



Examining the reduction in potable water consumption by households in Catalonia (Spain): Structural and contingent factors



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ABSTRACT

Water consumption by households is influenced by a host of factors, widely investigated in the literature. However, the effects of contingent situations like drought episodes and economic crises, which may strongly restrict direct water use in households, remain less explored, and especially a combination of both. Catalonia, a Mediterranean region, suffered the worst drought episode in the last 75 years in 2007 and 2008, followed immediately by the worst economic crisis also in several decades between 2009 and 2014 (though still fishtailing). Taking it as a case study and using metered water data for the household sector, we propose a generalized linear mixed model in which the influence of both the drought episode and the economic crisis on per capita water consumption by *comarques* (supra-municipal entities) is assessed using a drought index on one hand, and economic variables and the water price on the other hand. Likewise, demographic, territorial and climatic determinants, as well as environmental behaviour, are also evaluated. The dataset ($N = 287$) consists of panel data for the forty-one *comarques* of Catalonia covering the 2007 to 2013 period. Results confirm that the contingent factors analysed have contributed to further reduce per capita water consumption, being significant the drought index and water price. The proportion of elderly people, the household size and the proxy for environmental behaviour, also have a negative effect on consumption; whereas seasonal population has the expected positive effect. However, neither the climatic and economic variables analysed, nor urban density and the proportion of foreign population, are found to be significant. A better understanding of the factors influencing residential water consumption in a context of growing water scarcity and economic downturn may aid policy makers and water managers not only to improve the effectiveness and efficiency of demand-side management measures that affect households, but to address emerging social concerns such as water poverty.

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1. Introduction

Households represent a major source of pressure on natural resources such as water. In the European Union, households account for about 10% of total freshwater abstractions, although this figure may be significantly higher in urban areas and areas with scarce water resources, for instance Mediterranean urban environments (EEA, 2001). During the recent decades, however, water consumption in households of developed countries appears to be decreasing, at least on a per capita basis, due to economic,

technological and behavioural factors (Barraqué, Isnard, Montginoul, Rinaudo, & Souriau, 2011; March & Saurí, 2016; Weisz & Steinberger, 2010).

In this paper, we argue that the occurrence of contingent situations such as droughts and economic crises play an important role in explaining water consumption trends. Besides, both are becoming more frequent and their social and environmental impacts more severe. In the case of droughts, it is predicted that climate change will increase the frequency and intensity of such phenomena, particularly but not exclusively in semi arid climates such as the Mediterranean (IPCC, 2014). On the other hand, crises are part of economic cycles, with the novelty that due to globalisation, national economies are now increasingly dependent on global economic trends (Diamond & Rajan, 2008). For instance, the

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latest economic crisis, initially financial and American, became general and global (Cabana, 2009; Krugman, 2009; Varoufakis, 2011).

The impact of droughts has been already analysed in the literature together with economic, technological and behavioural factors such as income, water price, household water appliances, water restrictions or trust (see, among others Harlan, Yabiku, Larsen, & Brazel, 2009; Jorgesen, Graymore, & O'Toole, 2009; Survis & Root, 2012; Willis, Pearce, Mamerow, Jorgensen, & Martin, 2013; Willis, Stewart, Giurco, Talebpour, & Mousavinejad, 2013; as well as Table 6 in the results section for examples). However, few studies explore explicitly both droughts and economic crisis as contingent situations.

Taking Catalonia as a case study, the objective of this paper is to examine the extent to which contingent situations such as the worst drought episode in the last 75 years (Catalan Water Agency -hereafter- CWA, 2008a; Martín-Ortega & Markandya, 2009) and the worst recent economic crisis have contributed to the reduction in potable water consumption (both in absolute and in relative numbers) by Catalan households between 2007 and 2013. Our main hypothesis is that the outbreak of the economic crisis following the dramatic drought episode of 2007–2008 not only prevented the rebound effect, but entailed further diminutions that explain the important and steady decline along the period analysed, despite having one of the lowest per capita water consumption in the developed world.

Understanding contingent factors is also relevant because demand-side management measures, which are commonly implemented to address drought events and water poverty issues, need to take into account households' characteristics in order to be fair, in addition to effective (Jorgesen et al., 2009; March, Domènech, & Saurí, 2013; Renwick & Archibald, 1998; Willis, Pearce, et al., 2013). To this regard, March and Saurí (2016), analysing recent water consumption decline in the city of Barcelona found highly uneven social impacts in terms of accessibility and consumption of this resource. Besides, households are important stakeholders in droughts and economic crises, and their perception of the economic and the environmental events may influence their behaviours, and consequently, the future development of each event. For instance, water conservation efforts undertaken by citizens during recent droughts in Catalonia have proved essential to overcome all these episodes without significant interruptions in domestic supply (CWA, 2010; CWA, 2015; March et al., 2013).

