The Impact of Climate Change on the Pattern of Demand for Bottled Water and Non-Alcoholic Beverages

Article *in* Business Strategy and the Environment · May 2014

DOI: 10.1002/bse.1782

Sebastian Mirasgedis
National Observatory of Athens

Elena Georgopoulou
National Observatory of Athens

Y. Sarafidis
National Observatory of Athens

Katerina Papagiannaki
National Observatory of Athens

Business Strategy and the Environment
Bus. Strat. Env. (2013)
Published online in Wiley Online Library
(wileyonlinelibrary.com) **DOI:** 10.1002/bse.1782

The Impact of Climate Change on the Pattern of Demand for Bottled Water and Non-Alcoholic Beverages

S. Mirasgedis,[1]* E. Georgopoulou,[1] Y. Sarafidis,[1] K. Papagiannaki[1] and D. P. Lalas[2]
[1]*National Observatory of Athens, Athens, Greece*
[2]*FACE³TS S.A., Athens, Greece*

ABSTRACT
To date, the majority of the research literature on the impacts of climate change has addressed the negative aspect, i.e. the risks associated with a future permanent modification of climate. Potential opportunities have received much less attention and are rarely transformed into monetary values. Furthermore, manufacturing is one of the economic sectors where the influence of climate change remains practically unknown, although the economic performance of some industrial activities depends directly on climatic conditions – bottled water and non-alcoholic beverages (i.e. soft drinks and fruit juices) are among these. This paper aims to explore the link between weather and product sales in these sectors, and estimate in quantitative terms the potential impact of future climate change on their revenues. Historic data were explored through statistical analysis and appropriate regression models were developed. Models were applied for the historic (1961–90) and future climate (2021–50) and the difference in sales forms the expected quantified impact of climate change. The results indicate that significant opportunities may arise for some sectors from modifications in climate, provided their production infrastructure can meet the expected demand and their management strategies can successfully adapt to altered climatic conditions. Copyright © 2013 John Wiley & Sons, Ltd and ERP Environment.

Received 7 September 2012; revised 18 December 2012; accepted 10 January 2013
Keywords: climate change; impacts; industry; Greece; water; beverage

Introduction

A NUMBER OF STUDIES HAVE INVESTIGATED IN QUANTITATIVE TERMS THE RELATIONSHIP BETWEEN TEMPERATURE OR other meteorological parameters and the level of economic activity at either the sectoral (see for example Bahng and Kincade, 2012) or the whole economy level (e.g. Xu and Sun, 2011). In that respect, although a lot of research on the adverse effects of future climate change on physical and economic systems has been carried out and published, not much has been said to date on the economic opportunities that may arise from such a change. The consumption of number of products especially in the manufacturing sector is greatly influenced by weather conditions and thus their sales will probably be favorably affected by a future modification in climate.

*Correspondence to: S. Mirasgedis, National Observatory of Athens, Lofos Nimfon, Thesion, Athens 11810, Greece. E-mail: seba@noa.gr

Thus, while for power companies, households and most activities in the tertiary sector, heat waves represent a clear risk, for example by increasing further peak electricity demand for space cooling, for others, including manufacturers of beer, ice cream, soft drinks, juices, and bottled mineral water, these weather conditions are highly beneficial as high temperatures (usually during summer) are in most of cases associated with increased product sales.

The importance of weather and climate on business activities and the need to develop appropriate methods and tools for companies to deal with the potential risks but also opportunities associated with climate change have been identified and emphasized recently in several studies. Winn *et al.* (2011) have presented a conceptual framework for organizations and businesses to deal with climate change that takes in account the management of sustainability, crisis, risk, resilience and adaptive organizational change. Weinhofer and Busch (2012) in an exploratory case study in 11 electric utilities showed that while climate change is perceived as a material issue for their business, the implemented climate risk management follows the same approach used for other business risks because of incomplete knowledge of the effects of climate change. Wedawatta *et al.* (2011) explored the vulnerability of construction small and medium sized enterprises (SMEs) in the UK to weather extremes and potential responses and identified a lack of appropriate coping strategies.

Acknowledging the importance of weather for their activity, a number of companies and industry associations have also analyzed the annual variation of sales in relation to climatic variables and include this kind of analysis into their annual reports at either company or sectoral level (e.g. British Soft Drinks Association, 2008; BCI, 2009).

