FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR Portugal

ISCTE - INSTITUTO UNIVERSITÁRIO DE LISBOA

Behavioural Economics in Water Management

An overview of behavioural economics applications to residential water demand

Ricardo Correia - *Instituto Universitário de Lisboa (ISCTE-IUL), BRU - IUL, Lisboa, Portugal, ricardo.emanuel.correia@iscte.pt*
Catarina Roseta-Palma - *Instituto Universitário de Lisboa (ISCTE-IUL), BRU - IUL, Lisboa, Portugal, catarina.roseta@iscte.pt*

April 2012
Preliminary version

This research is supported by FCT - *Fundação para a Ciência e a Tecnologia* (Science and Technology Foundation), project «PTDC/EGE-ECO/114477/2009» and project «PEst-OE/EGE/UI0315/2011».

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR Portugal

Abstract

The promotion of economic instruments is an essential part of efficient water management everywhere, and it has been identified as a priority action by the European Commission. In this paper, we discuss the potential of economic instruments in a new light, looking into four behavioural economic applications that can have implications for water management. These applications are reference block pricing, asymmetric elasticities of residential water demand, reference transaction implications for cost recovery and tariff acceptability, and social comparison based on reference water consumption. According to our review of the literature on residential water demand there is scant evidence of the incorporation of psychological findings into economic analysis over the last decade. Therefore, we point out how insights from behavioural economics and related fields can contribute to new developments in water resource economics.

Keywords: water management, residential water demand, behavioural economics, prospect theory, asymmetric elasticities, reference transaction, social comparison, reference consumption.

JEL: Q25, D03

1. Introduction

The Water Framework Directive (article 9, (Directive 2000/60/EC 2000)) 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 (EC 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, research in behavioural economics has shown that traditional utility-maximization models often do not appropriately describe actual decisions of economic agents. To ascertain the potential of economic instruments in a new light, in this paper we will summarize four behavioural frameworks that can have implications for water management. For each framework we suggest one behavioural economic application (hereafter behavioural application), namely reference block pricing, asymmetric elasticities, reference transaction and social comparison through reference consumption.

There are some surveys with extremely well-organized information and which discuss water demand models, both generally, at a global level (Worthington & Hoffman 2008) and at an European level (Schleich & Hillenbrand 2009), and focusing 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. This review differs from the previous surveys in that our analysis focuses on the behavioural perspective. We refer the existing (slender) literature about behavioural economics in water management and develop the four behavioural applications mentioned above. Furthermore, we stress the importance of experimental data versus non-experimental data, besides the usual division between aggregate data and household data.

First we discuss reference block pricing, which relates primarily with 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; Elnaboulsi 2001). However, recent work on residential water demand (Monteiro & Roseta-Palma 2011) has shown that if water demand and costs respond to weather conditions, increasing marginal prices could be explained by water scarcity and customer heterogeneity in a setting where utilities maintain a balanced budget. Notwithstanding, the implications for tariff design of asymmetric value functions with loss aversion (Kahneman & 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 & 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 & 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. 1986) 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), but has not yet been used in water resource economics. Moreover, since a reference transaction could imply fairness constraints, the utilities could be inhibited from proposing reference terms (i.e. price) that would be perceived as unfair. Given the characteristics of water as an essential good, this could be one explanation for the insufficient cost-recovery levels attained by water utilities in many countries, in spite of the reference-transaction notion that firms are generally entitled to positive profit.

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 in the effectiveness of water pricing policies (Frondel & Messner 2008; Gaudin 2006). Nevertheless, only recently has social comparison been tested as a water management tool (Ferraro & Price 2011), and reference consumption information was the more effective tool of all the conservation strategies tested. Moreover, it could be interesting to study the impact of different social comparisons on the magnitude and persistence of price elasticities.

The remainder of the paper can be summarized as follows. Section 2 contains a literature review of behavioural economics in water management. Section 3 describes the behavioural applications and their potential contribution to water policy and water resources economics. Section 4 examines potential paths for future research in water management shedding light on the behavioural applications suggested. Section 5 concludes the paper.

