cost as so often recommended on efficiency grounds, such framing would also encourage a stronger consumption response. We briefly summarize the main theoretical results for the three different reference prices in table 6.1. We also propose a model based on reference expense where the relevant question is "what if consumers are not 'price-conscious' and are only aware of their total expense?". Given the simplifying assumptions of linear prices and a pre-existing value for the reference expense, our results are a straightforward extension of Putler (1992).

Tab. 6.1: Main theoretical results with three different reference-price possibilities

	Reference price			Gain and loss effect on current block		Impact on water consumption		
Scenarios	First block	Second block	Average	First block	Second block	Increase	Decrease	Expected theoretical results
Increasing block rates								
Case 1 ($p_{1r} = p_{11}$)	✓			No gain / loss term	Loss effect		✓	Consumers on second block will be affected by a sense of loss. Consumers on the first block or the kink, on the other hand, will react no differently than in traditional models.
Case 2 ($p_{1r} = p_{12}$)		✓		Gain effect	No gain / Loss term	✓		Consumers on first block or the kink will be affected by a sense of gain. Consumers on the second block will react according to traditional models.
Case 3 ($p_{1r} = \frac{p_{11}+p_{12}}{2}$)			✓	Gain effect	Loss effect	✓ (1st block)	✓ (2nd block)	Consumers on both first block or second block will move towards the kink point, "bunching" around the kink point.

Source: author's analysis.

We only explore IBR, due to both their tractability and their increasing application in developed and developing countries, as noted earlier, but the extension of the model to decreasing block rates is also a path for further research. These display some advantages, namely stabler flows from high-consumption costumers and decreasing revenue fluctuations, especially when there are also fixed charges (OECD, 2010; Griffin, 2006). Decreasing block rates may also be efficient, as shown in Elnaboulsi (2001). On the other hand, uniform rates are much simpler for utilities to apply and for consumers to understand, are efficient when consumers are homogeneous as long as they reflect marginal costs, and could even turn out to provide higher welfare levels than IBR for low-consumption and low-income households (Griffin and Mjelde, 2011).

We assume that all consumers know either their block structures or their expense, and that there are no price fairness concerns. Both assumptions could be challenged. The latter topic was discussed in Chapter 5. As for the former, it is often possible to distinguish between two types of consumers (or households): those who have price knowledge and those who are “naïve" (i.e. “price-ignorant"). For instance, considering the literature on residential water demand, Carter and Milon (2005) found that price-conscious households exhibit more responsiveness to both average and marginal prices, as expected. Additionally, the authors obtain a somewhat counter-intuitive conclusion that price awareness increases water consumption, which may be explained by price overestimation, in line with electricity demand literature (as pointed out in their article). Gaudin (2006) notes that the information provided to water consumers through the water bill alters the effectiveness of water pricing policy. Frondel and Messner (2008) use data from a household survey to corroborate that water pricing policies will only have significant effects in sophisticated households (i.e. " price-conscious"), while *naïve* households, the large majority of their sample, do not significantly reduce consumption when price increases. Finally, Martins and Moura e Sá (2011) argue that water bills fail to provide clear information to consumers, obscuring price signals and jeopardizing the effectiveness of pricing strategies. Despite this empirical evidence, most discussions of water demand seem to be broadly circumscribed to model specification, estimation techniques and economic outcomes (i.e. price and income elasticities) (Worthington and Hoffman, 2008; Arbués et al., 2003).

Finally, although the models in this chapter were developed having in mind residential water demand, the first model is applicable to any industries with nonlinear price schedules, while the second model can be used whenever there is a total expense to pay (and unit prices are not so salient to consumers), such as in communication and subscription services. Nonetheless, this exploratory work needs to be further developed and complemented with empirical tests using the methods developed

for discrete/continuous choice models, so price reactions under block rates can be clearly compared with those arising from uniform rates. There is also the possibility that consumers do not really react to prices when schedules are too complicated. Neoclassical theory suggests that consumers are price-conscious. Yet as noted in Liebman and Zeckhauser (2004), excessive complexity may lead the consumer to "schmedule", *i.e.* use an inaccurately discerned schedule instead of the true one. Developing models with heterogeneous consumers, as well as including the possibility of rational inattention (recently elaborated by Sitzia et al. (2015) and Grubb (2014)), would be valid extensions. Moreover, empirical strategies to assess consumer behaviour in such cases, and thereby deriving pricing policy lessons, seems a promising avenue for future research.

7. MAIN CONTRIBUTIONS

"I am convinced that, in human if not in financial terms, the most valuable areas of research in the twenty-first century will include humankind's understanding and management of water resources." (Merrett, 2005, p.8).

Water is an essential good for ecosystems and businesses, and although it is not a public good, it is a scarce resource that must be widely available to every person and therefore a merit good. In this thesis, we contribute to the advancement of water management through the incorporation of behavioural economic insights.

Behavioural economics as a scientific subfield started as early as the 1940s (Lambert, 2006) and can be divided between "old" and "new" behavioural economics. "Old" behavioural economics started with the "bounded rationality" of Herbert Simon (1955), the "new" behavioural economics started in 1979, with the prospect theory of Daniel Kahneman and Amos Tversky, proposed in one of the most widely cited papers in Econometrica (Kahneman and Tversky, 1979). Herbert Simon and Daniel Kahneman were two non-economists that won the Nobel Memorial Prize in Economic Sciences (also known as Nobel Prize in Economics), which may reveal that economic research could evolve also through more interactions with other social sciences.

In terms of theoretical framework we relied on prospect theory as a starting point, especially on reference dependence. Prospect theory has been mainly constrained within economics to applications in finance and insurance (Barberis, 2013). These research areas have been fruitful fields, due to the large availability of information on investors and transactions, and the emergence of "big data". The literature evolved to highlight "anomalies" or "market anomalies", a common term used by behavioural economists. These "anomalies" are characterized as empirical evidence that do not corroborate conventional economic theory and started in the 1980s with Richard Thaler (*e.g.* Thaler (1987)).

However insights from prospect theory, such as reference points and their potential applications can (and should) be applied to other fields. Water resource economics could be one of these fields, due to the relevance of water as a scarce

resource and human right since 2010 (Albuquerque and Roaf, 2012), as well as the potential risks associated with water resource sustainability.

Simon (2008) argues that the development of behavioural research (both empirical findings and theory) should be made through tests using empirical methods to validate economic theories. The methods proposed are surveys and experiments. These methods were not common in the economic sciences, although they have recently gained popularity among economists. This thesis provides the first clues about reference points and their determinants in residential water sector (chapter 4), which may have different applications. For example, field experiments in the residential water sector may use reference price or bill, as alternatives to the reference consumption used for social comparison (Ferraro and Price, 2011; Ferraro et al., 2011). Overall, experimental economists have shown that social comparison messages reduce water and electricity consumption (Ferraro and Miranda, 2013), and these behavioural nudges may have a persistent effect six years after its implementation (Bernedo et al., 2014). Further research can tackle this issue and enhance non-pecuniary conservation programs (Miranda, 2012), since nowadays one of the challenges to the researchers is to design and use these techniques.

In this thesis we tried to conciliate contributions from neoclassical and behavioural theories (chapter 6) based on the empirical evidence of the survey used (chapters 3). We draw potential policy recommendations based on the formation of reference points, namely that price (un)fairness should also be taken into account by policy-makers, since it would be relevant for water-conservation programs. Furthermore, policies regarding modern reporting and billing standards and reference points, such as the improvement of information quality in the water bills could be enhanced (chapter 4). Moreover, PPF could be a important tool for monitoring the effects of water policies on the consumers (chapter 5) and reference block price and bill could be used as a management tool by the water utilities (chapter 6).

According to Somervuori (2014) behavioural pricing research has been mainly focused on the price/perceived quality relationship and reference price, with the identification of anomalies of consumer responses to price information that challenge the mainstream economics. The author identifies five subareas of behavioural pricing from which we developed three, as described in table 7.1. The analysis of price awareness, the formation of reference points and perceived price fairness were developed in chapters 3, 4 and 5, respectively. The price elasticity estimation, using the reference-dependence model proposed in chapter 6 would be a interesting line of research to understand the impact of references in the estimation of water demand.

The understanding of consumer perception and price evaluation processes are still limited (Somervuori, 2014). Another avenue of further research can be the use

Tab. 7.1: Subareas of behavioural pricing explored in this thesis

Subareas of behavioural pricing	
Price awareness	✓
Reference price	✓
Price fairness	✓
Price elasticity estimation	-
Price–quality relationship	-

Source: author's analysis based on Somervuori (2014).

of external reference points (*e.g.* a reference price in the water bill) which can be a nudge. Since consumers tend to behave irrationally but in predictable ways (Ariely, 2009), they can be encouraged to make better choices through nudging (Thaler and Sunstein, 2008). Nudging is recommended in different contexts, from avoiding littering (Cialdini et al., 1990) to energy conservation (Costa and Kahn, 2013; Allcott and Mullainathan, 2010). In the latter, some reasons pointed for nudging are the small weight of the bill in household expenditure and politically difficult to impose price increases (Delmas and Lessem, 2014), as well as in water sector, according to chapter 3. This work also promoted a new avenue of research within JOPA, a Young Water Professionals group in Portugal, where we developed the first review of nudges in the water sector (Correia et al., 2015).

Overall, the main aim of this thesis was to use behavioural economics as a bridge to reach new ground on pricing and non-pricing strategies enhancing sustainable water consumption in households, as well as the promotion of water conservation in order to contribute to the development of economic instruments in water resource economics. The specific contributions and implications of the findings provided in each chapter of this thesis, as well as limitations, are summarised in table 7.2. The findings in this thesis contradict conventional economic theory, in some cases, but also raise concerns about the theory of reference points, whether using price as reference (Putler, 1992) or consumption as reference (Kőszegi and Rabin, 2006). Overall, our findings suggest that consumers are aware of neither average price nor monthly consumption, at least for the Portuguese residential water sector.

The two main questions that remain are why and how. Firstly, why does this happen? Why don't the majority of consumers have references for average price and monthly consumption? And how can this be reconciled with neoclassical theory, which assumes price and consumption as key elements in consumer choice? Independently of these findings, consumers still use water in their everyday life, therefore ways to enhance consumer awareness, as well as clarity and transparency of water bills, is one of the future avenues for policy.

Tab. 7.2: Synopsis of the main results of the studies

Chapters	Study name	Limitations	Main contributions	Policy implications (recommendations)
Chapter 2	Behavioural Economics in Water Management - An Overview of Behavioural Economics Applications to Residential Water Demand	- Relative high importance given to reference points literature, although behavioural economics field has much more to offer	We suggest four behavioural applications: reference block pricing; asymmetric elasticities; reference transaction; and social comparison through reference consumption.	Introduction of behavioural science insights into public policies as recommend by European Commission
Chapter 3	Do you know how much you pay for water?	- Development of more indicators on perceptions, clarity and simplicity of the water bill	- High consumer unawareness level of marginal (92% of our sample) and average price (93%) as well as monthly water consumption perceived (76%). Conversely, they are highly aware of their water bill (87%)	- The fact that the monthly water bill is better than the global tariff structure should be acknowledge in water policies - Public authorities, the government and water utilities should adopt a holistic approach to enhance consumer awareness to tackle misperceptions, as well as the lack of information that actually exists in the daily decision process of water consumers
Chapter 4	Water consumer behaviours and perceptions	- Use of probit models instead of using a perception scale for reference points - Use of "all-of-nothing" approach instead of special regressor method in outdoor and indoor water conservation choices studies - Use of individual variables instead of a global index to measure price fairness	- Price fairness perceptions explain water-saving and the adoption of modern billing procedures in residential water sector - Price fairness effect and submitting the meter readings have significant positive effects in the respondent's probability of having a reference price and consumption, respectively - People with higher income, who frequently look into details and know their tariff structure have higher probability of having reference points	- Pricing and non-pricing policies should account for price (un)fairness effect through improvement of information quality in the water bill or sensibilization campaigns - Promote water literacy and transparency among water consumers - Evaluate and monitor fairness concerns and promote clarification of water tariffs and water bill accounting for framing effects
Chapter 5	Perceived Price Fairness (PPF) - Determinants in residential water sector in Portugal	- Poor consumer knowledge about water price and transparency issues on the water bill	- Conceptual model of price fairness with price awareness - We suggest a list of determinants of PPF and variables to measure these determinants	- Development of indicators about fairness in residential water sector - Development of public policies accounting for reference transaction
Chapter 6	Nonlinear pricing with reference dependence	- Consumers are assumed to be price-conscious although they could be "naïve" (i.e. " price-ignorant") - Use of an increasing block rates (IBR) scenario only	- Hybrid model using neoclassical and behavioural theories - First analysis of reference-dependent preferences in a (increasing) block-rate setting	- Utilities dealing with capacity constraints or natural resource scarcity should advertise the first block price to frame other blocks as losses in order to induce conservation behaviour even without raising prices

Source: author's analysis.

Secondly, how can reference-dependent models cope with lack of awareness? Is it possible to use reference-dependent methodologies for other relevant variables, such as total monthly expenditure? What are the main references driving consumer perceptions and decision-making and how can they be incorporated into economic models? These are the questions that yet remain.

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APPENDIX

A. APPENDIX - DO YOU KNOW HOW MUCH YOU PAY FOR WATER?

A.1 Tables

Tab. A.1: Dwelling ownership and main residence by type of dwelling

	Type of dwelling								
	House*			Apartment			Total		
	No.	%	Cum %	No.	%	Cum %	No.	%	Cum %
Owner of the residence									
Yes	939	82.9	82.9	826	76.2	76.2	1,765	79.6	79.6
No	194	17.1	100.0	258	23.8	100.0	452	20.4	100.0
Total	1,133	100.0		1,084	100.0		2,217	100.0	
Main residence									
Yes	962	84.8	84.8	970	89.2	89.2	1,932	86.9	86.9
No	173	15.2	100.0	118	10.8	100.0	291	13.1	100.0
Total	1,135	100.0		1,088	100.0		2,223	100.0	

Source: Survey data. Note: *Detached or semi-detached house.