For example, in the UK Soft Drinks Report for the year 2008, the section analyzing the weather conditions during that year starts as follows: 'It was a promising start. In the absence of April showers, the UK basked in a balmy sun-filled month, fuelling expectations of heat wave conditions to come'. Similarly, the Irish Soft Drinks Report for the same year states that '. . .May set expectations soaring with the lowest rainfall and highest temperatures recorded for the five years from 2003'.

With regard to soft drinks in particular, the weather is considered a decisive factor for the industry's sales and the correlation between sales and temperature has been demonstrated in several studies (see for example Murray *et al.*, 2010 and Dubé, 2004). An additional critical parameter is precipitation; as soft drinks are usually consumed outdoors during the summer, continuous or frequent rain events will decrease the number of people out and about. Sunshine duration may also represent a complementary variable that may be examined (see for example British Soft Drinks Association, 2009; BCI, 2009).

A large seasonal increase in consumption as a result of weather conditions may represent not only an opportunity but also a risk for a company if it is not well-prepared for this increase. For example, the existing production capacity and safety stock of a company may not be sufficient to satisfy the higher demand, resulting in a temporal loss of market share that may have further consequences (WTI, 2009).

It should also be noted that reports on soft drinks sales nationally reveal that although favorable weather conditions during the summer significantly affect seasonal consumption, their effect on the total annual consumption is much less pronounced or even negligible, as non-climatic factors (e.g. household expenditure, availability of new or specifically targeted products) seem to play a more determining role. For example, although the summer of 2008 in Ireland was very rainy compared with 2006 (August 2008, precipitation 150 mm; August 2006, 60 mm), the annual consumption of soft drinks was more or less the same (2008, 858 million liters; 2006, 839 million liters).

Thus, in order to better estimate risks and opportunities associated with weather conditions, it seems important to develop a better understanding of the role of weather on sales by developing a quantitative model that can forecast the level of sales/ consumption of beverages as a function of climatic as well as non-climatic parameters. Although large manufacturers may have developed such models for their own use, the information published on this issue is scant. Regression analysis seems to be the main methodological tool applied in order to explore the link between weather variables and consumption/sales. Typically, correlation is determined on a month-by-month basis. In the cases of other beverage products (e.g. beer), this was based on a temperature threshold (usually 15 °C) above which an increase in consumption is triggered (Blom, 2009). Thus, an index called 'beverage degree days' (BDD) was formulated on the basis of maximum temperature and used similar to the way heating degree days (HDD) or cooling degree days (CDD) are used in energy analysis. By developing a linear regression model involving BDD for a large Norwegian brewery, Blom (2009) found that the determination coefficient (R^2) of the model was 64%, i.e. 64% of the changes in sales are associated with changes in accumulated BDDs. In addition, the model developed showed that a 1 °C of increase in maximum temperature during the summer season (May–September) results in a 3.4% increase in the industry's sales during this season.

DOI: 10.1002/bse

Statistical analysis needs to treat different product families separately since the influence of weather conditions on sales is not the same. For example, in a recent study (Ramanathan and Muyldermans, 2010) analyzing and quantifying the relative influence of a number of factors on the sales of a large UK soft drinks company, temperature was found to be an important factor for the 2 liter and 500 ml bottles but not for the 330 ml cans. Such differences are associated not only with market factors such as where each product family is sold (supermarkets, outdoor stores, etc.) but also with regional/ national particularities (e.g. types and locations of tourism activities).

It also needs to examine the suitability of various measures of the same variable, as for example maximum, mean or apparent temperature (which incorporates somewhat the effect of humidity), but also the absolute level of average local temperatures which varies substantially from location to location.

In view of the above, this paper aims to explore and quantify the link between climatic conditions and the sales of bottled water and other non-alcoholic beverages. Alcoholic beverages have not been included as their sales are affected by social factors that cannot be easily quantified and disaggregated. For the purposes of this study, a southern European country (Greece) where high temperatures are often reached and their effects should be clearly felt has been chosen. A second reason for choosing a southern country is the recent increase of heat waves there, occurrences of which are expected to become the norm in the future (Hansen *et al.*, 2012), based on all predictions carried out by numerous research groups worldwide of impending changes in climate. The possible influence of climate change on sales affects long-term business development planning, especially in choices of location of plants and warehouses. To address these aspects, one needs to first develop appropriate methodology to specify relevant forms and their annual variations of the climatic variables affecting consumption over decades in the future. This methodology can also be useful in similar studies of the impact of climate change on other consumer goods, thus providing useful information for relevant business risks and related costs.