2. Literature review of behavioural economics in water management

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 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 identified some significant heuristics and biases of human behaviour, especially under uncertainty (Kahneman & Tversky 1974)[1], but their major contributions to economics were published a few years later. In one Econometrica's most cited papers the authors developed Prospect Theory as an alternative model to Expected Utility Theory and the rational choice paradigm (Kahneman & Tversky 1979). This article is by far the major influence in changing the economic conceptual framework and establishing the growing field of behavioural economics[2].

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 & Thaler 2000)[3].

Despite the obvious rivalry between behavioural economic theory and standard rational 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 coexistence 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 program "(…) does not abandon the correct insights of neoclassical economics, but supplements these insights with the insights to be had from realistic new assumptions" (Rabin 2002, p.659).

The rivalry mentioned above 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 of 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 the next section.

---

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

[2] 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).

[3] For a more recent analysis of the types of departures *vide* Zarri (2010).

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). Diving into this literature we found that the incorporation of behavioural economics is almost none.

The subfield of behavioural water economics should focus on the development of water resource economics through the application of behavioural economics findings 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 & 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[4] (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 policymakers' 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 (link between the individual and the society). Therefore, insofar we are 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 emphasizes the demand side and sums up the main direct and indirect drivers which determine human behaviour towards water conservation. Their model emphasizes other behavioural variables besides trust (e.g. past water use behaviour, outdoor-area interest and use, pricing attitude), although the authors advise that there could be other variables to discover.

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

Finally, another issue within the framework of behavioural economics is the impact of social comparison as a water conservation strategy (Ferraro & 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 in longer periods.

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 in the energy sectors (Strengers 2011; Barberán & Arbués 2009)[5]. Naturally, demand analysis is also the purpose of the few published papers, described above, 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 paper. 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[6].

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?

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

- Neoclassical hegemony :
    - Environmental models are underpinned by the hegemony of standard neoclassic economic theory (Shogren & Taylor 2008; Venkatachalam 2007), and water resource economics is not an exception, as will be described in section 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 to obtain reliable (and real) variables (e.g. appropriate income per household) and to collect information from several sources of household data.

[5] This one-sided approach can be criticized, Merrett (2005), for instance, 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).

[6] Very 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.

- 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 wastewater 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 (see section 2.3).
- Status quo bias:
    - "Resistance to change" of water resource economists to behavioural economic models[7], which is in a broader sense connected to status quo bias in human behaviour. Or as stated by MacFadyen (2006, p.195) "(…) 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".

In response to the second question, there are some arguments in favour of incorporation of psychological insights into water resources 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:
    - Policymakers 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 policies (Winkler & 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 & Winett 1982, p.422) seems to be a trivial statement. However, the residential water demand literature is focused on the "economic", leaving the "behaviour" to the sidelines.

If economics is about studying economic agents' behaviour (e.g. consumers, firms, investors), there is indeed redundancy in "behavioural economics" (Simon 2008; Thaler 1999). We think data plays a major role in this issue. Shogren and Taylor state that data is essential because it "(…) is a necessary condition to fully understand the relevance of any behavio[u]ral bias to economic phenomena" (Shogren & 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 WISE (Water Information System for Europe) in 2007 (WISE 2007). However, there is still no globally available micro-data.

---

[7] 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.

The scarcity of individual household consumption data and of potential conditioning factors which are difficult to measure (e.g. past water use patterns, attitude towards restrictions) is another important issue (Jorgensen et al. 2009). Additionally, 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).

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

2.3. Literature review based on a behavioural perspective

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

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 of the data used by the studies includes: aggregate data (AD), household data (HD), experimental household data (EHD) if the data is collected directly from households through experiments and/or household surveys and experimental aggregate data (EAD) if we have experimental data at the aggregate level related to one or more communities. These categories are summarized in Figure 1.