Tab. A.2: Monthly net household income and household size by type of dwelling

	Type of dwelling					
	House*		Apartment		Total	
	No.	%	No.	%	No.	%
Monthly net household income						
Less than 500 Euros	179	18.3	129	13.1	308	15.7
501-1,000 Euros	296	30.3	284	28.8	580	29.5
1,001-1,500 Euros	220	22.5	280	28.4	500	25.5
1,501-2,000 Euros	130	13.3	135	13.7	265	13.5
More than 2,001 Euros	152	15.6	158	16.0	310	15.8
Total	977	100.0	986	100.0	1,963	100.0
Household size						
one	130	11.5	176	16.2	306	13.8
two	394	34.8	399	36.6	793	35.7
three	282	24.9	301	27.6	583	26.2
four or more	326	28.8	213	19.6	539	24.3
Total	1,132	100.0	1,089	100.0	2,221	100.0

Source: Survey data. Note: *Detached or semi-detached house.

Tab. A.3: Respondents' characteristics by type of dwelling

	Type of dwelling					
	House*		**Apartment**		**Total**	
	No.	%	No.	%	No.	%
Gender						
Male	569	50.1	489	44.9	1,058	47.5
Female	567	49.9	601	55.1	1,168	52.5
Total	1,136	100.0	1,090	100.0	2,226	100.0
Level of Schooling						
Does not read nor write	20	1.8	3	0.3	23	1.0
Primary education	579	51.2	400	36.8	979	44.2
Secondary education	483	42.7	606	55.8	1,089	49.1
Higher education	49	4.3	77	7.1	126	5.7
Total	1,131	100.0	1,086	100.0	2,217	100.0
Water bill payer						
Yes	1,009	89.1	1,036	95.3	2,045	92.1
No	124	10.9	51	4.7	175	7.9
Total	1,133	100.0	1,087	100.0	2,220	100.0
Water bill awareness						
Never	102	9.0	62	5.7	164	7.4
Rarely	84	7.4	81	7.5	165	7.4
Sometimes	116	10.2	102	9.4	218	9.8
Often	62	5.5	87	8.0	149	6.7
Always	769	67.9	755	69.5	1,524	68.6
Total	1,133	100.0	1,087	100.0	2,220	100.0
Reason why looked						
Increase in the total paid	136	55.1	127	50.4	263	52.7
Decrease in the total paid	3	1.2	7	2.8	10	2.0
No	108	43.7	118	46.8	226	45.3
Total	247	100.0	252	100.0	499	100.0
Information awareness						
Total amount	458	44.9	486	47.8	944	46.3
Detailed information	562	55.1	531	52.2	1,093	53.7
Total	1,020	100.0	1,017	100.0	2,037	100.0

Source: Survey data. Note: *Detached or semi-detached house.

Tab. A.4: Consumer habits and decisions by type of dwelling

	Type of dwelling					
	House*		**Apartment**		**Total**	
	No.	%	No.	%	No.	%
Concerns to avoid evaporation						
No	67	9	10	20	77	10
Yes	654	91	39	80	693	90
Total	721	100	49	100	770	100
Do you wash full loads?						
No	95	9	84	8	179	9
Yes	915	91	939	92	1,854	91
Total	1,010	100	1,023	100	2,033	100
Do you wash your car with a hose?						
No	75	34	33	58	108	39
Yes	148	66	24	42	172	61
Total	223	100	57	100	280	100
Is there an alternative to publicly supplied water?						
No	823	73	1,069	99	1,892	86
Yes	307	27	9	1	316	14
Total	1,130	100	1,078	100	2,208	100
Do you pay the water bill by direct debit?						
No	606	54	530	49	1,136	52
Yes	509	46	546	51	1,055	48
Total	1,115	100	1,076	100	2,191	100
Do you receive an electronic water bill?						
No	1,062	95	1,029	95	2,091	95
Yes	58	5	52	5	110	5
Total	1,120	100	1,081	100	2,201	100

Source: Survey data. Note: *Detached or semi-detached house.

B. APPENDIX - WATER CONSUMER BEHAVIOURS AND PERCEPTIONS

B.1 Modelling Framework

B.1.1 Probit model with sample selection

The sample selection bias addresses the sometimes neglected issue in this literature, that a dependent dummy variable of water conservation choice is observed only for a limited and non-random sample. Consider a probit model with sample selection in which a latent equation can be denoted as a linear model of the latent variable y_j*, for j observations. This method models the probability of the consumer making a choice, where y_j* is an unobservable magnitude that represents the net benefit of consumer j taking an action (*e.g.* watering the garden in the morning or at night to avoiding evaporation). The explanatory variables are represented as vector x, where β is a set of unknown parameters for x, and with additive error ε_j (Baum, 2006):

$$y_j* = x_j\beta + \varepsilon_{1j}, \tag{B.1}$$

where the error term is assumed to be normally distributed (*i.e.* $\mathcal{N}(0,1)$). In the presence of sample selection if we only run this regression the information on missing values (both for y_j* and x_j* factors) will not be used in the model B.1.

Moreover, consider a probit equation in which we observe the water-saving decision, in other words the binary response outcome (instead of the latent variable y_j^* itself):

$$y_j^{probit} = (y^* > 0), \quad i.e. \quad y_j^{probit} = \begin{cases} 1 & \text{if} \quad y^* > 0 \\ 0, & \text{otherwise} \end{cases} \tag{B.2}$$

Equation B.2 models the probability with which each household (*i.e.* j observation) adopts a water-saving behaviour (*i.e.* 1) (Nauges, 2014), for that choice.

Since, in same case, the dependent variable is not observable (*e.g.* the behaviour of avoiding evaporation when watering the garden depends if the consumer has a garden), the probability of y_j^{select} being observed accounts for this potential selectivity issue that can be stated in the following selection equation:

$$y_j^{select} = (z'\gamma + \varepsilon_{2j} > 0) \tag{B.3}$$

where again the error term is assumed to have a standard normal distribution, and $\rho = \text{corr}(\varepsilon_{1j}, \varepsilon_{2j})$. To identify the model, the factors z must have variables other than the ones included in vector x (Nauges, 2014). These variables are also know as excluded instruments, because they are not included in the main equation, only in equation B.3. When the potential correlation (ρ) between the error terms

of equations B.2 and B.3 is nonzero (*i.e.* significantly different from zero), the standard binary probit yields biased and inconsistent estimates of y_j^{probit}. In the cases where selection is non-random the probit model with sample selection (Stata command *heckprob*) is recommended since it provides consistent estimations, as well as asymptotically efficient.

For additional technical details see Baum (2006) and Stata software documentation. For empirical evidence addressing sample selection in the context of water saving behaviours see Nauges (2014).

B.1.2 Special regressor model

In econometrics literature the endogeneity bias from regressors of binary choice models have receive significant attention (Dong and Lewbel, 2015; Lewbel, 2014, 2000), specially with dealing with non-continuous explanatory variables. In seminal work by Lewbel (2000) the development of the special regressor method consists in a general approach that does not require a continuous distribution of endogenous regressors, *i.e.* these covariates can be continuous, limited, censored or discrete. The advantages gained from the special regressor method, over linear probability models, control functions, maximum likelihood (Dong and Lewbel, 2015) is made at the exchange of three assumptions, choose a special exogenous regressor V conditionally independence of ε that will be additive in the model with respect to this latent error, as well as having a large support and being conditionally continuous distributed.

Following Dong and Lewbel (2015) consider a conventional binary choice model of the decision or choice D, a dummy variable:

$$D = I(X'\beta + \varepsilon \geq 0), \tag{B.4}$$

where explanatory factors are represented as the vector X with a vector of unknown parameters to be estimated as β coefficients and ε an unobserved error term. Plus, consider that the indicator function ($I(\cdot)$) for conventional probit model varies between two value, if its argument $\cdot$ is true will be equal to one and will be zero otherwise. Where we will have two special cases, the standard probit technique will have ε with a standard normal distribution ($N(0,1)$) and for logit model the ε will have a logistic distribution. The aim of the special regressor model is after estimating β get the decision probabilities as well as the marginal effects of explanatory regressors X. The special regressor will be represented as a model of the same type of equation B.4, however including the (special) exogenous regressor V, which is normalized:

$$D = I(X'\beta + V + \varepsilon \geq 0) \tag{B.5}$$

and where the ε have unknown variance (σ_ε^2). Instead in standard probit the variance of the error term ε is normalized to one, but this is equivalent to normalised to one the β of the regressor, and often could be more correct in terms of economic sense (Dong and Lewbel, 2015). These authors suggest that a simple method is to corroborate the slope graphically of the non-parametric regression of D on special regressor V and explanatory factors X, given prove of the monotonic (increasing) relationship, and this can be done through the use of the Kernel-weighted local polynomial regression Bontemps and Nauges (2015).

In the case we have a endogenous regressors we will a have latent nonparametric instrumental variables model (Lewbel, 2014), where Z represent a vector of instruments satisfying the properties $E(Z'\varepsilon) = 0$ and $E(Z'X)$ with full rank that allow the construction of a variable T such that a linear 2SLS regression of T on X given Z yields the desired β (Dong and Lewbel, 2015). The variable T is defined as:

$$T = \frac{D - I(V \geq 0)}{f_{V|Z}(V \mid Z)}, \tag{B.6}$$

where the $f_{V|Z}$ is the conditional probability density function of special regressor V given the instruments Z. Under the assumed model for special regressor V and the two previous properties mentioned ($E(Z'\varepsilon) = 0$ and $E(Z'X)$ full rank) (Dong and Lewbel, 2015; Lewbel, 2014) needed for the 2SLS model we get the special regressor estimator. This simple estimator can be obtained using five step procedure, assuming that we have j observations on D_j, X_j, V_j and Z_j, and that S_j is a vector of explanatory variables (X_j) and instruments (Z_j).

Step 1: Special regressor V should have mean zero, if not we must demean it.

Step 2: Assume $\hat{c}$ is the estimated coefficients of S_j in an ordinary least squares linear regression and compute the residuals for each j (U_j) as the differences between the observed special regressor estimates (V_j) and its predictions ($\widehat{U_j}$).

Step 3: For each observation j let the $\hat{f}_j$ be the non-parametric kernel density estimator of U. This is

$$\hat{f}_j = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{\widehat{U_j} - \widehat{U_i}}{h}\right), \quad \text{for} \quad j = 1, ..., n \tag{B.7}$$

where K stands for the kernel (symmetric) density function similar to the standard normal density, and h is a bandwidth.

Step 4: For each observation j create the data $\widehat{T_j}$ as follows:

$$\widehat{T_j} = \frac{D_j - I(V_j \geq 0)}{\hat{f}_j}, \tag{B.8}$$

Step 5: Based on a linear 2SLS regression compute the $\hat{\beta}$ with respect to X vector, of the $\widehat{T_j}$ on X, given the chosen instruments (Z). Afterwards, choice probabilities and the marginal effects of interest can be computed following Lewbel et al. (2012). The procedure described above can be implemented in statistical software in an easy and intuitively manner (an example is *sspecialreg* command provided for Stata software and developed by Baum (2013)).

For additional information see Dong and Lewbel (2015), Lewbel et al. (2012), and Lewbel (2014, 2000) and Stata software documentation. For an empirical application in the residential water sector see Bontemps and Nauges (2015).

B.2 Brief literature review of the determinants of water-saving behaviours in outdoor and indoor uses

Tab. B.1: Brief literature review of the type of variables used in studies about the water-saving behaviours in outdoor and indoor uses

Studies	Dependent variable(s)	Household and respondents factors	Attitudinal and behavioural factors	Political factors	Climate factors
(Grafton, 2014)*	6 water-saving behaviours (indoor and outdoor uses)	income (-), male (+ and -), age (+ and -), household size (+ and -), education (-), owner (+), years in residence (+ and -), urban or suburban area (-)	ranking of environmental concerns (+ and -), resource depletion and environmental concerns (+), "environmental concern" index (+)	Voter (+), environmental organization supporter (+)	-
(Nauges, 2014)	5 water-saving behaviours (indoor and outdoor uses)	logincome (-), volumetric charge (+), male (-), age (+ and -), education (s.i.), owner (+ and -), years in residence (+ and -), urban or suburban area (-)	environmental concerns (+ and -), "environmental concern" index (+)	Voter (+ and -), environmental organization supporter (+)	-
(Dupont and Renzetti, 2013)	Lawn watering and garden watering	income (+), marginal price of water (+ and -), price variation (+), increasing volumetric charge (+), education (+), children (-), household size (+)	-	non-price water policies (-)	Rainfall (-) and temperature (+)
(Grafton et al., 2011)	5 water-saving behaviours (indoor and outdoor uses)	income (-), volumetric charge (+), age (+ and -), education (+ and -), adults (+ and -), children (+ and -), rooms (+), detached house (+ and -), size of residence (-), urban or suburban area (+ and -)	environmental concerns (+ and -)	Voter (+), environmental organization member (+), and supporter (+)	-

Source: Author's analysis

Note: (+) and (-) represent a positive or negative statistically significant impact and "s.i." stands for a "statistically insignificant" impact of the independent variables. *This study used spearman correlation to determine statistically significant effects of the regressors.