The structure of this paper is as follows: the next section presents the methodological framework developed for estimating the dependence of bottled water and other non-alcoholic beverage sales on weather variables, then we describe the data used in the study. Following this we address the possible future implications on demand for these products in Greece under climate change. Finally, we summarize the main findings of the study and draw our conclusions.

Methodological Framework

Overview

The methodological framework developed and implemented in this study comprises three basic stages. First, a demand model for sales is constructed that aims to quantify the extent to which the demand for several products classified under the beverage sector (e.g. juices, soft drinks, bottled mineral water and carbonated water) is a function of climatic and socio-economic factors. For this, a statistical approach (multiple regression models) based on historical monthly data for the last 10 years (i.e. 2002–11) for Greece is applied. Second, the results from a regional climate model are used to specify the changes in climatic conditions in Greece in the upcoming decades (i.e. the period 2021–50) compared to historic climate (1961–90). The A1B scenario of the Intergovernmental Panel for Climate Change (IPCC) Special Report on Emission Scenarios (SRES) has been chosen for the present analysis, which is considered as a scenario of medium climate change ‘intensity’ and matches with all EU policies on emission restrictions until 2020. Third, the regression models developed previously are used to estimate future demand of the examined products in Greece that can be attributed to climate change. Details for the first two parts follow.

The Demand Model

In the context of this study, several multiple regression models have been developed and tested in order to quantify the influence of various climatic and socio-economic factors on the monthly demand for various products of the beverage sector in Greece.

DOI: 10.1002/bse

Several factors, internal and external parameters to the industry (Agnew and Thornes, 1995), influence the sales of specific products of the beverages industry in a region. The former comprise the product prices (in general, as the prices go down the demand goes up), the total amount of money spent in advertising campaigns, the in-store promotions, the availability of competitive products, the level of development of distribution networks, etc. The latter include the number of inhabitants and visitors (defining the size of the market), general economic conditions influencing the available income for spending, consumer preferences and social trends. They also comprise weather variability (e.g. one is more likely to buy a soft drink in hot weather), holiday periods, other special conditions (e.g. bottled water sales are higher in areas with degraded water resources), etc.

The development of analytical models for simulating the demand for specific beverages in relation to the above-mentioned parameters requires a significant amount of data in appropriate temporal analysis, which, in general are not always available. In order to deal with this difficulty, for each product examined in the context of this analysis we have developed and tested several models, which incorporate a limited number of robust economic drivers, as well as several meteorological parameters, as explanatory variables. The models finally selected, incorporate only the statistically significant independent parameters according to the results of the statistical analysis.

Regression models developed in the context of this study in order to simulate the demand of bottled water and non-alcoholic beverages have the following general form:

$$\log(DE_t) = c + \sum_i a_i \log(PM_{i,t}) + \sum_j b_j \log(SM_{j,t}) + \sum_k d_k \log(E_{k,t}) + ft + \sum_{l=2}^{4} p_l S_{lt} + qSE_t + e_t \tag{1}$$

where c, a_i, b_j, d_k, f, p_l (l from 2 to 4) and q are the coefficients to be estimated from the regression analysis and e_t is the residual term.

The dependent variable (total amount of sales of a specific product in month t) appears in the above equation in logarithmic form in order to reduce the serial correlation and the heteroscedasticity of the models developed (Makridakis *et al.*, 1998). Thus, possible loss of forecast accuracy, which is sometimes caused when the independent variables of a forecast model take in the future values that differ substantially from those in the past on which the regression of the model has been based, is avoided. We have examined four products, namely juices, soft drinks, mineral bottled water and carbonated water, considering the total volume of sales, as well as the demand per product and packaging size.

The explanatory variables used in the model comprise:

- A number of primary meteorological parameters ($PM_{i,t}$), namely the maximum, mean and minimum temperature ($T_{\max}$, T_{mean} and $T_{\min}$ correspondingly), precipitation (Pr), sunshine duration (SD) and relative humidity (RH).
- Secondary meteorological parameters ($SM_{j,t}$) aiming at describing in a more effective way the meteorological parameters which influence consumer preferences and behavior. To this end, we have used the apparent temperature (T_{app}), which is estimated on a monthly basis from the corresponding values of maximum temperature and relative humidity using the following formula (Steadman, 1984):

$$\begin{aligned} T_{\text{app}} &= -1.3 + 0.92T_{\max} + 2.2e \\ e &= \frac{RH}{100} 6.105 \exp\left(\frac{17.27T_{\max}}{237.7 + T_{\max}}\right) \times 10^{-1} \end{aligned} \tag{2}$$