Figure 1 Type of data used in residential water demand studies

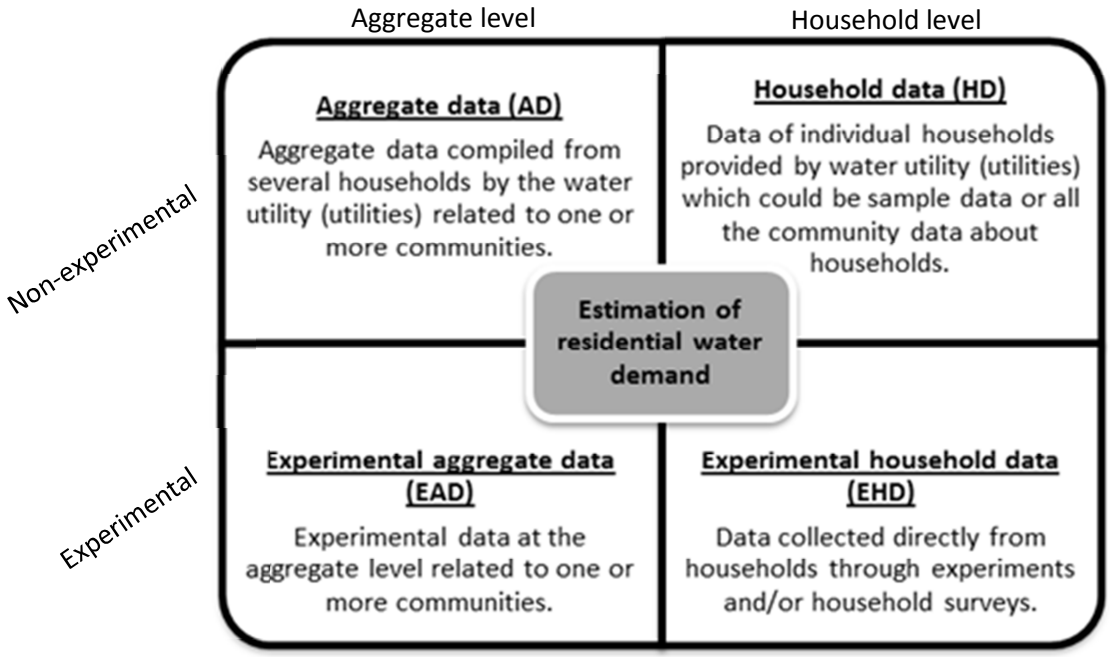

Table 1 summarizes 25 papers that estimate residential water demand and that have been published since 2000. The great majority used panel data and the periodicity of the data is mostly annual or monthly, with some exceptions. Typically the price elasticity of residential water demand in these studies 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 & 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 is obtained through experimental design or surveys. Two studies use surveys to obtain aggregate data from water utilities, namely Bell and Griffin (2008), which inquired 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 program to enforce the use of water-saving technology in some communities of the richest regions of the country (i.e. richest in income per capita terms) during a given period. 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 program would compensate the water savings for a global implementation of the program in all regions. In this case we would have EAD.

Table 1 Brief overview of residential water demand studies since 2000

Author(s) (Year)	Study Area	Data set	Periodicity	Type of data	Price Elasticity (PE)	Income Elasticity (IE)
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	EHD	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 (10 meter readings) [1996-1998]	HD	Aggregated: -0.57	Wealth semi-elasticity[(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]	EHD	[-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.

Table 1 Continued

Author(s) (Year)	Study Area	Data set	Periodicity	Type of data	Price Elasticity (PE)	Income Elasticity (IE)
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]	EHD	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 (10 meter readings) [1996-1998]	HD	-0.08	0.79
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 [Sep98;Jun03]	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]

Table 1 Continued

Author(s) (Year)	Study Area	Data set	Periodicity	Type of data	Price Elasticity (PE)	Income Elasticity (IE)
Carter and Milon (2005)	Florida (USA)	Panel	Monthly data [1997-1999]	EHD	**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 [Dec91;Sep00]	HD	Average: -0.49 Peak period: -0.55 Off-peak period: -0.46	0.58
Arbués et al. (2004)(3)	Zaragoza (Spain)	Panel	Quarterly (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.]	EHD	n.a.	n.a.

Source: Authors' analysis of the papers.

Notes: Aggregated data (AD) is the data compiled from several households by the water utility (utilities) related to one or more communities; Household data (HD) is data of individual household provided by water utility (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 and/or household surveys; Experimental aggregated data (EAD) is 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 1000€. (2) This study used a 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 facility used in the water demand estimation that was obtained through a telephone survey.

In the case of EHD some experiments have focused on residential water demand during the last decade (Martins & Moura e Sá 2011; Frondel & Messner 2008; Olmstead et al. 2007; Carter & Milon 2005; Krause et al. 2003; Higgs & Worthington 2001). A very 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 clearness and simplicity, because current bills could compromise price signals and consequently the effectiveness of price strategies.