B.3 Brief literature review of the determinants of the preference for drinking tap water

Tab. B.2: Brief review of the type of variables used in studies about the decision between drinking tap water or alternative sources

Studies	Dependent variable(s)	Household and respondents variables	Water quality variables	Trust variables
(Bontemps and Nauges, 2015)	drinking tap water	log(income) (-), water price (-), age (-), children (-); town or suburban and owns a car (s.i.)	tap water satisfaction index (+), Water quality environmental index (s.i.)	-
(Francisco, 2014)	purchase bottled or purified water	education (+), household size (-), children (0-5 years) (+), bottled/purified water price (-); age, children (6-18 years) and income (s.i.)	Safe to drink without treatment (dummy) (-)	perceived trust based on government information about safe water (s.i.)
(Nauges, 2014)	satisfaction with taste and healthy impacts	age (-), urban area (+), environmental concern index (s.i. and +); education and children (s.i.)	(instrumented) satisfaction level with taste (+) and healthy impacts (+)	trust about the environmental impacts of products (-)
(Johnstone and Serret, 2012)	purchase bottled water	income (+), owns a car (+), volumetric charge (-), waste concerns (-); household size, age, children, urban area and male (all s.i.)	satisfaction level with taste (+) and healthy impacts (+)	trustworthy government information about environmental concerns (s.i.)
(Um et al., 2002)	purchase bottled water	income, household size, home ownership, type of house, administrated area, age, education (all s.i.)	tap water quality perceived (+), expectations about future quality (s.i.)	-

Source: Author's analysis

Note: (+) and (-) represent a positive or negative statistically significant impact and "s.i." stands for a "statistically insignificant" impact of the independent variables.

B.4 List of variables with definitions, units and sources

Tab. B.3: List of variables of interest with definitions, units and sources

Variable	Definition	Unit	Source
aavcons	Average water consumption by household	cubic meters	Survey
aavprice	Average water price paid by household	€	Survey
afford	The percentage of actual average monthly bill in the income fitted	Percentage	Survey
avcons6m	Average water consumption by household in the last 6 months	cubic meters	Survey
avpmun	Average water price paid by household for each municipality	€	Water utilities
avvioqual	Average percentage of tests not complying with the limits imposed in the quantity of chemicals in the water, between 1993 and 2012	Percentage	ERSAR
children	Dwelling with at least one children	(1, 0)	Survey
ddebit	Pay the water bill by direct debit	(1, 0)	Survey
dettot	Are you aware of the detailed information in the water bill or just the total amount paid	(1, 0)	Survey
dishwach	How many dishwashers are there in your house?	-	Survey
drinktap	Do you usually prefer to drink tap water?	(1, 0)	Survey
dwetype	Type of dwelling is 1 if it is detached or semi-detached house or 0 if it is an apartment	(1, 0)	Survey
ebill2012	Respondent receive an electronic water bill (only for municipality with this service in 2012)	(1, 0)	Survey
elder	Number of household members with 65 or more years of age	-	Survey
employed	Number of household members who are employed		

Tab. B.4: List of variables of interest with definitions, units and sources (continued)

Variable	Definition	Unit	Source
expenscarce	Water should be more expensive where it is scarce	1: totally disagree; 2: disagree; 3: neither agree nor disagree; 4: agree; 5: totally agree	Survey
fair	The price you pay for water is fair	1: totally disagree; to 5: totally agree	Survey
fairprice	Respondent totally agree with the statement "The price you pay for water is fair" and totally disagree with "The tariffs charged for an essential good such as water are unfair"	(1, 0)	Survey
freqdet	The consumer is often or always aware of the detail in the water bill	(1, 0)	Survey
heducation	Respondent with higher education, undergrated or higher	(1, 0)	Survey
hpayers	Payers represent at least half of the household size	(1, 0)	Survey
hsize	Household size	Numeric	Survey
inactive	Number of household members who are inactive but not retired or students	Numeric	Survey
inastudent	The proportion of household members who are either inactive or student	Percentage	Survey
incfitted	income fitted obtained through the regression in table B.7	Numeric	Survey
income	Monthly net household income by categories in the survey, categories 1: €500 or less; 2: €501-€1000; 3: €1001-€1500; 4: €1501-€2000; 5: €2001-€2500; 6: €2501-€3000; 7: €3001-€3500; 8: More than €3500	Numeric	Survey
knowIBR	Respondent know its tariff structure is an increasing block rate (IBR)	(1, 0)	Survey
loss	The water price should be increased if the water utility incurs a loss	1: totally disagree; to 5: totally agree	Survey
mainresidence	Dwelling is the main residence	(1, 0)	Survey
male	Respondent is male	(1, 0)	Survey

Tab. B.5: List of variables of interest with definitions, units and sources (continued)

Variable	Definition	Unit	Source
maxtempdev	Deviation between the temperature in beginning of the summer of 2012 (April-June) compared with maximum temperature over the last 15 years by municipality	Celsius degrees	IPMA
meter	Do you usually submit the meter reading to the water utility?	(1, 0)	Survey
owner	Owner of the residence	(1, 0)	Survey
p16education	Respondent does not read nor right or has primary education (1-6 years of schooling)	(1, 0)	Survey
p19education	Respondent does not read nor right or has primary education (1-9 years of schooling)	(1, 0)	Survey
p56education	Respondent with at least primary education with 5-6 years of education	(1, 0)	Survey
payers	Number of payers of the monthly water bill in the household	Numeric	Survey
pearn	Percentage of employed and retired members divided by the household size	Percentage	Survey
percbillt	Total monthly water bill perceived in Euro	€	Survey
pool	Dummy if the dwelling has a swimming pool	(1, 0)	Survey
precdev	Deviation between the precipitation in beginning of the summer of 2012 (April-June) compared with precipitation over the last 15 years by municipality	millimetres	IPMA
referencebill	Respondent gives a value for the monthly total bill	(1, 0)	Survey
refblockprice	Do you know the per cubic meter price associated with each block?	(1, 0)	Survey
referencecons	Respondent gives a value for the average monthly consumption perceived	(1, 0)	Survey
referenceprice	Respondent gives a value for the average price	(1, 0)	Survey
runwat	Do you make use of the water that flows while you wait for it to get warm?	(1, 0)	Survey

Tab. B.6: List of variables of interest with definitions, units and sources (continued)

Variable	Definition	Unit	Source
school	Numbers of years of schooling of the respondent (categories)	1: does not read nor right (0 years); 2: Primary education (1-4); 3: Primary education (5-6); 4: Primary education (7-9); 5: Secondary education (10-12); 6: Higher education - undergraduate (13-15); 7: Higher education - master (16-17); 8: Higher education - PhD (more than 17 years)	Survey
tap	How many taps are there in your house?	(1, 0)	Survey
unemployed	Number of household members who are unemployed	Numeric	Survey
unfairprice	Totally agree with a statement "The tariffs charged for an essential good such as water are unfair"	(1, 0)	Survey
uniform	Water tariffs should be equal in all the country	1: totally disagree; to 5: totally agree	Survey
urban	Respondent are located in an urban area	(1, 0)	INE
washmach	How many washing machines are there in your house?	Numeric	Survey
watsummer	Number of times a week people water the garden during the Spring/Summer	Numeric	Survey
well	Is there an alternative to publicly supplied water?	(1, 0)	Survey
wsfullload	Do you wash full loads, when possible?	(1, 0)	Survey
wshortage	Water shortage experience	(1, 0)	Survey
wssoap	Do you close the tap while soaping in the shower?	(1, 0)	Survey
wstank	Does your dwelling have a laundry tub or water deposit/tank for rainwater harvesting?	(1, 0)	Survey
wswatgarden	Do you water your garden/backyard/vegetable garden in the morning or at night to avoid evaporation?	(1, 0)	Survey

B.5 Estimation of income fitted variable *incfitted* for the special regressor method

Tab. B.7: OLS estimated coefficients of income (with sampling weights) to obtain the linear prediction of fitted income

Variables	income
school	0.367***
	(0.019)
male	0.389***
	(0.056)
hsize	0.334***
	(0.027)
pearn	1.428***
	(0.104)
owner	0.307***
	(0.070)
pool	0.356***
	(0.134)
tap	0.053***
	(0.010)
dishwach	0.347***
	(0.066)
Municipality 1 (reference)	-
2.municipality	-0.105
	(0.102)
3.municipality	-0.374***
	(0.098)
4.municipality	-0.149
	(0.102)
5.municipality	-0.419***
	(0.143)
6.municipality	-0.359***
	(0.117)
7.municipality	-0.273***
	(0.098)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.8: OLS estimated coefficients of income with sampling weights to obtain the linear prediction of income fitted (continued)

Variables	income
8.municipality	-0.220**
	(0.096)
9.municipality	-0.262*
	(0.143)
10.municipality	-0.304***
	(0.092)
11.municipality	-0.191**
	(0.083)
12.municipality	-0.429***
	(0.097)
13.municipality	-0.291***
	(0.100)
Constant	-1.411***
	(0.152)
Observations	1,836
R^2	0.533
p-value	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.9: Summary statistics of the variable income fitted (*incfitted*) used as special regressor

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
incfitted	2.878	0.949	0.046	8.097

B.6 Special regressor method estimated average index and coefficients

Tab. B.10: Average index, marginal effects at means on the probability to have consumer perception awareness based on reference points

Variables	referenceprice	referencebill	referencecons
incfittedd	0.0453***		0.070***
	(0.012)		(0.027)
knowIBR	-0.241***	0.159***	-0.390**
	(0.087)	(0.058)	(0.179)
fairprice	-0.100	0.049	-1.570**
	(0.389)	(0.443)	(0.772)
freqdet	0.039**	-0.019***	0.072**
	(0.015)	(0.007)	(0.034)
urban	0.004	-0.003	-0.021
	(0.009)	(0.009)	(0.017)
meter	0.003	-0.003	0.021
	(0.008)	(0.006)	(0.015)
mincfittedd		0.028**	
		(0.012)	
Constant	0.050*	-0.036*	0.133**
	(0.026)	(0.021)	(0.058)

Note: Standard errors in parentheses based on three special regressor models (1,556 observations) were calculated using 250 bootstrapping samples, *sspecialreg* command in Stata was used. The predicted probabilities were based on the average index function, as suggested by Lewbel et al. (2012), and provided by the previous Stata command Baum (2013).
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

Tab. B.11: Special regressor estimated coefficients on the probability to have consumer perception awareness based on reference points

Variables	referenceprice	referencebill	referencecons
knowIBR	-7.329***	6.602***	-6.978***
	(1.455)	(1.342)	(1.416)
fairprice	-4.500	7.811	-7.717
	(8.522)	(9.215)	(10.203)
freqdet	1.252***	-0.793***	1.371***
	(0.316)	(0.290)	(0.313)
urban	-0.113	0.173	-0.277
	(0.272)	(0.253)	(0.282)
meter	0.144	-0.101	0.431*
	(0.247)	(0.227)	(0.253)
Municipality 1 (reference)	-	-	-
2.municipality	1.754***	-1.527***	1.808***
	(0.548)	(0.520)	(0.574)
3.municipality	0.094	-0.064	0.035
	(0.534)	(0.491)	(0.542)
4.municipality	2.076***	-1.773***	1.952***
	(0.603)	(0.558)	(0.610)
5.municipality	0.068	-0.211	0.229
	(0.699)	(0.652)	(0.722)
6.municipality	0.459	-0.536	0.771
	(0.697)	(0.693)	(0.771)
7.municipality	0.706	-0.599	0.825*
	(0.455)	(0.427)	(0.470)
8.municipality	0.646	-0.614	0.741*
	(0.402)	(0.381)	(0.422)
9.municipality	1.659**	-1.434**	1.422*
	(0.774)	(0.709)	(0.781)
10.municipality	0.122	-0.259	0.172
	(0.448)	(0.433)	(0.477)
11.municipality	0.536	-0.486	0.752*
	(0.378)	(0.350)	(0.390)
12.municipality	1.629***	-1.486***	1.663***
	(0.544)	(0.515)	(0.562)
13.municipality	1.197**	-0.949**	1.823***
	(0.497)	(0.466)	(0.523)
Constant	1.090**	-1.138**	1.201**
	(0.535)	(0.496)	(0.530)
Observations	1,556	1,556	1,556
chi^2	29.47	35.23	38.98
p-value	0.030	0.006	0.002

Note: Standard errors in parentheses for special regressor models using Stata command *sspecialreg*. The options used were standard kernel density approach, the Silverman's rule of thumb for automated bandwidths and trimming option at 5% level (Ghosh and Vogt, 2012).
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

B.7 Kernel-weighted local polynomial regression of reference points on special regressor

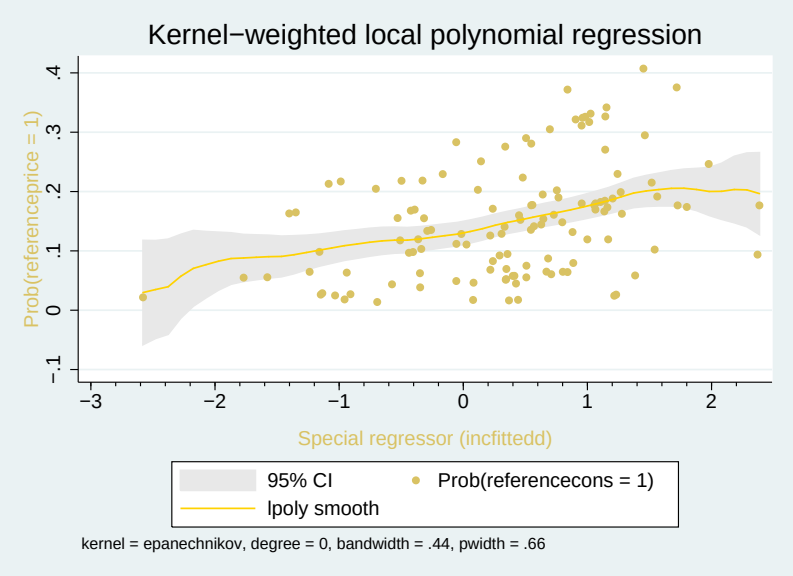

Fig. B.1: Kernel-weighted local polynomial regression of *referenceprice* on special regressor *incfittedd*