- A number of selected economic variables ($E_{k,t}$) aiming at describing the exogenous economic environment. To this end, we have used the number of overnight stays during month t, which serve as a measure of the tourist activity in the region, and the household expenditure in month t which serve as a measure of the overall economic environment and the willingness of the permanent population to spend money on consumer goods.
- The time (t) in months aiming at taking into account the potential long-term trends in the monthly sales of the product in question. This trend can be related to social, economic or demographic factors that result in a systematic change to the total volume of sales in case the analysis undertaken on a sub-sectoral level or to a variety of parameters which influence the market share of a specific enterprise in case the analysis is undertaken at a company level.

DOI: 10.1002/bse

- Three dummy variables ($S_{l,t}$), which aim at representing the potential seasonal variability in the sales of each product that does not relate to specific weather conditions. An index l taking values within the interval [2,4] has been used, to represent three seasons of the year (i.e. $l = 2$ for spring, $l = 3$ for summer and $l = 4$ for autumn). The consumption during winter is the baseline consumption in the model. It should be noted that any season of the year could have been selected as the baseline season for the model without affecting the results of the analysis. Each dummy variable has only two allowable values, 0 or 1. The variable $S_{l,t}$ takes the value of 1 if the t-observation belongs to season I and 0 otherwise. We use one dummy variable less than the number of periods (four seasons per year) to avoid multi-collinearity problems (Makridakis *et al.*, 1998).
- One dummy variable (SE_t), with a view to cover months of the year when special events (e.g. holidays) influence the demand for a product. This variable takes the value of 1 if the month t includes special events such as Christmas and the mid-August holiday period and 0 otherwise.

Again, a logarithmic form was preferred in order to express the meteorological and economic parameters incorporated in the models developed, in order to avoid serial correlation and heteroscedasticity. Furthermore, it should be pointed out that these models, though able to produce (given the simplifications adopted and the uncertainty in the future inputs) only approximate estimates of the future long-term demand of bottled water and non-alcoholic beverages, can provide considerable insight on the potential changes attributable to weather variability.

Estimation of Future Regional Climate

Projections of anthropogenic emissions of greenhouse gases (GHGs) and other constituents are necessary to predict future climate change. Since the long-term evolution of GHG emissions is characterized by large uncertainties, a range of emissions scenarios has been generated by the IPCC on the basis of explicitly different packages of socio-economic and technological conditions ('storylines'). Four qualitative storylines are usually considered that yield four sets of scenarios called 'families': A1, A2, B1 and B2. They cover in a consistent way a wide range of key future characteristics such as demographic change, economic development and technological change, resulting in a substantial variation of GHG emissions (IPCC, 2000).

In the present analysis, the A1B scenario of the IPCC/SRES has been chosen, as it is considered a scenario of medium climate change 'intensity' and is consistent with EU policies on emission restrictions until 2020. In order to specify the changes of climatic conditions in Greece in the upcoming decades (i.e. during 2021–50) compared with historic climate (1961–90) the results of a regional climate model (RCM), namely the RACMO2 climatic model developed by the Royal Dutch Meteorological Institute (Meijgaard *et al.*, 2008), utilizing the A1B scenario emissions pathway have been used.

The use of a RCM rather than the use of a global climate model (GCM) has been dictated by the considerable variation in terrain characteristics (long coastlines in close proximity to mountainous regions as is the case in the Mediterranean) which results in considerable spatial climatic variations that cannot be discernible with the low resolution (a few hundred kilometers) of GCMs (CCSP, 2008).

In an attempt to construct comparable results on a monthly basis for a 30-year period, it was decided that simple mean values of meteorological parameters for each month averaged over the whole period would not capture the true variability present in both the past and the future 30-year period. Instead, the well-established approach for long-term analysis of making use of a typical meteorological year (TMY) was preferred, which, however, would be a special purpose TMY taking into account the ranking of the variables as identified in the demand model.