Frondel and Messner'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"), which include the majority of the individuals, according to their sample, do not significantly diminish their water consumption with price increases. Carter and Milon (2005), in a prior study, 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 counterintuitive conclusion that price awareness increases water consumption which may be explained by price-overestimation, in line with electricity literature as pointed out in their article.

Olmstead et al. (2007) use experimental household data from a previous study[8] and suggest that the difference between the price-elasticities under IBT and uniform rates could be explained by behavioural responses to price structures or city-level heterogeneity.

Krause et al. (2003) developed 6 lab experiments in New Mexico (USA) 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 does not allow testing for this heterogeneity.

[8] Household level data obtained through mail surveys and historic billing data (Mayer et al. 1999).

Higgs and Worthington (2001) use a 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, experimental data is not being used very enthusiastically by economists in residential water demand studies. This could be explained by the resistance of the researchers (i.e. "social scientists") to lab experiments[9], which are criticized because of their lack of realistic features and lack of generalization to real world (Falk & Heckman 2009). Non-experimental data (i.e. AD and HD) is used by most of the studies, with lab experiments and field experiments left to the sidelines[10].

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

We proceed to discuss the four behavioural applications we propose, highlighting their potential contribution to the enrichment of this literature.

3. Discussion of behavioural applications and their effects in water management

In this section we suggest four applications of behaviour 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 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.

[9] Lab experiments are sometimes underestimated comparing with field experiments due to the implicit consideration of superiority of field data over lab data. However, Falk and Heckman argue that lab experiments should be done more often (*vide* Falk and Heckman (2009) for further details).

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

Table 2 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 elasticities of residential water demand	- Redefinition of tariff structures - Revision of the effectiveness of pricing policy - Influence on price elasticities in terms of magnitude and persistence	-
Kahneman et al.(1986)	Reference transaction	Reference transaction impact on cost recovery 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: Authors' analysis.

i) 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 the isolation effect[11] (Kahneman & Tversky 1979). Prospect theory assumes an asymmetric value function with three characteristics: value depends on the deviation from the (neutral) reference point[12] (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 the 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 costumers ensure "substantial revenues" and "stable flows", the water utilities could be in such cases reluctant 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 comparing with increasing block tariffs.

Despite this extensive discussion of block-tariff settings in water, the impact of asymmetric value functions with loss aversion (Kahneman & 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).

Furthermore, loss aversion indicates that individuals are more sensitive to variations interpreted as losses and consequently IBT 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.

---

[11] 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 is 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 the change of the framework (i.e. framing effects). For additional information *vide* Kahneman and Tversky (1979).

[12] 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.

This behavioural application could have several implications to sectors with nonlinear 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.

ii) Asymmetric elasticities of residential water demand

Asymmetric price elasticity (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 point (i.e. 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 the 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.

The 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 & Hunt 2007; Gately & 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 & Huntington 2002).

The existence of APE could have several policy implications, from 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 implicitly 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.

iii) Reference transaction impact on cost recovery 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. 1986). 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 the article 9 of the Water Framework Directive (Directive 2000/60/EC 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. 1986) could be tested using an experiment that inquires water users and managers of water utilities in at least two different ways within the scope of cost recovery. 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 are entitled to a positive reference profit? Both questions seem important in order to develop new approaches to cost recovery. 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 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 should be entitled to a positive reference profit, which would minimize the issue of insufficient cost recovery. The essentiality of the good in question and the traditionally low prices may provide clues to answer these questions.

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 of the educational level of the individuals, the type of the 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 vs. private ownership of utilities, since the reference transaction could be seen differently by consumers in each case.

iv) 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 & Price 2011). The authors show that social comparison has the strongest impact on consumer behaviour, using as reference consumption the 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 the neighbours and an efficient consumption level of the 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 reacts 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.

This social comparison framework which frames users into a reference-consumption framework could have some potential contributions to water management, such as development of water conservation strategies, redefinition of water policies and influence 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 frame the reader into some of the application and effects in the water demand studies. In the next section we discuss further research of the suggested behavioural applications.

4. Future Research in water management

The existing literature on residential water demand exhibits the clear supremacy of standard neoclassic economic theory. Therefore, further research on water demand should use behavioural economics frameworks and account for behavioural failures[13].