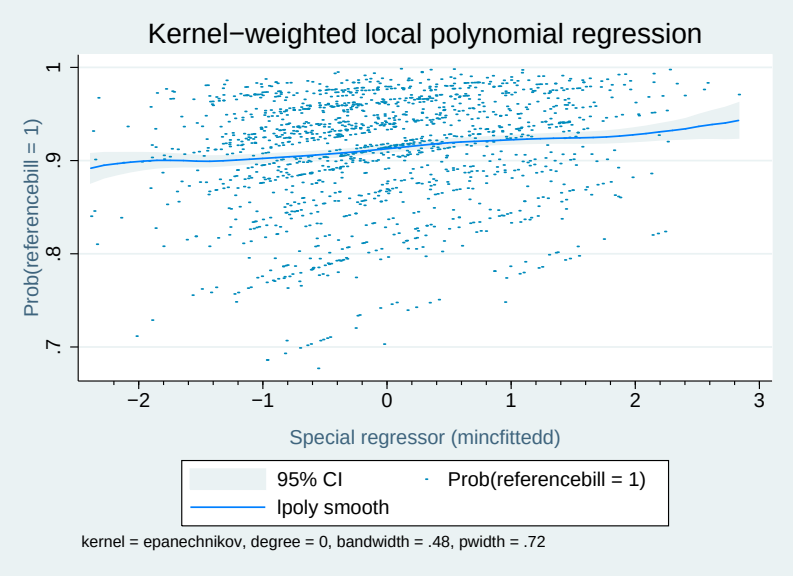

Fig. B.2: Kernel-weighted local polynomial regression of *referencebill* on special regressor *mincfittedd*

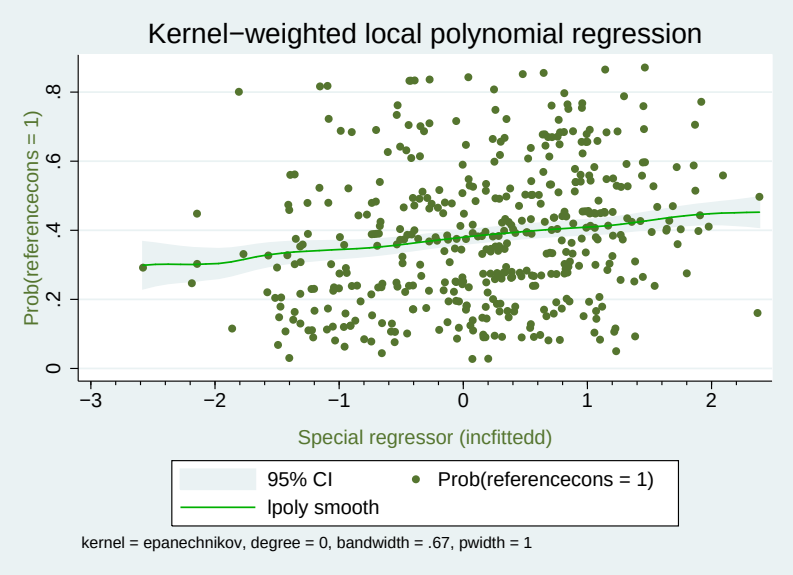

Fig. B.3: Kernel-weighted local polynomial regression of *referencecons* on special regressor *incfittedd*

B.8 Tables

Tab. B.12: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
aavcons	2188	8.409	6.389	.083	57
aavprice	2188	3.744	7.478	.296	149.97
afford	2009	7.016	6.957	.512	182.348
avcons6m	2183	7.62	6.081	-4.833	47.833
avpmun	2188	3.699	1.236	1.674	6.034
avvioqual	2188	3.006	1.617	.802	6.494
children	2099	.387	.487	0	1
ddebit	2158	.482	.5	0	1
dettot	2012	.536	.499	0	1
dishwach	2086	.572	.499	0	2
drinktap	2175	.419	.493	0	1
dwetype	2182	.507	.5	0	1
ebill2012	2179	.037	.188	0	1
elder	2041	.439	.733	0	4
employed	2179	1.226	.959	0	10
expenscarce	2051	2.258	1.153	1	5
fair	2067	3.132	1.166	1	5
fairprice	2001	.013	.115	0	1
freqdet	2012	.465	.499	0	1
heducation	2188	.28	.449	0	1
hpayers	2186	.807	.395	0	1
hsize	2186	2.71	1.215	1	14
inactive	2173	.242	.486	0	3
inastudent	2170	.215	.244	0	1
incfitted	2009	2.882	.938	.046	8.097
income	1937	2.997	1.617	1	8
knowIBR	2188	.388	.487	0	1
loss	2042	1.977	1.044	1	5
mainresidence	2185	.871	.335	0	1
male	2188	.477	.5	0	1
maxtempdev	2188	.591	1.198	-1.185	2.234
meter	2160	.191	.393	0	1
owner	2179	.797	.402	0	1
p16education	2188	.286	.452	0	1
p19education	2188	.447	.497	0	1
p56education	2188	.787	.41	0	1

Notes: Number of observations (Obs.), means, standard deviations(Std. Dev.), minimum (Min) and maximum (Max) values of each variable. Since in the analysis performed in chapter 4 we excluded 45 outliers (negative values of monthly water consumption, and other extreme or odd values, such as the number of household members who contribute to pay the water bill being zero) the final number of observations may not add up with summary statistics of chapter 3, appendix A.

Tab. B.13: Summary statistics (continued)

Variable	Obs	Mean	Std. Dev.	Min	Max
payers	2188	1.623	.547	1	4
pearn	2170	.705	.301	0	2
percbillt	1912	20.021	13.282	1.6	100
pool	2187	.035	.183	0	1
precdev	2188	27.492	9.413	13.281	37.565
referencebill	2188	.874	.332	0	1
refblockprice	2178	.084	.277	0	1
referencecons	2188	.235	.424	0	1
referenceprice	2188	.066	.248	0	1
runwat	2174	.323	.468	0	1
school	2181	4.389	1.598	1	8
tap	2135	6.342	3.008	2	30
unemployed	2174	.221	.509	0	5
unfairprice	2036	.142	.35	0	1
uniform	2058	2.014	1.183	1	5
urban	2188	.682	.466	0	1
washmach	2180	.962	.219	0	2
watsummer	747	3.711	2.885	0	14
well	2171	.14	.347	0	1
wsfullload	2003	.914	.28	0	1
wshortage	2152	.235	.424	0	1
wssoap	2103	.768	.422	0	1
wstank	2184	.065	.247	0	1
wswatgarden	749	.903	.297	0	1

Notes: Number of observations (Obs.), means, standard deviations(Std. Dev.), minimum (Min) and maximum (Max) values of each variable. Since in the analysis performed in chapter 4 we excluded 45 outliers (negative values of monthly water consumption, and other extreme or odd values, such as the number of household members who contribute to pay the water bill being zero) the final number of observations may not add up with summary statistics of chapter 3, appendix A.

Tab. B.14: Final probit model estimated coefficients on the probability to have consumer perception awareness based on reference points, with sampling weights

Variables	referenceprice	referencebill	referencecons
incfitted	0.225***	-0.139**	0.088*
	(0.069)	(0.064)	(0.052)
freqdet	0.485***	0.424***	0.445***
	(0.144)	(0.112)	(0.095)
knowIBR	0.535***	0.253**	0.690***
	(0.135)	(0.119)	(0.100)
fairprice	-0.753**	0.591	0.263
	(0.336)	(0.439)	(0.388)
urban	-0.458***	0.082	-0.201*
	(0.149)	(0.143)	(0.111)
meter	0.151	0.202	0.627***
	(0.150)	(0.137)	(0.113)
Municipality 1 (reference)	-	-	-
2.municipality	0.186	-0.522**	0.111
	(0.211)	(0.203)	(0.160)
3.municipality	-0.583*	-0.218	-0.011
	(0.317)	(0.266)	(0.211)
4.municipality	0.121	-0.526**	-0.108
	(0.243)	(0.213)	(0.182)
5o.municipality -	-0.654**	0.585**	
		(0.298)	(0.262)
6.municipality	0.154	0.189	0.368*
	(0.241)	(0.288)	(0.192)
7.municipality	0.649***	-0.774***	0.530***
	(0.211)	(0.197)	(0.164)
8.municipality	0.161	-0.483**	0.287*
	(0.217)	(0.194)	(0.158)
9.municipality	-0.838*	-0.472	-0.304
	(0.445)	(0.296)	(0.250)
10.municipality	-0.330	-0.024	-0.279
	(0.277)	(0.225)	(0.180)
11.municipality	0.093	-0.032	0.292**
	(0.216)	(0.202)	(0.146)
12.municipality	-0.347	-0.412**	0.262
	(0.268)	(0.208)	(0.167)
13.municipality	0.297	-0.443**	0.887***
	(0.213)	(0.214)	(0.159)
Constant	-2.525***	1.711***	-1.698***
	(0.295)	(0.266)	(0.216)
Observations	1,660	1,700	1,700
χ^2	124.3	81.81	187.3
p-value	0	4.12e-10	0
Pseudo R^2	0.148	0.0726	0.159

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.15: Final probit models estimated coefficients on the probability to adopt outdoor water-saving behaviours with sampling weights

Variables	wstank	wswatgarden
dwetype	1.172***	
	(0.226)	
tap	0.051**	0.041
	(0.023)	(0.026)
well	0.649***	0.112
	(0.183)	(0.225)
children	0.002	-0.562**
	(0.196)	(0.227)
elder	0.045	-0.384**
	(0.122)	(0.154)
inactive	0.277*	0.328*
	(0.168)	(0.182)
percbillt	-0.001	0.023***
	(0.007)	(0.008)
unfairprice	-0.115	-0.870***
	(0.243)	(0.264)
avcons6m	-0.051***	
	(0.016)	
watsummer		0.199***
		(0.052)
Municipality 1 (reference)	-	-
2.municipality	-0.112	-0.388
	(0.352)	(0.387)
3.municipality	0.041	0.271
	(0.309)	(0.479)
4.municipality	0.143	0.462
	(0.336)	(0.500)
5.municipality	0.785**	0.205
	(0.317)	(0.496)
6.municipality	-0.072	1.341***
	(0.263)	(0.456)
7.municipality	0.593**	0.065
	(0.291)	(0.360)
8.municipality	0.204	0.242
	(0.262)	(0.358)
9.municipality	0.769**	1.000**
	(0.350)	(0.441)
10.municipality	-0.222	1.201**
	(0.291)	(0.575)
11.municipality	-0.218	0.987**
	(0.293)	(0.466)
12.municipality	0.062	0.000
	(0.301)	(0.000)
13.municipality	-0.301	0.427
	(0.274)	(0.290)
Constant	-2.737***	-0.091
	(0.368)	(0.411)
Observations	1,609	502
χ^2	127.7	96.33
p-value	0.000	0.000
Pseudo R^2	0.312	0.273

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

Tab. B.16: Heckman probit models estimated coefficients on the probability to watering the garden in the coolest parts of the day with sampling weights

Variables	wswatgarden
tap	0.054*
	(0.029)
well	0.121
	(0.225)
children	-0.569**
	(0.251)
elder	-0.378**
	(0.158)
inactive	0.344*
	(0.188)
percbillt	0.024***
	(0.007)
unfairprice	-0.849***
	(0.272)
watsummer	0.196***
	(0.056)
Municipality 1 (reference)	-
2.municipality	-0.499
	(0.399)
3.municipality	0.350
	(0.445)
4.municipality	0.303
	(0.545)
5.municipality	0.424
	(0.617)
6.municipality	1.476***
	(0.473)
7.municipality	-0.064
	(0.379)
8.municipality	0.231
	(0.352)
9.municipality	1.081**
	(0.469)
10.municipality	1.171**
	(0.560)
11.municipality	0.844*
	(0.505)
12.municipality	5.742***
	(0.823)
13.municipality	0.606*
	(0.363)
Constant	-0.589
	(0.787)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

Tab. B.17: Heckman probit models estimated coefficients on the probability to watering the garden in the coolest parts of the day with sampling weights (continued)

Probit models with sampling weights and robust standard errors

Variables	wswatgarden
Selection equation	
washmach	0.515***
	(0.186)
pool	0.887***
	(0.214)
incfitted	0.174***
	(0.057)
Municipality 1 (reference)	-
2.municipality	-0.326**
	(0.152)
3.municipality	0.459***
	(0.166)
4.municipality	-0.314**
	(0.157)
5.municipality	1.495***
	(0.246)
6.municipality	1.123***
	(0.162)
7.municipality	-0.225
	(0.156)
8.municipality	0.142
	(0.138)
9.municipality	0.587***
	(0.208)
10.municipality	0.139
	(0.138)
11.municipality	-0.354***
	(0.133)
12.municipality	0.073
	(0.150)
13.municipality	1.117***
	(0.147)
Constant	-1.765***
	(0.260)
Observations	1,805
χ^2	281.5
p-value	0.000
Wald test of $\rho = 0$, $\chi^2(1)$	0.370
p-value	0.543

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computations using Stata 12.1

Tab. B.18: Average marginal effects on the probability to adopt outdoor water-saving behaviours, including other variables in the literature

Variables	wstank	wsgarden
dwetype	0.073***	
	(0.017)	
tap	0.004**	0.004
	(0.002)	(0.004)
well	0.044***	-0.001
	(0.013)	(0.029)
children	-0.006	-0.069**
	(0.014)	(0.030)
elder	0.004	-0.056***
	(0.010)	(0.021)
inactive	0.022*	0.042*
	(0.012)	(0.025)
percbillt	-0.000	0.003***
	(0.001)	(0.001)
unfairprice	-0.005	-0.097***
	(0.018)	(0.033)
avcons6m	-0.003***	
	(0.001)	
income	0.000	0.013
	(0.004)	(0.009)
school	0.000	-0.014
	(0.004)	(0.009)
owner	0.023	0.046
	(0.016)	(0.033)
urban	-0.008	-0.035
	(0.014)	(0.031)
precdev	0.001	-0.003
	(0.001)	(0.004)
maxtempdev	0.005	0.045
	(0.009)	(0.036)
watsummer		0.028***
		(0.007)
Observations	1,461	449

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.19: Probit models estimated coefficients on the probability to adopt outdoor water-saving behaviours, including other variables in the literature