Specifically, the influence of the 2007–2008 drought is examined using a drought index of our own elaboration based on drought legislation passed by the government of Catalonia. On the other hand, the effects of the economic crisis are addressed with the variables unemployment, income and water price. Likewise, we also consider climatic, demographic and territorial factors typically included in the analysis of water consumption determinants such as temperature, rainfall, population age, household size and urban density; together with other factors less common in the literature but relevant for the characteristics of the study area: the proportion of foreigners, already investigated in March, Perarnau, and Saurí (2012) and Bernardo, Fageda, and Termes (2015), and as a novelty, an estimate of seasonal population in order to account for second homes. We also include a proxy variable for environmental behaviour.

Another novelty of this research is the scale of the geographical area taken as a case study. Previous studies in Catalonia had focused on urban environments, especially the city of Barcelona and its Metropolitan Area (Bernardo et al., 2015; March et al., 2012), the Metropolitan Region (Domene & Saurí, 2006; March & Saurí, 2010) and also some municipalities in the northern province of Girona

(García-Acosta, 2012); but none has dealt with the entire territory of Catalonia, comprising 947 municipalities and 41 *comarques*¹ totalling more than 7.5 million people (Fig. 1). Similarly, econometric studies in the developed world tend to focus on urban environments and rarely cover the broader regional areas (but see Jorgesen, Martin, Pearce, & Willis, 2014). The added value of the analysis at this geographical scale consists in a greater diversity of households and urban typologies, as well as in a major heterogeneity in local water policies, and types of service management and supply systems.

The remainder of this paper is organized as follows. We introduce next the study area focusing in recent droughts and the economic crisis in order to contextualize the decreasing trend in potable water consumption by Catalan households since the early 2000s. In section 3 we present the variables used to test the influence of contingency and structural factors as well as the statistical method applied. In section 4 we analyse the effects of the demographic, territorial, climatic, economic, drought and environmental behaviour factors and we compare and discuss our results with other econometric studies on the determinants of residential water consumption. To conclude we summarize the main findings, outline the data limitations found and suggest future research.

2. Droughts, economic crisis and water consumption in Catalonia

Regarding economic trends and drought episodes in Catalonia during recent years, we can distinguish two contrasting periods (Fig. 2): a first period characterized by economic bonanza but water shortages (1998–2008) and a second period (2009–2014) of water bonanza but economic hardship.

Until 2008, GDP per inhabitant had grown at rates between 3.9 and 6.7% per annum. In 2008 it fell to zero, and in 2009 Spain officially entered in recession. In that year, Catalan GDP per capita recorded a decline of 5.5% (Idescat, 2016). After a slight upturn in 2010, the following three years recorded negative rates again (see Table 1). The magnitude of the crisis provoked the loss of population in Catalonia for the first time since statistics are available (1986): more than 17,000 people in 2013, 34,000 in 2014 and 10,000 in 2015 (see Fig. 3).

Despite the recovery of official macroeconomic figures in 2014, Badia and Subirana (2015) estimated for that year that around 120,000 people (1.6% of the population) were deprived of water at home because they could not afford to pay the bill, whilst for the Catalan Water Agency (CWA) water poverty could affect as many as 400,000 homes in the region. The magnitude and persistence of water poverty, among other social and political factors resulting from the economic crisis, have stimulated remunicipalisation debates in towns currently served by private companies (Barcelona, Terrassa, Badalona, Ripollet, and many more).

On the other hand, 2008 was the peak of the drought episode initiated in 2007 and officially ended in January 2009. This drought was considered as the worst since 1945 for the CWA (CWA, 2008b). The episode was the culmination of a drought cycle that began in 1998, during which only 2001 and 2003 recorded average rainfall

¹ Administrative division traditionally found in Catalonia above the municipal level and below the provincial level. *Comarques* are local territorial entities formed by a group of neighbouring municipalities with its own government, roughly equivalent to a US or UK county. Their main functions are to promote territorial balance and to assist municipalities in the provision of services, such as drinking water supply and sanitation. Currently there are 42 *comarques*, the last one created in 2015.

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