[13] 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 & Taylor 2008, p.27).

As argued by Thaler (1999) the logical evolution will be the incorporation of behavioural features into economic models. Nowadays the challenge is to understand that the highway where the herd of researchers is travelling could be the slowest way. Exploring alternative approaches and rethinking the frameworks is not the highway, but it could be the new way. New empirical results could promote discussion of new hypothesis and new lines of reasoning (Smith 2008). Nevertheless, the development of environmental economics data and social and psychological data (Jorgensen et al. 2009; Smith 2008) is essential: without a proper vehicle, travelling will be a footslog.

The availability of data for residential water demand studies is probably one of the important pieces missing in the puzzle. The importance of data wealth has been proven by the developments of behavioural finance (Thaler 1999). The challenge of development, collection and systematization is left to researchers, and this will be the first step in further research on behavioural applications in water management.

This paper aimed to discuss behavioural applications that could reshape the understanding of major issues in water management, namely through four different ideas: reference block pricing, asymmetric elasticities, reference transaction and social comparison (and reference consumption).

Reference block pricing is an unexplored line of research focusing on the implications of loss aversion in the decision process of water consumers for consumption choices and water conservation. On one hand, future studies could analyse reference block tariffs within different pricing structure (e.g. increasing and decreasing block rate structures). On the other hand, this literature could also focus on the impact of shifts between block tariffs.

The topic of asymmetric elasticities has not been analysed so far in residential water demand literature. Primarily, the study of price elasticity of water demand is essential in the domain of pricing policies and thus testing APE is essential to a correct evaluation of water policy. Likewise, AIE should also be tested in this literature. The argument underpinning this research is that the assumption of symmetric elasticities in residential water demand literature needs to be tested.

The reference transaction framework could be an explanation of the insufficient level of cost recovery through tariff revenues. Then again, the limitations to profit maximization imposed by fairness constrains contradict the idea that water utilities are entitled to a positive reference profit. Although both ideas come from the reference transaction framework, they have antagonistic effects and their combined impact needs to be explored.

Lastly, social comparison (and reference consumption) is a recent topic which has been explored in residential water demand through a field experiment (Ferraro & Price 2011). According to the authors, economists have only recently shifted their attention to non-pecuniary strategies, such as social comparison. Therefore, several promising lines of research can be developed. For example, the comparative study of different types of social comparison and the application of the findings from energy conservation literature, such as efficient consumption levels, are two potential options for further research in this area. Furthermore, the use of differentiation between household sizes in experimental design could result in new findings.

Notwithstanding these four topics there are other areas of water resources economics in which behavioural applications could also be applied. The topics of supply analysis, investment decisions in water infrastructures, policy analysis, cost-benefit analysis, efficiency, water losses and water marketing, among others are some potential entrants. For instance, in water marketing Garrido (2007) used a lab experiment to test specific market regulations of the Water reform in Spain and conclude that eliminating the existent trading restrictions will 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 (i.e. inquiries), experiments based on direct observation, either in laboratorial context, also known as experimental economics, or in observation of decision-making process in natural environment (e.g. case studies based on direct observation of individuals and of decisions in business firms). These methods have some limitations for economists, which simultaneously are challenged by the techniques of experimentation and data collection as well as interpretation of survey data. Thus, behavioural economists which aim to develop empirical tests of economic theory will probably have to invest some (significant) time to development its skills in at least one of the above methods. Possibly, these additional skills will give an edge to behavioural economists and ultimately contribute to the redesigning of water resource economics. Although outside the scope of this paper, further research should be focused on the advantages and limitations of different type of experiments (i.e. lab experiments and field experiments) in contrast with the typical use of non-experimental data.

Furthermore, if water resource economists were to grasp the differences between "rational" consumer and "normal" consumer[14] through empirical behaviour analysis, that could lead us to improve water management 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, investment decisions).

5. Conclusions

One of the aims of this paper 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. Nowadays, the fields of behavioural economics and experimental economics are an integral part of mainstream economics, as can be attested by many articles in top economic journals which cover these topics (Santos 2011). We aim to motivate the inclusion of more behavioural economics assumptions into studies of water demand.

[14] Based on the dichotomy "rational" investor and "normal" investor suggested by Statman (1999), which can be similarly applied to consumer behaviour.