Variables	wstank	wsgarden
dwetype	1.040***	
	(0.223)	
tap	0.060**	0.035
	(0.026)	(0.030)
well	0.632***	-0.011
	(0.195)	(0.241)
children	-0.080	-0.576**
	(0.205)	(0.245)
elder	0.053	-0.468***
	(0.136)	(0.163)
inactive	0.308*	0.356*
	(0.167)	(0.196)
percbillt	-0.002	0.025***
	(0.008)	(0.008)
unfairprice	-0.069	-0.811***
	(0.255)	(0.274)
avcons6m	-0.049***	
	(0.017)	
watsummer		0.231***
		(0.063)
income	0.006	0.111
	(0.061)	(0.076)
school	0.004	-0.118*
	(0.060)	(0.071)
owner	0.332	0.387
	(0.230)	(0.269)
urban	-0.117	-0.297
	(0.201)	(0.259)
precdev	0.013	-0.027
	(0.019)	(0.030)
maxtempdev	0.078	0.379
	(0.131)	(0.300)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's computations using Stata 12.1

Tab. B.20: Probit models estimated coefficients on the probability to adopt outdoor water-saving behaviours, including other variables in the literature (continued)

Variables	wstank	wsgarden
Municipality 1 (reference)	-	-
2.municipality	-0.173	-1.391
	(0.487)	(1.150)
3.municipality	0.127	-1.091**
	(0.450)	(0.511)
4.municipality	0.297	0.607
	(0.374)	(0.556)
5.municipality	0.795*	-0.513
	(0.442)	(1.084)
6.municipality	0.204	0.023
	(0.456)	(0.570)
7.municipality	0.356	-1.078
	(0.454)	(1.138)
8.municipality	0.298	-1.241*
	(0.369)	(0.662)
9.municipality	1.003**	-0.083
	(0.504)	(0.537)
10.municipality	-0.085	0.096
	(0.431)	(0.603)
11.municipality	0.042	0.000
	(0.419)	(0.000)
12o.municipality	0.000	0.000
	(0.000)	(0.000)
13o.municipality	0.000	0.000
	(0.000)	(0.000)
Constant	-3.414***	1.263
	(0.755)	(0.776)
Observations	1,461	449
χ^2	131.9	102.3
p-value	0.000	0.000
Pseudo R^2	0.320	0.314

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's computations using Stata 12.1

Tab. B.21: Average marginal effects on the probability to adopt outdoor water-saving behaviours without sampling weights

Variables	wstank	wsgarden
dwetype	0.107***	
	(0.020)	
tap	0.005***	0.011***
	(0.002)	(0.004)
well	0.063***	0.016
	(0.014)	(0.030)
children	-0.000	-0.053*
	(0.013)	(0.031)
elder	0.006	-0.028
	(0.008)	(0.019)
inactive	0.019*	0.032
	(0.011)	(0.025)
percbillt	0.000	0.002*
	(0.001)	(0.001)
unfairprice	-0.022	-0.096***
	(0.017)	(0.034)
avcons6m	-0.003***	
	(0.001)	
watsummer		0.017***
		(0.006)
Observations	1,609	502

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.22: Probit models estimated coefficients on the probability to adopt outdoor water-saving behaviours without sampling weights

Variables	wstank	wsgarden
dwetype	1.125***	
	(0.198)	
tap	0.048***	0.071***
	(0.018)	(0.026)
well	0.666***	0.102
	(0.144)	(0.198)
children	-0.001	-0.344*
	(0.138)	(0.195)
elder	0.060	-0.182
	(0.080)	(0.122)
inactive	0.201*	0.205
	(0.113)	(0.160)
percbillt	0.002	0.016*
	(0.006)	(0.008)
unfairprice	-0.233	-0.625***
	(0.178)	(0.220)
avcons6m	-0.036***	
	(0.012)	
watsummer		0.109***
		(0.040)
Municipality 1 (reference)	-	-
2.municipality	-0.116	-0.363
	(0.339)	(0.353)
3.municipality	0.068	0.361
	(0.295)	(0.433)
4.municipality	0.145	0.432
	(0.316)	(0.443)
5.municipality	0.800***	0.223
	(0.303)	(0.417)
6.municipality	0.020	1.157***
	(0.248)	(0.420)
7.municipality	0.583**	-0.024
	(0.277)	(0.333)
8.municipality	0.197	0.243
	(0.249)	(0.312)
9.municipality	0.788**	0.795
	(0.348)	(0.496)
10.municipality	-0.194	1.113**
	(0.279)	(0.503)
11.municipality	-0.205	0.924*
	(0.290)	(0.475)
12.municipality	0.104	0.000
	(0.294)	(0.000)
13.municipality	-0.260	0.263
	(0.261)	(0.268)
Constant	-2.812***	-0.056
	(0.286)	(0.395)
Observations	1,609	502
χ^2	159.5	53.21
p-value	0.000	0.000
Pseudo R^2	0.255	0.183

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's computations using Stata 12.1

Tab. B.23: Final probit model estimated coefficients on the probability to adopt indoor water-saving behaviours with sampling weights

Variables	wsfullload	wssoap	runwat
inastudent	0.861***		
	(0.247)		
aavprice	-0.017**		
	(0.007)		
wshortage	0.405**		
	(0.190)		
unfairprice	-0.473***		
	(0.160)		
expenscarce	-0.158***		
	(0.056)		
loss	-0.148***		
	(0.055)		
referenceprice	0.685**		
	(0.318)		
referencebill	0.419**		
	(0.167)		
knowIBR	0.302**	0.257***	
	(0.123)	(0.094)	
employed		-0.152***	
		(0.048)	
p56education		-0.739***	
		(0.157)	
heducation		-0.359***	
		(0.096)	
dettot		0.260***	
		(0.091)	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.24: Final Probit model estimated coefficients on the probability to adopt indoor water-saving behaviours with sampling weights (continued)

Variables	wsfullload	wssoap	runwat
dishwach			-0.258***
			(0.084)
hpayers			-0.274***
			(0.101)
male			-0.287***
			(0.080)
p16education			0.342***
			(0.090)
meter			0.383***
			(0.099)
refblockprice			0.485***
			(0.130)
aavcons			-0.016**
			(0.007)
Municipality 1 (reference)	-	-	-
2.municipality	0.092	-0.093	0.143
	(0.202)	(0.154)	(0.131)
3.municipality	0.056	-0.208	-0.445**
	(0.267)	(0.178)	(0.177)
4.municipality	0.337	-0.501***	-0.166
	(0.251)	(0.140)	(0.147)
5.municipality	0.271	0.136	-0.189
	(0.403)	(0.290)	(0.206)
6.municipality	0.037	0.320*	-0.201
	(0.239)	(0.181)	(0.156)
7.municipality	-0.235	0.118	-0.006
	(0.194)	(0.154)	(0.134)
8.municipality	-0.096	0.006	-0.017
	(0.184)	(0.154)	(0.130)
9.municipality	0.081	-0.035	0.124
	(0.301)	(0.237)	(0.205)
10.municipality	0.164	-0.357**	-0.024
	(0.206)	(0.143)	(0.133)
11.municipality	0.378*	-0.400***	0.107
	(0.202)	(0.128)	(0.118)
12.municipality	0.438*	-0.049	0.326**
	(0.238)	(0.148)	(0.135)
13.municipality	0.120	0.151	-0.093
	(0.212)	(0.161)	(0.143)
Constant	1.437***	1.565***	-0.056
	(0.249)	(0.168)	(0.155)
Observations	1,761	1,927	2,037
χ^2	92.03	114.2	110.6
p-value	0.000	0.000	0.000
Pseudo R^2	0.138	0.092	0.064

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.25: Average marginal effects on the probability to adopt indoor water-saving behaviours, encompassing all variables with sampling weights

Variables	wsfullload	wssoap	runwat
inastudent	0.087***	0.088	-0.051
	(0.033)	(0.061)	(0.068)
aavprice	-0.002**	-0.000	-0.001
	(0.001)	(0.002)	(0.002)
wshortage	0.045*	0.034	0.045
	(0.023)	(0.033)	(0.037)
unfairprice	-0.061***	-0.005	-0.044
	(0.019)	(0.041)	(0.042)
expenscarce	-0.022***	0.029**	-0.015
	(0.007)	(0.012)	(0.013)
loss	-0.017**	-0.019	-0.003
	(0.007)	(0.014)	(0.014)
referenceprice	0.083*	0.101	-0.008
	(0.047)	(0.062)	(0.065)
referencebill	0.052**	-0.064	0.012
	(0.022)	(0.049)	(0.052)
knowIBR	0.042**	0.084***	0.003
	(0.017)	(0.029)	(0.031)
employed	-0.006	-0.036**	0.007
	(0.009)	(0.016)	(0.017)
p56education	-0.026	-0.214**	-0.031
	(0.026)	(0.087)	(0.062)
heducation	-0.012	-0.087***	0.006
	(0.019)	(0.030)	(0.035)
dettot	0.006	0.084***	0.004
	(0.016)	(0.028)	(0.031)
dishwach	0.008	-0.031	-0.090***
	(0.018)	(0.031)	(0.032)
hpayers	-0.013	-0.069*	-0.115***
	(0.021)	(0.039)	(0.039)
male	-0.004	0.035	-0.084***
	(0.015)	(0.028)	(0.030)
p16education	-0.051**	0.100	0.100*
	(0.024)	(0.068)	(0.054)
meter	0.009	0.006	0.134***
	(0.019)	(0.036)	(0.036)
refblockprice	-0.027	-0.048	0.156***
	(0.040)	(0.049)	(0.057)
aavcons	0.000	-0.008***	-0.007***
	(0.001)	(0.002)	(0.003)
Observations	1,550	1,615	1,660

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.26: Probit model estimated coefficients on the probability to adopt indoor water-saving behaviours, encompassing all variables with sampling weights

Variables	wsfullload	wssoap	runwat
inastudent	0.756***	0.302	-0.151
	(0.276)	(0.210)	(0.203)
aavprice	-0.017**	-0.001	-0.003
	(0.008)	(0.006)	(0.005)
wshortage	0.394*	0.119	0.134
	(0.208)	(0.115)	(0.109)
unfairprice	-0.532***	-0.016	-0.130
	(0.168)	(0.141)	(0.126)
expenscarce	-0.188***	0.099**	-0.043
	(0.061)	(0.043)	(0.037)
loss	-0.149**	-0.064	-0.008
	(0.061)	(0.048)	(0.043)
referenceprice	0.719*	0.349	-0.024
	(0.399)	(0.216)	(0.194)
referencebill	0.453**	-0.221	0.037
	(0.196)	(0.171)	(0.155)
knowIBR	0.365***	0.289***	0.009
	(0.138)	(0.102)	(0.093)
employed	-0.055	-0.123**	0.021
	(0.078)	(0.054)	(0.051)
p56education	-0.230	-0.737**	-0.093
	(0.226)	(0.300)	(0.185)
heducation	-0.100	-0.301***	0.016
	(0.160)	(0.106)	(0.104)
dettot	0.050	0.290***	0.013
	(0.139)	(0.098)	(0.093)
dishwach	0.066	-0.107	-0.268***
	(0.159)	(0.107)	(0.097)
hpayers	-0.116	-0.237*	-0.343***
	(0.180)	(0.134)	(0.118)
male	-0.031	0.122	-0.249***
	(0.132)	(0.096)	(0.091)
p16education	-0.444**	0.343	0.296*
	(0.209)	(0.236)	(0.162)
meter	0.075	0.020	0.399***
	(0.160)	(0.124)	(0.109)
refblockprice	-0.238	-0.167	0.464***
	(0.346)	(0.169)	(0.171)
aavcons	0.000	-0.026***	-0.022***
	(0.011)	(0.008)	(0.008)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.27: Final probit model estimated coefficients on the probability to adopt indoor water-saving behaviours, encompassing all variables with sampling weights (continued)

Variables	wsfullload	wssoap	runwat
Municipality 1 (reference)	-	-	-
2.municipality	0.032	-0.147	0.138
	(0.229)	(0.167)	(0.151)
3.municipality	-0.107	-0.201	-0.440**
	(0.277)	(0.191)	(0.193)
4.municipality	0.358	-0.465***	-0.330*
	(0.312)	(0.168)	(0.181)
5.municipality	0.462	-0.026	-0.258
	(0.531)	(0.335)	(0.248)
6.municipality	0.038	0.079	-0.283
	(0.266)	(0.206)	(0.175)
7.municipality	-0.249	-0.059	0.044
	(0.208)	(0.175)	(0.154)
8.municipality	-0.090	-0.032	0.032
	(0.197)	(0.168)	(0.145)
9.municipality	0.124	-0.075	-0.040
	(0.354)	(0.251)	(0.237)
10.municipality	0.157	-0.228	0.017
	(0.220)	(0.158)	(0.149)
11.municipality	0.298	-0.421***	0.104
	(0.209)	(0.139)	(0.130)
12.municipality	0.344	-0.034	0.176
	(0.293)	(0.173)	(0.158)
13.municipality	0.074	-0.009	-0.058
	(0.255)	(0.190)	(0.166)
Constant	1.994***	1.882***	0.199
	(0.413)	(0.405)	(0.310)
Observations	1,550	1,615	1,660
χ^2	109.7	129.7	105.2
p-value	0.000	0.000	0.000
Pseudo R^2	0.161	0.121	0.071

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.28: Average marginal effects on the probability to adopt indoor water-saving behaviours, encompassing all variables without sampling weights