The development of the special purpose TMY is based on the selection, following statistical criteria, of actual single months from a multi-year database that are then merged into a TMY (Argiriou *et al.*, 1999). Among the different methods available for TMY generation, the Sandia National Laboratories method using Filkenstein–Schafer (FS) statistical method (Hall *et al.*, 1978) is selected, as it is one of the most common methodologies used for generating a TMY (Argiriou *et al.*, 1999; Sawaqed *et al.*, 2005; Skeiker, 2007; Jiang, 2010). The daily values computed by the RACMO2 climatic model are utilized for the selection of a typical month on the basis of seven daily meteorological parameters, namely the maximum, mean and minimum temperature, precipitation, sunshine duration and relative humidity. The procedure is as follows:

DOI: 10.1002/bse

Step 1: For each meteorological parameter mentioned above and each year of the selected 30-year period (i.e. 1961–90 or 2021–50), the daily values of the parameter during each month of the year are sorted (short-term sorting) in increasing order (x_1, x_2, ..., x_n). In addition, for the same meteorological parameter and each month of the year, the daily values of the parameter during that month and all years of the selected 30-year period are sorted in increasing order (long-term sorting). Next, for each daily variable x in the sorting, the cumulative distribution function $CDF_n(x)$ is calculated with the following function:

$$CDF_n(x) = \begin{cases} 0 & \text{for} \quad x < x_1 \\ \dfrac{k - 0.5}{n} & \text{for} \quad x_k \leq x < x_{k+1} \\ 1 & \text{for} \quad x \geq x_n \end{cases} \tag{3}$$

where $CDF_n(x)$ is the value of the cumulative distribution function for daily variable x, n is the total number of sorted elements and k is the rank order number. From its definition, $CDF_n(x)$ is a monotonically increasing step function with steps of size $1/n$ occurring at x_i and is bounded by 0 and 1. The calculation of $CDF_n(x)$ is performed both over short-term and long-term sorting.

Step 2: The FS statistics for each month m of a specific year y are calculated according to the following equation:

$$FS_x(y, m) = \frac{1}{N} \sum_{i=1}^{N} \left| CDF_m(x_i) - CDF_{y,m}(x_i) \right| \tag{4}$$

where FS is the FS statistics, CDF_m is the long-term (30 years in this study) and $CDF_{y,m}$ is the short-term (for the year y) cumulative distribution function of the daily variable x for month m, x_i is a sorted element in a set of N observations, and N is the number of daily data for month m.

Step 3: A weighting factor WF_x is applied to the FS statistics for each meteorological parameter x (FS_x). In this way, a weighted sum, WS, is derived for each month of each year in the selected 30-year period (1961–90 or 2021–50):

$$WS(y, m) = \frac{1}{m} \sum_{i=1}^{m} WF_x \ \ FS_x(y, m) \tag{5}$$

where WF_x are the weighting factors, one for each variable, and m is the number of meteorological parameters considered (seven in this study). For each month of the year, 5 months having the smallest weighted sum of the FS statistics of the seven meteorological parameters are selected.

Step 4: To finally select the typical meteorological months from the five candidate months identified at the end of Step 3, the simpler selection process introduced by Pissimanis *et al.* (1988), which uses the root mean square difference (RMSD) of the key parameter (solar radiation in the original method) as the selection criterion, is applied:

$$\text{RMSD} = \sqrt{\frac{\sum_{i=1}^{N} \left| KP_{y,m,i} - KP_m \right|}{N}} \tag{6}$$

where N is the number of daily readings for the month, $KP_{y,m,i}$ is the daily values of the key meteorological parameter of year y, month m and day i, and KP_m is the long term mean daily values of the key meteorological parameter.

DOI: 10.1002/bse

Data

The food and beverage industry constitutes one of the most significant and dynamic manufacturing sectors of the Greek economy. In 2009, the sector accounted for 25.3% of the total turnover of manufacturing, produced 31% of the relevant overall gross added value and employed approximately 22.9% of workers in industry. The sub-sectors of bottled water and soft drinks (NACE Rev.2 code 1107) and juices (NACE Rev.2 code 1032) account for 15% of the total sales in the food and beverage industry.