We suggest four behavioural applications: reference block pricing, asymmetric elasticities, reference transaction and social comparison (and reference consumption). The first three applications have never been applied to residential water demand, as far as we know, and the last one was only recently applied (Ferraro & Price 2011), with some recent development also in energy economics (Allcott 2011).

The literature review we provide in this article, covering residential water demand studies over the last decade, shows scant evidence of applications of behaviour and experimental economics.

This paper addresses potential explanations for the underdevelopment of this literature and tries to clarify why behavioural economics and psychological insights should be used in water resources economics. In our view, one of the fundamental issues which contribute to the "slow" development of the behavioural economics in the water domain is the deficit of readily available economic and social psychological information, which needs to be periodically collected, compiled and organised always respecting the confidentially 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 induce water resource economics to recruit new researchers.

Furthermore, it should be stressed that although behavioural economics is 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 & Tversky (1979), behavioural economics is based on both empirical and theoretical foundations. Therefore, the development of residential water demand argued in this paper is implicitly based on a dual approach which tries to incorporate both.

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

References

Adeyemi, O.I. & Hunt, L.C., 2007. Modelling OECD industrial energy demand: Asymmetric price responses and energy-saving technical change. *Energy Economics*, 29(4), pp.693–709.

Allcott, H., 2011. Social Norms and Energy Conservation. *Journal of Public Economics*, Forthcoming.

Arbués, F., Barberán, R. & Villanúa, I., 2004. Price impact on urban residential water demand: A dynamic panel data approach. *Water Resources Research*, 40, W11402.

Arbués, F., Garcia-Valinas, M.A. & Martinez-Espineira, R., 2003. Estimation of residential water demand: a state-of-the-art review. *Journal of Socio-Economics*, 32(1), pp.81–102.

Arbués, F. & Villanúa, I., 2006. Potential for pricing policies in water resource management: estimation of urban residential water demand in Zaragoza, Spain. *Urban Studies*, 43(13), pp.2421–2442.

Arbués, F., Villanúa, I. & Barberán, R., 2010. Household size and residential water demand: an empirical approach. *Australian Journal of Agricultural and Resource Economics*, 54(1), pp.61–80.

Bandiera, O., Barankay, I. & Rasul, I., 2011. Field experiments with firms. *Journal of Economic Perspectives*, 25(3), pp.63–82.

Barberán, R. & Arbués, F., 2009. Equity in domestic water rates design. *Water resources management*, 23(10), pp.2101–2118.

Bell, D.R. & Griffin, R.C., 2008. An annual quasidifference approach to water price elasticity. *Water Resources Research*, 44, W08420.

Bell, D.R. & Griffin, R.C., 2011. Urban Water Demand with Periodic Error Correction. *Land Economics*, 87(3), pp.528–544.

Brown, K., 2002. Water scarcity: forecasting the future with spotty data. *Science*, 297(5583), p.926.

Camerer, C.F., 2004a. Behavioral Economics: Past, Present, Future. In *Advances in behavioral economics*. Princeton and Oxford: Princeton University Press, pp. 1–52.

Camerer, C.F., 2004b. Prospect theory in the wild: Evidence from the field. In *Advances in behavioral economics*. Princeton and Oxford: Princeton University Press, pp. 148–161.

Carter, D.W. & Milon, J.W., 2005. Price knowledge in household demand for utility services. *Land Economics*, 81(2), pp.265–283.

Diakité, D., Semenov, A. & Thomas, A., 2009. A proposal for social pricing of water supply in Côte d'Ivoire. *Journal of Development Economics*, 88(2), pp.258–268.

Directive 2000/60/EC, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities*, 22(12).

EC, 2007. *Communication from the Commission to the European Parliament and the Council: Towards sustainable water management in the European Union - First stage in the implementation of the Water Framework Directive 2000/60/EC. COM (2007) 128 final*, Brussels: Commission of the European Communities.

Elnaboulsi, J.C., 2009. An incentive water pricing policy for sustainable water use. *Environmental and Resource Economics*, 42(4), pp.451–469.

Elnaboulsi, J.C., 2001. Nonlinear pricing and capacity planning for water and wastewater services. *Water resources management*, 15(1), pp.55–69.