Variables	wsfullload	wssoap	runwat
inastudent	0.085***	-0.012	-0.030
	(0.029)	(0.047)	(0.050)
aavprice	-0.002***	-0.000	-0.002
	(0.001)	(0.002)	(0.002)
wshortage	0.044**	0.028	0.023
	(0.017)	(0.024)	(0.027)
unfairprice	-0.058***	0.009	-0.039
	(0.016)	(0.029)	(0.032)
expenscarce	-0.018***	0.023**	0.001
	(0.005)	(0.009)	(0.010)
loss	-0.014**	0.001	-0.002
	(0.006)	(0.010)	(0.011)
referenceprice	0.084*	0.071	0.005
	(0.044)	(0.047)	(0.050)
referencebill	0.043**	-0.062	-0.015
	(0.019)	(0.038)	(0.039)
knowIBR	0.023*	0.056**	0.009
	(0.014)	(0.022)	(0.024)
employed	0.001	-0.031***	-0.016
	(0.007)	(0.012)	(0.014)
p56education	0.005	-0.149***	-0.041
	(0.024)	(0.056)	(0.047)
heducation	0.003	-0.061***	-0.018
	(0.015)	(0.022)	(0.027)
dettot	0.012	0.065***	0.033
	(0.013)	(0.021)	(0.023)
dishwach	0.019	0.003	-0.037
	(0.014)	(0.023)	(0.025)
hpayers	0.000	-0.071**	-0.086***
	(0.018)	(0.029)	(0.030)
male	-0.018	0.020	-0.112***
	(0.013)	(0.021)	(0.022)
p16education	-0.023	0.093**	0.082*
	(0.022)	(0.044)	(0.042)
meter	-0.001	0.012	0.071**
	(0.016)	(0.027)	(0.028)
refblockprice	0.007	0.007	0.082*
	(0.031)	(0.040)	(0.045)
aavcons	-0.001	-0.006***	-0.004*
	(0.001)	(0.002)	(0.002)
Observations	1,550	1,615	1,660

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.29: Probit model estimated coefficients on the probability to adopt indoor water-saving behaviours, encompassing all variables without sampling weights

Variables	wsfullload	wssoap	runwat
inastudent	0.688***	-0.043	-0.092
	(0.228)	(0.166)	(0.151)
aavprice	-0.018***	-0.000	-0.005
	(0.005)	(0.006)	(0.005)
wshortage	0.356**	0.100	0.070
	(0.139)	(0.086)	(0.082)
unfairprice	-0.469***	0.031	-0.118
	(0.132)	(0.102)	(0.096)
expenscarce	-0.148***	0.082**	0.003
	(0.042)	(0.032)	(0.029)
loss	-0.117**	0.002	-0.007
	(0.049)	(0.036)	(0.033)
referenceprice	0.680*	0.252	0.016
	(0.355)	(0.169)	(0.150)
referencebill	0.349**	-0.222	-0.045
	(0.157)	(0.137)	(0.118)
knowIBR	0.184*	0.197**	0.026
	(0.111)	(0.077)	(0.072)
employed	0.008	-0.109***	-0.048
	(0.061)	(0.042)	(0.041)
p56education	0.037	-0.529***	-0.124
	(0.198)	(0.198)	(0.142)
heducation	0.027	-0.218***	-0.054
	(0.126)	(0.080)	(0.080)
dettot	0.096	0.229***	0.098
	(0.103)	(0.075)	(0.070)
dishwach	0.151	0.011	-0.111
	(0.117)	(0.082)	(0.075)
hpayers	0.001	-0.252**	-0.259***
	(0.148)	(0.103)	(0.091)
male	-0.146	0.072	-0.339***
	(0.105)	(0.073)	(0.068)
p16education	-0.189	0.331**	0.248*
	(0.180)	(0.157)	(0.128)
meter	-0.008	0.042	0.215**
	(0.132)	(0.096)	(0.085)
refblockprice	0.059	0.023	0.246*
	(0.250)	(0.142)	(0.135)
aavcons	-0.005	-0.020***	-0.011*
	(0.008)	(0.006)	(0.006)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.30: Probit model estimated coefficients on the probability to adopt indoor water-saving behaviours, encompassing all variables without sampling weights (continued)

Variables	wsfullload	wssoap	runwat
Municipality 1 (reference)	-	-	-
2.municipality	0.063	-0.116	0.127
	(0.215)	(0.158)	(0.146)
3.municipality	-0.096	-0.183	-0.430**
	(0.266)	(0.183)	(0.190)
4.municipality	0.374	-0.486***	-0.385**
	(0.296)	(0.161)	(0.172)
5.municipality	0.561	0.083	-0.263
	(0.506)	(0.305)	(0.243)
6.municipality	0.071	0.179	-0.225
	(0.238)	(0.193)	(0.168)
7.municipality	-0.273	-0.033	0.040
	(0.198)	(0.165)	(0.148)
8.municipality	-0.023	-0.005	0.047
	(0.182)	(0.159)	(0.140)
9.municipality	0.127	-0.043	-0.084
	(0.339)	(0.245)	(0.232)
10.municipality	0.197	-0.223	-0.010
	(0.212)	(0.151)	(0.144)
11.municipality	0.304	-0.385***	0.173
	(0.204)	(0.133)	(0.128)
12.municipality	0.353	-0.017	0.160
	(0.280)	(0.165)	(0.152)
13.municipality	0.125	0.027	0.023
	(0.246)	(0.180)	(0.158)
Constant	1.486***	1.557***	0.104
	(0.355)	(0.299)	(0.249)
Observations	1,550	1,615	1,660
χ^2	109.9	141.1	108.6
p-value	0.000	0.000	0.000
Pseudo R^2	0.136	0.099	0.06

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.31: Final probit model estimated coefficients on the probability to adopt modern billing standards with sampling weights

Variables	ddebit	ebill2012
p19education	-0.498***	-0.641***
	(0.081)	(0.143)
owner	0.937***	0.424**
	(0.102)	(0.180)
hsize	-0.086***	
	(0.031)	
urban	0.312***	
	(0.099)	
aavprice	0.012***	
	(0.004)	
unfairprice	-0.207*	
	(0.110)	
meter	-0.238**	0.268*
	(0.096)	(0.150)
Municipality 1 (reference)	-	-
2.municipality	0.350***	-
	(0.133)	
3.municipality	0.454***	-
	(0.175)	
4.municipality	0.206	-
	(0.138)	
5.municipality	0.439**	-
	(0.221)	
6.municipality	-0.008	-
	(0.166)	
7.municipality	0.105	-0.068
	(0.139)	(0.213)
8.municipality	0.069	0.017
	(0.129)	(0.199)
9.municipality	0.320	-0.583
	(0.212)	(0.435)
10.municipality	0.074	-
	(0.133)	
11.municipality	-0.284**	-0.008
	(0.125)	(0.181)
12.municipality	0.249*	0.033
	(0.133)	(0.190)
13.municipality	0.214	0.135
	(0.139)	(0.195)
Constant	-0.645***	-1.767***
	(0.172)	(0.219)
Observations	1,989	1,306
chi^2	192.3	37.43
p-value	0.000	0.000
Pseudo R^2	0.124	0.073

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.32: Average marginal effects on the probability to adopt modern billing standards, encompassing all variables without sampling weights

Variables	ddebit	ebill2012
p19education	-0.183***	-0.066***
	(0.020)	(0.016)
owner	0.273***	0.023
	(0.026)	(0.018)
hsize	-0.025***	0.002
	(0.009)	(0.005)
urban	0.093***	-0.013
	(0.030)	(0.017)
aavprice	0.004***	-0.000
	(0.002)	(0.001)
unfairprice	-0.048	-0.008
	(0.031)	(0.019)
meter	-0.054**	0.048***
	(0.027)	(0.015)
Observations	1,989	1,229

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.33: Probit model estimated coefficients on the probability to adopt modern billing standards, encompassing all variables without sampling weights

Variables	ddebit	ebill2012
p19education	-0.508***	-0.562***
	(0.060)	(0.130)
owner	0.759***	0.200
	(0.078)	(0.156)
hsize	-0.069***	0.016
	(0.024)	(0.040)
urban	0.258***	-0.108
	(0.083)	(0.147)
aavprice	0.012***	-0.002
	(0.004)	(0.006)
unfairprice	-0.135	-0.066
	(0.085)	(0.165)
meter	-0.151**	0.407***
	(0.076)	(0.126)
Municipality 1 (reference)	-	-
2.municipality	0.367***	-
	(0.130)	
3.municipality	0.429**	-
	(0.169)	
4.municipality	0.222	-
	(0.135)	
5.municipality	0.425**	-
	(0.212)	
6.municipality	-0.029	-
	(0.159)	
7.municipality	0.107	-0.038
	(0.134)	(0.216)
8.municipality	0.067	-0.012
	(0.126)	(0.197)
9.municipality	0.309	-0.606
	(0.209)	(0.433)

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.34: Probit model estimated coefficients on the probability to adopt modern billing standards, encompassing all variables without sampling weights (continued)

Variables	ddebit	ebill2012
10.municipality	0.071	-
	(0.130)	
11.municipality	-0.291**	0.007
	(0.121)	(0.183)
12.municipality	0.234*	0.033
	(0.129)	(0.191)
13.municipality	0.201	0.021
	(0.135)	(0.205)
Constant	-0.525***	-1.553***
	(0.145)	(0.258)
Observations	1,989	1,229
chi^2	229.9	34.77
p-value	0.000	0.000
Pseudo R^2	0.092	0.061

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.35: Average marginal effects on the probability to adopt modern billing standards, encompassing all variables

Variables	ddebit	ebill2012
p19education	-0.171***	-0.075***
	(0.026)	(0.019)
owner	0.322***	0.047**
	(0.031)	(0.022)
hsize	-0.029***	-0.000
	(0.010)	(0.006)
urban	0.107***	-0.014
	(0.034)	(0.017)
aavprice	0.004***	-0.000
	(0.001)	(0.001)
unfairprice	-0.071*	0.007
	(0.038)	(0.023)
meter	-0.082**	0.030*
	(0.033)	(0.017)
Observations	1,989	1,229

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.36: Probit model estimated coefficients on the probability to adopt modern billing standards, encompassing all variables

Variables	ddebit	ebill2012
p19education	-0.498***	-0.657***
	(0.081)	(0.148)
owner	0.937***	0.409**
	(0.102)	(0.183)
hsize	-0.086***	-0.003
	(0.031)	(0.051)
urban	0.312***	-0.124
	(0.099)	(0.151)
aavprice	0.012***	-0.002
	(0.004)	(0.006)
unfairprice	-0.207*	0.061
	(0.110)	(0.199)
meter	-0.238**	0.268*
	(0.096)	(0.150)
Municipality 1 (reference)	-	-
2.municipality	0.350***	-
	(0.133)	
3.municipality	0.454***	-
	(0.175)	
4.municipality	0.206	-
	(0.138)	
5.municipality	0.439**	-
	(0.221)	
6.municipality	-0.008	-
	(0.166)	
7.municipality	0.105	-0.020
	(0.139)	(0.219)
8.municipality	0.069	0.034
	(0.129)	(0.202)
9.municipality	0.320	-0.645
	(0.212)	(0.423)

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.37: Probit model estimated coefficients on the probability to adopt modern billing standards, encompassing all variables (continued)

Variables	ddebit	ebill2012
10.municipality	0.074	-
	(0.133)	
11.municipality	-0.284**	0.033
	(0.125)	(0.187)
12.municipality	0.249*	0.057
	(0.133)	(0.196)
13.municipality	0.214	0.102
	(0.139)	(0.211)
Constant	-0.645***	-1.650***
	(0.172)	(0.287)
Observations	1,989	1,229
chi^2	192.3	38.48
p-value	0.000	0.000
Pseudo R^2	0.124	0.074

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.38: Final probit model estimated coefficients on the probability to drink tap water, comparison without and with sampling weights

Variables	drinktap (without sampling weights)	drinktap (with sampling weights)
avpmun	-0.153***	-0.152***
	(0.058)	(0.059)
avvioqual	-0.273***	-0.272***
	(0.052)	(0.052)
unemployed	0.250***	0.237***
	(0.058)	(0.077)
mainresidence	-0.275***	-0.222*
	(0.091)	(0.121)
fair	0.048*	0.061*
	(0.026)	(0.034)
urban	0.160*	0.150
	(0.083)	(0.096)
Municipality 1 (reference)	-	-
2.municipality	-1.129***	-1.107***
	(0.163)	(0.165)
3.municipality	-1.456***	-1.458***
	(0.213)	(0.217)
4.municipality	-1.820***	-1.817***
	(0.184)	(0.185)
5.municipality	0.486*	0.477*
	(0.250)	(0.254)
6.municipality	1.547***	1.540***
	(0.215)	(0.217)
7.municipality	-0.938***	-0.929***
	(0.208)	(0.208)
8.municipality	-0.786***	-0.787***
	(0.116)	(0.116)
9.municipality	-0.578***	-0.572***
	(0.197)	(0.197)
10.municipality	-0.772***	-0.774***
	(0.128)	(0.129)
11.municipality	-0.025	-0.017
	(0.193)	(0.193)
12o.municipality	0.000	0.000
	(0.000)	(0.000)
13o.municipality	0.000	0.000
	(0.000)	(0.000)
Constant	1.514***	1.427***
	(0.287)	(0.306)
Observations	2,044	2,044
chi^2	249.0	235.0
p-value	0.000	0.000
Pseudo R^2	0.097	0.078

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.39: Average marginal effects on the probability to drink tap water, including other relevant variables in the literature

Variables	drinktap (without sampling weights)	drinktap (with sampling weights)
avpmun	-0.047**	-0.048**
	(0.022)	(0.023)
avvioqual	-0.102***	-0.106***
	(0.021)	(0.023)
unemployed	0.084***	0.063*
	(0.026)	(0.035)
mainresidence	-0.114***	-0.091*
	(0.034)	(0.047)
fair	0.023**	0.027**
	(0.009)	(0.013)
urban	0.057*	0.056
	(0.031)	(0.037)
incfitted	-0.006	-0.031
	(0.025)	(0.034)
hsize	0.014	0.020
	(0.015)	(0.019)
children	-0.006	-0.026
	(0.031)	(0.042)
school	0.012	0.012
	(0.013)	(0.017)
owner	0.045	0.100**
	(0.031)	(0.041)
carown	-0.098***	-0.078
	(0.035)	(0.049)
Observations	1,854	1,854

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.40: Probit model estimated coefficients on the probability to drink tap water, including other relevant variables in the literature