Falk, A. & Heckman, J.J., 2009. Lab experiments are a major source of knowledge in the social sciences. *Science*, 326(5952), p.535.

Ferraro, P.J. & Price, M.K., 2011. Using Non-Pecuniary Strategies to Influence Behavior: Evidence from a Large Scale Field Experiment. *NBER Working Paper No. 17189*, pp.1–34.

Festinger, L., 1954. A theory of social comparison processes. *Human relations*, 7(2), pp.117–140.

Foxall, G.R., 1995. Environment-impacting consumer behavior: An operant analysis. *Advances in Consumer Research*, 22, p.262-262.

Frondel, M. & Messner, M., 2008. Price perception and residential water demand: Evidence from a German household panel. In *16th Annual Conference of the European Association of Environmental and Resource Economists in Gothenburg*. pp. 1–13.

Garcia, S. & Reynaud, A., 2004. Estimating the benefits of efficient water pricing in France. *Resource and energy economics*, 26(1), pp.1–25.

Garcia-Valiñas, M.A., 2005. Efficiency and equity in natural resources pricing: A proposal for urban water distribution service. *Environmental and Resource Economics*, 32(2), pp.183–204.

Garrido, A., 2007. Water markets design and evidence from experimental economics. *Environmental and Resource Economics*, 38(3), pp.311–330.

Gately, D. & Huntington, H.G., 2002. The Asymmetric Effects of Changes in Price and Income on Energy and Oil Demand. *Energy Journal*, 23(1), pp.19–55.

Gaudin, S., 2006. Effect of price information on residential water demand. *Applied Economics*, 38(4), pp.383–394.

Goldstein, N.J., Cialdini, R.B. & Griskevicius, V., 2008. A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of Consumer Research*, 35(3), pp.472–482.

Griffin, R.C., 2006. *Water resource economics: the analysis of scarcity, policies, and projects*, Cambridge, Massachusetts: MIT Press.

Griffin, R.C. & Mjelde, J.W., 2011. Distributing water's bounty. *Ecological Economics*, (72), pp.116–128.

Higgs, H. & Worthington, A., 2001. Consumer preferences and water charging options in a large urban municipality: a case study. *Public Works Management and Policy*, 5(3), pp.209–217.

Ho, T.H., Lim, N. & Camerer, C.F., 2006. Modeling the psychology of consumer and firm behavior with behavioral economics. *Journal of Marketing Research*, 43(3), pp.307–331.

Hoffmann, M., Worthington, A. & Higgs, H., 2006. Urban water demand with fixed volumetric charging in a large municipality: the case of Brisbane, Australia. *Australian Journal of Agricultural and Resource Economics*, 50(3), pp.347–359.

Jorgensen, B., Graymore, M. & O'Toole, K., 2009. Household water use behavior: An integrated model. *Journal of environmental management*, 91(1), pp.227–236.

Kahneman, D., Knetsch, J.L. & Thaler, R., 1986. Fairness as a constraint on profit seeking: Entitlements in the market. *The American economic review*, 76(4), pp.728–741.

Kahneman, D., Slovic, P. & Tversky, A., 1982. *Judgement under uncertainty: Heuristics and biases*, Cambridge: Cambridge University Press.

Kahneman, D. & Tversky, A., 1974. Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), pp.1124–1131.

Kahneman, D. & Tversky, A., 1979. Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 47(2), pp.263–292.

Kenney, D.S. et al., 2008. Residential Water Demand Management: Lessons from Aurora, Colorado. *Journal of the American Water Resources Association (JAWRA)*, 44(1), pp.192–207.

Krause, K., Chermak, J.M. & Brookshire, D.S., 2003. The demand for water: Consumer response to scarcity. *Journal of Regulatory Economics*, 23(2), pp.167–191.

Krishna, A., 2009. Behavioral pricing. In *Handbook of pricing research in marketing*. Massachusetts: Edward Elgar Publishing, Inc., pp. 76–90.

MacFadyen, A.J., 2006. Beliefs in Behavioral and Neoclassical Economics. In *Handbook of Contemporary Behavioral Economics*. New York: M.E. Sharpe, pp. 183–201.

Martínez-Espiñeira, R., 2007. An estimation of residential water demand using co-integration and error correction techniques. *Journal of Applied Economics*, 10(1), pp.161–184.