Variables	drinktap (without sampling weights)	drinktap (with sampling weights)
avpmun	-0.134**	-0.134**
	(0.063)	(0.064)
avvioqual	-0.293***	-0.293***
	(0.062)	(0.063)
unemployed	0.241***	0.175*
	(0.074)	(0.099)
mainresidence	-0.327***	-0.252*
	(0.098)	(0.132)
fair	0.065**	0.073**
	(0.027)	(0.035)
urban	0.162*	0.154
	(0.088)	(0.102)
incfitted	-0.018	-0.085
	(0.073)	(0.095)
hsize	0.041	0.056
	(0.042)	(0.053)
children	-0.018	-0.071
	(0.089)	(0.117)
school	0.033	0.033
	(0.037)	(0.048)
owner	0.128	0.276**
	(0.088)	(0.114)
carown	-0.280***	-0.215
	(0.102)	(0.135)
Municipality 1 (reference)	-	-
2.municipality	-1.210***	-1.203***
	(0.179)	(0.181)
3.municipality	-1.431***	-1.458***
	(0.226)	(0.234)
4.municipality	-1.763***	-1.768***
	(0.203)	(0.205)
5.municipality	0.648**	0.579**
	(0.282)	(0.289)
6.municipality	1.527***	1.488***
	(0.237)	(0.241)
7.municipality	-1.005***	-0.999***
	(0.235)	(0.238)
8.municipality	-0.775***	-0.800***
	(0.121)	(0.123)
9.municipality	-0.611***	-0.610***
	(0.203)	(0.206)

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

Tab. B.41: Probit model estimated coefficients on the probability to drink tap water, including other relevant variables in the literature (continued)

Variables	drinktap (without sampling weights)	drinktap (with sampling weights)
10.municipality	-0.748***	-0.765***
	(0.133)	(0.136)
11.municipality	-0.075	-0.058
	(0.215)	(0.218)
12o.municipality	0.000	0.000
	(0.000)	(0.000)
13o.municipality	0.000	0.000
	(0.000)	(0.000)
Constant	1.443***	1.379***
	(0.345)	(0.394)
Observations	1,854	1,854
chi^2	242.1	223.0
p-value	0.000	0.000
Pseudo R^2	0.103	0.088

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations using Stata 12.1

C. APPENDIX - NONLINEAR PRICING WITH REFERENCE DEPENDENCE

C.1 Sign of the difference term with decreasing and increasing block rates

Considering that FC, p_{1i}, p_{1i+1} and x_{1i} are non-negative by definition, with decreasing block rates we have $d_k < 0$ because $-FC \leq 0$ and $-\sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} < 0$ since $p_{1i} > p_{1i+1} \equiv p_{1i} - p_{1i+1} > 0$ reflecting that higher blocks have smaller prices due to the decreasing rate structure. With IBR $d_k \lessgtr 0$ since $-FC \leq 0$ but $\sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} < 0$, d_k will depend on the relation $-FC \lessgtr \sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i}$.

$$\text{Therefore, } d_k = \begin{cases} > 0 & -FC > \sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} \\ = 0 & -FC = \sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} \\ < 0 & -FC < \sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} \end{cases}.$$

Finally, with an uniform block rate $d_k \leq 0$ since the only relevant term is $-FC \leq 0$. Assuming that the block's price are always different within a decreasing block rate and IBR structures. With decreasing block rates we have $d_k < 0$ because $-\sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} < 0$ and with IBR $d_k > 0$ $-\sum_{i=1}^{k-1}(p_{1i} - p_{1i+1})\,x_{1i} > 0$. Trivially, with an uniform block rate we have $d_k = 0$ since the $FC = 0$. Assuming that the block's price are always different within a decreasing block rates and IBR structures.

C.2 Generalized Slutsky Equation

Suppose that we are analyzing the decrease in the price of the second block (p_{12}), according to the literature (Olmstead et al., 2007; Moffitt, 1986) the change in p_{12} has no effect on the first block's consumption. We state that due to gain and loss terms this is will be true only if the reference price is not connect directly or indirectly to p_{12}. For illustration purposes, consider the three reference prices[60] we analyse, in the case of consumption on the first block x_{11}^*.

The first case, if the reference price is the price of first block ($p_{1r} = p_{11}$) the unit loss will be zero ($l_1 = 0$), as well as the unit gain ($g_1 = 0$)[61]. Trivially, there is no price reference effects. In the second case, if the reference price is the price of second block ($p_{1r} = p_{12}$), thus the unit loss will be zero ($l_1 = 0$), but the unit gain will be difference between p_{12} and p_{12} representing the gain effect ($g_1 = p_{12} - p_{11}$)[62].

60. Recall the three different reference prices suggested: i) $p_{1r} = p_{11}$, ii) $p_{1r} = p_{12}$, and iii) $p_{1r} = \frac{p_{11}+p_{12}}{2}$.

61. Recall that unit loss is $l_k = I(p_{1k} - p_{1r})$, and the unit gain as $g_k = (1 - I)\,(p_{1r} - p_{1k})$, where p_{1r} is the reference price. In this first case, $l_1 = 0(p_{11} - p_{11}) = 0$ and $g_1 = (1 - 0)\,(p_{11} - p_{11}) = 0$.

62. In this case the reference point is the price of the second block, thus $l_1 = 0(p_{11} - p_{12}) = 0$ and $g_1 = (1 - 0)\,(p_{12} - p_{11}) = (p_{12} - p_{11})$.

Tab. C.1: Summary of the unit gain and unit loss for two-block IBR

Reference prices \ gain and loss effects	l_1	g_1	l_2	g_2
Case 1 ($p_{1r} = p_{11}$)	0	0	$p_{12} - p_{11}$	0
Case 2 ($p_{1r} = p_{12}$)	0	$p_{12} - p_{11}$	0	0
Case 3 ($p_{1r} = \frac{p_{11}+p_{12}}{2}$)	0	$\frac{1}{2}(p_{12} - p_{11})$		0

Therefore, this suggest that change in p_{12} affects the consumption on the first block. The third case assumes the average price between the two blocks ($p_{1r} = \frac{p_{11}+p_{12}}{2}$), in this sense it is expected that the gain effect will also affect the consumption on the first block. Since the unit loss will be zero again ($l_1 = 0$), but the unit gain will be difference between the average price and price on the first block which will be given by the gain term $g_1 = \frac{1}{2}(p_{12} - p_{11})$[63].

Again by way of illustration, consider the three reference prices now in the case of consumption on the second block x_{12}^*. When the reference price is the price of first block ($p_{1r} = p_{11}$) the unit loss will be the difference between prices of the second block and first block ($l_2 = p_{12} - p_{11}$), which will affect the consumption on second block, with no unit gain effects ($g_2 = 0$). In the second case, if the reference price is the price of first block ($p_{1r} = p_{12}$), thus both the unit loss and unit gain will be zero ($l_2 = 0, g_2 = 0$). Trivially, there is no price reference effects if the reference price is the price of the second block and consumption occurs on this same block. The third case assumes the average price between the first and the second block ($p_{1r} = \frac{p_{11}+p_{12}}{2}$), thus is expected that the loss effect will also affect the consumption on the second block. The unit loss will be $l_2 = \frac{1}{2}(p_{12} - p_{11})$, but the unit gain will be zero ($g_2 = 0$). The results are summarized on Table C.1.

The effect of own-price changes can be expressed by a generalized Slutsky Equation with the typical substitution and income effects (SE and IE, respectively) plus a gain/loss effect (GLE), with respect to the reference price (Putler, 1992).

$$\frac{\partial x_1}{\partial p_{1k}} = \underbrace{\frac{\partial h_1}{\partial p_{1k}}}_{\text{SE}} - \underbrace{x_1 \frac{\partial x_1}{\partial M}}_{\text{IE}} + \underbrace{\left[(1-I)\frac{\partial M}{\partial g_k} - I\frac{\partial M}{\partial l_k}\right]\frac{\partial x_1}{\partial M}}_{\text{GLE}} \tag{C.1}$$

Assume for simplicity that $x_1 = x_1(p_{1k}, l_k, g_k, M + d_k)$ is Marshallian demand function and $h_1 = h_1(p_{1k}, l_k, g_k, e(p_{1k}, U)$ is Hicksian demand function, given price p_{1k}, l_k and g_k that denotes the typical loss and gain terms, virtual income (income plus difference term) $M + d_k$, and expenditure function given price and utility level, $e(p_{1k}, U)$. Additionally, I is the binary variable takes the value one if the price of the block is higher than the reference price and zero otherwise, as already stated.

63. In the case of the average price as a reference price, $l_1 = 0(p_{11} - \frac{p_{11}+p_{12}}{2}) = 0$ and $g_1 = (1-0)\,(\frac{p_{11}+p_{12}}{2} - p_{11}) = \frac{1}{2}(p_{12} - p_{11})$.

The partial derivative of the Marshallian demand function or own-price elasticity may be affected by both the price of the block and the reference price:

$$\frac{\partial x_1}{\partial p_{1k}} = \frac{\partial x_1}{\partial p_{1k}} + x_1 \frac{\partial x_1}{\partial M} - (1 - I)\frac{\partial x_1}{\partial g_k} + I\frac{\partial x_1}{\partial l_k} \tag{C.2}$$

Notice that this expression allows that own-price demand elasticity will be equal to conventional demand theory, if there no reference price loss/gain effects.

D. APPENDIX - PORTUGUESE HOUSEHOLD WATER CONSUMPTION SURVEY (PORTUGUESE VERSION)

Default Question Block

Nome do Inquiridor

Entidade Gestora

Nº Identificação Cliente

COMECE AQUI O INQUÉRITO

Este questionário tem como objectivo a recolha de dados sobre a gestão e conservação de água para serem utilizados num projecto de investigação liderado pelo ISCTE - Instituto Universitário de Lisboa em parceria com a Entidade Reguladora dos Serviços de Água e Resíduos e a ....(refira o nome da Entidade Gestora). O ISCTE-IUL garante o total anonimato deste inquérito e a confidencialidade dos dados recolhidos.
A duração do questionário é de 10 minutos.

Tem 16 anos ou mais?

- Sim
- Não. (**Termine o inquérito aqui. Agradeça a colaboração e desligue o telefone**)

Reside há mais de 1 ano na sua habitação?

- Sim
- Não. (**Termine o inquérito aqui. Agradeça a colaboração e desligue o telefone**)

Género:

(Não leia esta pergunta)

- Masculino
- Feminino
- Não Sei/ Não Responde

Freguesia:

- Freguesia
- Não Sei/ Não Responde

É o(a) proprietário(a) deste alojamento?

- Sim
- Não
- Não Sei/ Não Responde

Este alojamento é a sua residência principal?

- Sim
- Não
- Não Sei/ Não Responde

Tem responsabilidade no pagamento da factura da água deste alojamento?

- Sim
- Não
- Não Sei/ Não Responde

A.1. Com que frequência costuma tomar conhecimento da informação presente nas facturas da água?

(Leia as opções de resposta ao consumidor)

- Nunca
- Raramente
- Às vezes
- Quase Sempre
- Sempre
- Não Sei/ Não Responde

(Se o consumidor respondeu “Nunca” passar para pergunta 1.1., se respondeu “Sempre” passar à pergunta A.3.)

A.2. Quando obteve a informação da factura, isso deveu-se a um aumento ou diminuição do montante a pagar?

- Sim. Aumento
- Sim. Diminuição
- Não.
- Não Sei/ Não Responde

A.3. Costuma ter conhecimento do valor a pagar ou do detalhe da factura?

- Valor a pagar
- Detalhe

Não Sei/ Não Responde

1. Caracterização do agregado familiar

1.1. Quantas pessoas compõem o agregado familiar?

- nº de pessoas
- Não Sei/ Não Responde

1.2. Quantas pessoas do agregado familiar têm 65 anos ou mais?

- nº pessoas
- Não Sei/ Não Responde

1.3. Quantas pessoas do agregado familiar são menores de 18 anos?

- nº pessoas
- Não Sei/ Não Responde

1.4. Quantas pessoas do agregado familiar contribuem para o pagamento da despesa da água e saneamento?

- nº pessoas
- Não Sei/ Não Responde

1.5. Quantos anos de escolaridade completos tem?

(NÃO leia as opções de resposta!)

- Não sabe ler/escrever (0 anos)
- 1º ciclo (1 a 4 anos)
- 2º ciclo (5 a 6 anos)
- 3º ciclo (7 a 9 anos)
- Ensino Secundário (10 a 12 anos)
- Licenciatura/ Bacharelato (13 a 15 anos)
- Mestrado (16 a 17 anos)
- Doutoramento (mais de 17 anos)
- Não Sei/ Não Responde

1.6. Dos elementos que constituem o agregado familiar, quantos são:

(Leia cada uma das opções de resposta)

- Profissionais Activos
- Estudantes
- Desempregado(a)s
- Reformado(a)s/ Aposentado(a)s
- Outros Inactivos (Ex.:Domestica(o)s, menores de 6 anos, ...)
- Não Sei/ Não Responde

1.7. Indique em qual das opções se encontra o rendimento líquido mensal do seu agregado familiar.

(Leia as opções de resposta ao consumidor)

Menos de 500 €	Entre 501€ e 1000€	Entre 1001€ e 1500€	Entre 1501€ e 2000€	Entre 2001€ e 2500€	Entre 2501€ e 3000€	Entre 3001€ e 3500€	Mais de 3500€	Não Sei/ Não Responde
○	○	○	○	○	○	○	○	○

2. Caracterização do alojamento

2.1. O alojamento em que reside é:

Moradia	Apartamento	Não Sei/ Não Responde
○	○	○

2.2. Quais os elementos que fazem parte do seu alojamento:

a) Tem piscina?

(Exclua qualquer tipo de piscinas insufláveis.)

- ○ Sim
- ○ Não
- ○ Não Sei/ Não Responde

b) Possui Tanques ou Depósitos para captação da água da chuva?

- ○ Sim
- ○ Não
- ○ Não Sei/ Não Responde

b1) Utiliza outro método de captação da água da chuva?

- ( ) Sim. Qual?
- ( ) Não
- ( ) Não Sei/ Não Responde

2.2.1. Tem Jardim/ Quintal/ Horta ?

- [ ] Sim, Jardim.
- [ ] Sim, Quintal.
- [ ] Sim, Horta.
- [ ] Não. (Passe à pergunta 2.2.4)
- [ ] Não Sei/ Não Responde. (Passe à pergunta 2.2.4)

2.2.1.1. Em média, quantas vezes por semana os rega?

- [ ] Nº de vezes Primavera/ Verão (ler esta opção de resposta)
- [ ] Frequência de rega inferior a uma vez por semana Pri/Ver (ex: 1 vez por mês)
- [ ] Nº de vezes Outono/Inverno (ler esta opção de resposta)
- [ ] Frequência de rega inferior a uma vez por semana Out/Inv (ex: 1 vez por mês)
- [ ] Não Sei/ Não Responde

2.2.2. Rega o jardim/quintal/horta de manhã/noite para evitar a evaporação?

Sim	Não	Não Sei/ Não Responde
( )	( )	( )

2.2.3. Utiliza água da rede para as regas?

Sim	Não	Não Sei/ Não Responde
( )	( )	( )

2.2.4. Utiliza algum método de poupança de água, na descarga do autoclismo, por ex. uma garrafa de água?

- ( ) Sim
- ( ) Não
- ( ) Outro método
- ( ) Não Sei/ Não Responde

2.2.5. Tem carro?

- ( ) Sim.
- ( ) Não (**Passe à pergunta 2.3**)

Não Sei/ Não Responde (**Passe à pergunta 2.3**)

2.2.5.1 Se possui automóvel, costuma lavá-lo com água da rede?

Sim,

Com:

Balde e Esponja

Mangueira

Outros

Não

Não Sei/ Não Responde

2.3. Tendo em conta o seu alojamento, indique o nº de:

	nº Answer 1	Não Sei/ Não Responde Não Sei/ Não Responde
Polibãs		
Banheiras		
Nº Total de Torneiras		
Torneiras com redutor de caudal		
Máquinas de Lavar Roupa		
Maquinas de Lavar Louça		
Autoclismos de descarga simples		
Autoclismos de descarga dupla		

3. Hábitos de consumo

3.1. Costuma tomar duche ou banho de imersão?

Duche

Banho Imersão. (Passe à pergunta 3.3)

Não Sei/ Não Responde

3.2. Fecha a torneira do duche enquanto se ensaboa?

- Sim
- Não
- Não Sei/ Não Responde

3.3. Aproveita a água do duche/ banho que corre enquanto aquece?

- Sim
- Não
- Não Sei/ Não Responde

3.4. A sua residência possui alternativas ao abastecimento de água pela rede?

- Sim. Qual?
- Não
- Não Sei/ Não Responde

3.5. Fecha a torneira enquanto escova os dentes?

- Sim
- Não
- Não Sei/ Não Responde

3.6. Sempre que possível, utiliza as máquinas de lavar com carga completa?

- Sim
- Não
- Não Sei/ Não Responde

3.7. Bebe preferencialmente água da torneira?

- Sim
- Não
- Não Sei/ Não Responde

4. Dados relativos à facturação

4.1. Tem por hábito comunicar a leitura do consumo?

- Sim
- Não
- Não Sei/ Não Responde

4.2. Faz o pagamento por débito em conta?

- Sim
- Não
- Não Sei/ Não Responde

4.3. Recebe a factura da água em formato electrónico (em vez de ser pelo correio)?

- Sim
- Não
- Não Sei/ Não Responde

4.4. Quantos são os escalões do seu tarifário de abastecimento de água?

- Nº de Escalões
- Não Sei/ Não Responde

4.5. Conhece o preço por metro cúbico de água associado a cada escalão?

- Sim
- Não
- Não Sei/ Não Responde

4.6. Qual o preço médio aproximado que paga por cada metro cúbico de água?

- Euros
- Não Sei/ Não Responde

4.7. Indique se no tarifário praticado o preço é:

Uniforme (sempre igual)	Crescente (aumenta à medida que aumenta o consumo)	Decrescente (diminui à medida que aumenta o consumo)	Mistos	Não Sei/ Não Responde
○	○	○	○	○

4.8. Em média, quantos metros cúbicos de água consome mensalmente o seu agregado?

- (Escreva a resposta)
- Não Sei/ Não Responde

4.9. De quanto é que foi a sua última factura da água mensal?

- Euros

Não Sei/ Não Responde

4.10. No último ano registou alguma interrupção no fornecimento de água por indisponibilidade do serviço?

- Não
- Sim. Em que mês/meses?
- Não Sei/ Não Responde

4.11. No último ano identificou perdas ou fugas de água no interior da sua habitação?

- Não
- Sim. Em que mês/meses?
- Não Sei/ Não Responde

4.12. Mencione qual (quais) as componentes que considera serem cobradas na sua factura de água:

(Leia as opções de resposta ao consumidor)

	Sim	Não	Não Sei/ Não Responde
Água			
Taxa de Recursos Hídricos			
Águas Residuais (Saneamento)			
Resíduos Sólidos			
IVA (Imposto sobre o Valor Acrescentado)			
Outra. Indique qual?			

5. Opiniões sobre sustentabilidade ambiental e financeira.

Numa escala de 1 a 5 em que o nº 1 significa “Discordo Totalmente” e o 5 “Concordo totalmente” indique em que medida concorda com as afirmações.

	Discordo totalmente	Discordo	Nem Concordo nem Discordo	Concordo	Concordo Totalmente	Não Sei/ Não Responde
a) A água existente é suficiente para os usos que se fazem dela.						
b) A água deveria ser mais cara para evitar desperdícios.						
c) A sua família consome água acima das suas necessidades.						
d) A água é um bem escasso.						
e) A sua família tem um consumo de água moderado.						

f) A água deve ser mais cara onde for mais escassa.						
g) As empresas fornecedoras de água devem ter receitas que permitam pagar os custos do serviço.						
h) Mesmo em situações de escassez, o preço da água não deveria aumentar.						
i) O preço que pago pela água é justo.						
j) O preço da água deveria ser aumentado caso a empresa fornecedora de água apresente prejuízo.						
k) As tarifas da água deveriam ser iguais em todo o território nacional.						
l) As tarifas cobradas por um bem essencial como a água são injustas.						

A sua colaboração foi muito importante neste estudo. Muito obrigado(a) pelo tempo dispensado!

(Desligue o telefone)

Sugestão / Reclamação do Cliente (CASO NÃO SE APLIQUE DEIXE EM BRANCO)

Indique se o inquérito ficou "Completo" ou "Incompleto", caso o tenha conseguido levar o até ao fim ou não.

- Completo
- Incompleto

ATENÇÃO O BOTÃO QUE SE SEGUE SUBMETE O INQUÉRITO!!!

E. APPENDIX - PORTUGUESE HOUSEHOLD WATER CONSUMPTION SURVEY (ENGLISH VERSION)

Tab. E.1: Description of the questions in the survey and coding

Description	Coding
Water utility identification number	-
Costumer identification number	-
Are you 16 years or more?	1:yes; 2:no
Did you live for more than 1 year in your housing?	1:yes; 2:no
Gender	1:male; 2:female
Parish	1: Parish; 2:do not know/do not answered
Are you the owner of the dwelling?	1: yes; 2: no; 3: do not know/do not answered
Is this dwelling your main residence	1: yes; 2: no; 3: do not know/do not answered
Are you responsible for paying the water bill	1: yes; 2: no; 3: do not know/do not answered
How often are you aware of the information in the water bill?	1: never; 2: rarely; 3: sometimes; 4: often; 5: always
When you obtained the information from the water bill, was it due to an increase or a decrease in the total to pay	1: yes, increase; 2: yes, decrease; 3: no; 4: do not know/do not answered
Are you aware of the detailed information in the water bill or just the total amount to pay?	1: total; 2: detail; 3: do not know/do not answered
Household size	1: number of persons 2: do not know/do not answered
Number of household members with 65 or more years of age	1: number of persons 2: do not know/do not answered
Number of household members under 18 years of age	1: number of persons 2: Do not know/Do not answered
Number of household members who contribute to pay the water bill	1: number of persons 2: Do not know/Do not answered
Numbers of years of schooling of the respondent	1: does not read nor right (0 years); 2: primary education (1-4 years); 3: primary education (5-6 years); 4: primary education (7-9 years); 5: secondary education (10-12 years); 6: higher education - undergraduate (13-15 years); 7: higher education - master (16-17 years); 8: higher education - PhD (more than 17 years); 9: do not know/do not answered
Number of household members who are	1: employed; 2: students; 3: unemployed; 4: retired; 5: inactive; 6: do not know/do not answered
Monthly net household income	1: less than €500; 2: €501-€1000; 3: €1001-€1500; 4: €1501-€2000; 5: €2001-€2500; 6: €2501-€3000; 7: €3001-€3500; 8: More than €3500

Tab. E.2: Description of the questions in the survey and coding (continued)

Description	Coding
Type of dwelling	1: detached or semi-detached house; 2: apartment; 3: do not know/do not answered
Does your dwelling have a pool?	1: yes; 2: no; 3: do not know/do not answered
Does your dwelling have a laundry tub or water deposit/tank for rainwater harvesting?	1: yes; 2: no; 3: do not know/do not answered
Do you use other rainwater capture method?	1: yes; 2: no; 3: do not know/do not answered
Do you have a garden, backyard, vegetable garden?	1: yes, garden; 2: yes, backyard; 3: yes, vegetable garden; 4: no; 5: do not know/do not answered
How many times a week do you water your garden/backyard/vegetable garden?	1: number of times on Spring/ Summer 2: water frequency less than once a week on Spring/ Summer 3: number of times on Fall/Winter 4: : water frequency less than once a week on Fall/Winter 5: do not know/do not answered
Do you water your garden, backyard, vegetable garden in the morning or at night to avoid evaporation?	1: yes; 2: no; 3: do not know/do not answered
Do you water your garden/backyard/vegetable garden with water from the public supply network?	1: yes; 2: no; 3: do not know/do not answered
Do you use any water saving method to flush your toilet?	1: yes, bottle; 2: no; 3: yes, other method ; 4: do not know/do not answered
Do you have a car?	1: yes; 2: no; 3: do not know/do not answered
Do you wash your car with water from the public supply network?	1: yes, with: bucket and a sponge ; hose; others; 2: no; 3: do not know/do not answered
Considering your dwelling type indicate the number of	1: shower-baths: number do not know/do not answered 2: bathtubs number do not know/do not answered 3: taps number do not know/do not answered 4: taps with flow regulator number do not know/do not answered 5: washing machines number do not know/do not answered 6: dishwashers? number do not know/do not answered 7: simple toilet cisterns number do not know/do not answered 8: dual flush toilet cisterns number do not know/do not answered
Do you shower or take a bath?	1: shower; 2: bath; 3: do not know/do not answered
Do you close the tap while soaping in the shower?	1: yes; 2: no; 3: do not know/do not answered

Tab. E.3: Description of the questions in the survey and coding (continued)

Description	Coding
Do you make use of the water that flows while you wait for it to get warm?	1: yes; 2: no; 3: do not know/do not answered
Is there an alternative to publicly supplied water in your house?	1: yes; which?; 2: no; 3: do not know/do not answered
Do you close the tap while you brush your teeth?	1: yes; 2: no; 3: do not know/do not answered
Do you wash full loads, when possible?	1: yes; 2: no; 3: do not know/do not answered
Do you usually prefer to drink tap water?	1: yes; 2: no; 3: do not know/do not answered
Do you usually submit the meter reading to the water utility?	1: yes; 2: no; 3: do not know/do not answered Do you pay the water bill by direct debit? 1: yes; 2: no; 3: do not know/do not answered
Do you receive an electronic water bill?	1: yes; 2: no; 3: do not know/do not answered
How many blocks are there in your water supply tariff?	1: number of blocks 2: do not know/do not answered
Do you know the per cubic meter price associated with each block?	1: yes; 2: no; 3: do not know/do not answered
What is the approximate average price you pay for each cubic meter of water consumed?	1:euros 2: do not know/do not answered
What is your tariff structure?	1: uniform; 2: increasing; 3: decreasing; 4: mixed; 5: do not know/do not answered
How many cubic meters of water does your household consume monthly on average?	1. cubic meters 2: do not know/do not answered
How much was the last total amount of your water bill?	1: euros 2: do not know/do not answered
Have you experienced any interruption in the water supply service in the last year?	1: no; 2: yes. Which months?; 3: do not know/do not answered
Have you experienced any water losses or leakages in the last year?	1: no; 2: yes. Which months?; 3: do not know/do not answered
Please identify the components that you think is being charged on your water bill	1: water – yes, no, do not know/do not answered; 2: water resources tax– yes, no, do not know/do not answered; 3: sewerage service– yes, no, do not know/do not answered; 4: municipal solid waste service– yes, no, do not know/do not answered; 5: value-added tax– yes, no, do not know/do not answered; 6: others. Which?

Tab. E.4: Description of the questions in the survey and coding (continued)

Description	Coding
On a scale from 1 to 5 where 1 means " Strongly Disagree " and 5 " strongly agree " to indicate how much you agree with the statements	
The existing water is enough for its uses	1: totally disagree; 2: disagree; 3: neither agree nor disagree; 4: agree; 5: totally agree; 6: do not know/do not answered
Water should be more expensive to avoid waste	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Your family consumes more water than it needs	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Water is a scarce good	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Your family has moderate water consumption	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Water should be more expensive where it is scarce	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Water utilities should have enough revenues to cover the costs of providing the service	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Even in scarce situations water price should not increase	1: totally disagree to 5: totally agree; 6: do not know/do not answered
The price you pay for water is fair	1: totally disagree to 5: totally agree; 6: do not know/do not answered
The water price should be increased if the water utility incurs a loss	1: totally disagree to 5: totally agree; 6: do not know/do not answered
Water tariffs should be equal in all the country	1: totally disagree to 5: totally agree; 6: do not know/do not answered
The tariffs charged for an essential good such as water are unfair	1: totally disagree to 5: totally agree; 6: do not know/do not answered