Martínez-Espiñeira, R. & Nauges, C., 2004. Is all domestic water consumption sensitive to price control? *Applied economics*, 36(15), pp.1697–1703.

Martins, R. & Fortunato, A., 2007. Residential water demand under block rates: a Portuguese case study. *Water policy*, 9(2), pp.217–230.

Martins, R. & Moura e Sá, P., 2011. Promoting sustainable residential water use: a Portuguese case study in ownership and regulation. *Policy Studies*, 32(3), pp.291–301.

Mayer, P.W. et al., 1999. *Residential end uses of water*, Denver: American Water Works Association Research Foundation.

Mazzanti, M. & Montini, A., 2006. The determinants of residential water demand: empirical evidence for a panel of Italian municipalities. *Applied Economics Letters*, 13(2), pp.107–111.

Merrett, S., 2005. *The price of water: studies in water resource economics and management*, London: IWA Publishing.

Monteiro, H. & Roseta-Palma, C., 2011. Pricing for scarcity? An efficiency analysis of increasing block tariffs. *Water Resources Research*, 47(6), p.W06510.

Mullainathan, S. & Thaler, R., 2000. *Behavioral economics*, Cambridge: National Bureau of Economic Research.

Musolesi, A. & Nosvelli, M., 2007. Dynamics of residential water consumption in a panel of Italian municipalities. *Applied Economics Letters*, 14(6), pp.441–444.

OECD, 2010. *Pricing water resources and water and sanitation services*, Paris: Organisation for Economic Co-operation and Development Publishing.

Olmstead, S.M., Michael Hanemann, W. & Stavins, R.N., 2007. Water demand under alternative price structures. *Journal of Environmental Economics and Management*, 54(2), pp.181–198.

Putler, D.S., 1992. Incorporating reference price effects into a theory of consumer choice. *Marketing Science*, 11(3), pp.287–309.

Rabin, M., 2002. A perspective on psychology and economics. *European economic review*, 46(4-5), pp.657–685.

Raux, C., Souche, S. & Croissant, Y., 2009. How fair is pricing perceived to be? An empirical study. *Public Choice*, 139(1), pp.227–240.

Ruijs, A., Zimmermann, A. & Van den Berg, M., 2008. Demand and distributional effects of water pricing policies. *Ecological Economics*, 66(2-3), pp.506–516.

Santos, A.C., 2011. Behavioural and experimental economics: are they really transforming economics? *Cambridge Journal of Economics*, 35(4), pp.705–728.

Schleich, J. & Hillenbrand, T., 2009. Determinants of residential water demand in Germany. *Ecological Economics*, 68(6), pp.1756–1769.

Shogren, J.F. & Taylor, L.O., 2008. On Behavioral-Environmental Economics. *Review of Environmental Economics and Policy*, 2(1), pp.26–44.

Simon, H.A., 2008. Behavioural economics. In *The New Palgrave dictionary of economics*. Palgrave Macmillan, pp. 221–225.

Smith, V.K., 2008. Reflections on the Literature. *Review of Environmental Economics and Policy*, 2(1), pp.130–145.

Statman, M., 1999. Behaviorial finance: Past battles and future engagements. *Financial Analysts Journal*, pp.18–27.

Strengers, Y., 2011. Beyond demand management: co-managing energy and water practices with Australian households. *Policy Studies*, 32(1), pp.35–58.

Thaler, R., 1999. The end of behavioral finance. *Financial Analysts Journal*, pp.12–17.

Venkatachalam, L., 2007. Environmental economics and ecological economics: Where they can converge? *Ecological Economics*, 61(2-3), pp.550–558.

Winkler, R.C. & Winett, R.A., 1982. Behavioral interventions in resource conservation: A systems approach based on behavioral economics. *American Psychologist*, 37(4), pp.421–435.

WISE, 2007. WISE - The Water Information System for Europe. *WISE*. Available at: http://water.europa.eu/.

Worthington, A. & Hoffman, M., 2008. An empirical survey of residential water demand modelling. *Journal of Economic Surveys*, 22(5), pp.842–871.

Zarri, L., 2010. Behavioral economics has two “souls”: Do they both depart from economic rationality? *Journal of Socio-Economics*, 39(5), pp.562–567.