The regression models presented in this paper were developed utilizing historical data for sales for specific beverage products provided by two large Greek enterprises, covering a 10-year period from 2002 to 2011. These companies account for a significant percentage of the market for bottled water and non-alcoholic beverages and therefore can be considered to be a 'guide' for the behavior of the whole sector against weather and future climate change. More specifically, the company that provided sales data for bottled mineral water and carbonated water has a large distributional network covering almost all the Greek territory. The second company that provided data for juices and soft drinks covers mainly the metropolitan area of the capital of Greece (i.e. Athens, where approximately 40% of the permanent population as well as a large number of visitors reside). The data set used comprises monthly sales data (in volume), disaggregated per product and type of selling pack (e.g. 500 ml bottle, 330 ml can etc.). Figure 1 shows the sales profile of the four products examined (bottled mineral water, carbonated water, juices and soft drinks) over the 10-year period (2002–11). As shown, the sales of all beverages in question exhibit a significant seasonal variation. Specifically, the demand for bottled mineral water and carbonated water increases significantly during the summer. The sale of juices follows a similar profile; however, the demand first peaks at the end of spring/early summer, then declines and recovers temporarily in September. As the data on juices derive from a company mainly active in the Athens area, the above-mentioned seasonal sales' profile can be explained by the fact that many permanent residents leave the capital during the summer vacation period (particularly in August). The sales of soft drinks follow a trend similar to that of juices, with an additional peak in December probably due to the Christmas holiday. Figure 1 also shows that for all products examined, the seasonal and hence weather-sensitive effect is superimposed on a long-term increase in sales. This is particularly noticeable for juices and soft

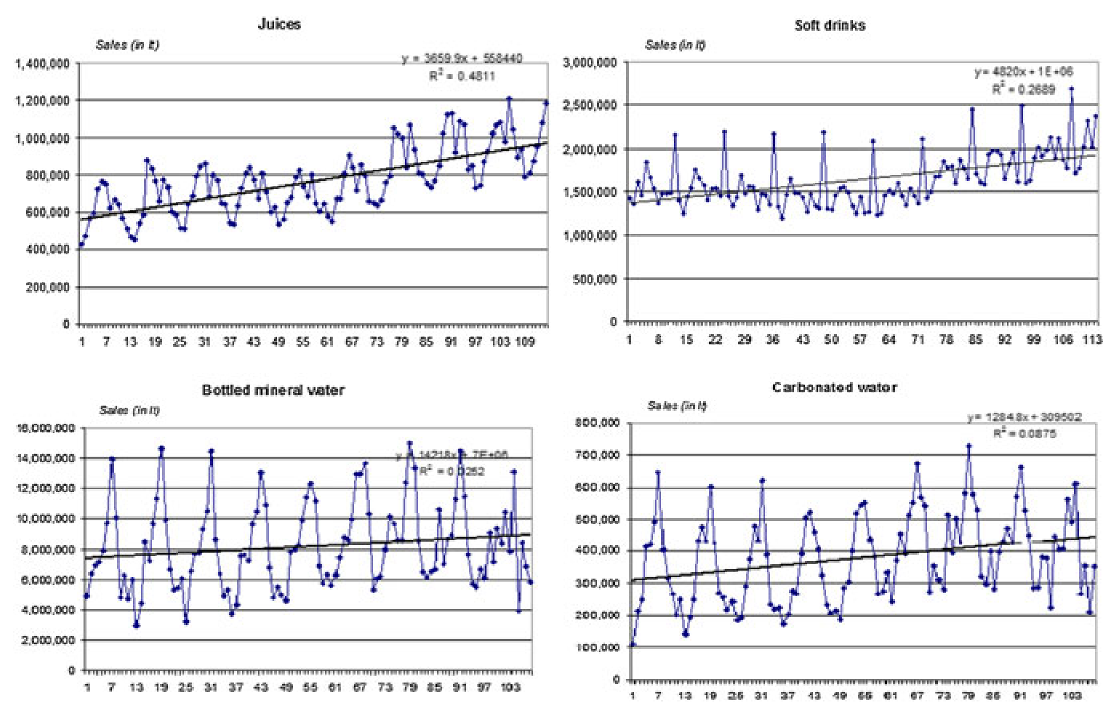

Figure 1. Monthly demand for bottled mineral water and other non-alcoholic beverages in Greece (2002–11)

DOI: 10.1002/bse

drinks and can possibly be attributed either to a substantial expansion of these two sub-sectors during the reference period or/and a dynamic development of the specific company, which provided the data on sales.

Necessary historical weather data for the period 2002–11 were derived from a first-class meteorological station (so classified according to the criteria set by the World Meteorological Organization) located in the center of Athens. Since almost half of the total Greek population lives in the greater Athens area, and consequently consumes a relevant portion of bottled mineral water and non-alcoholic beverages, the meteorological data utilized constitute a representative basis for analyzing the behavior of consumers in Greece in response to weather conditions.

The experience of many companies worldwide indicates that several weather elements can influence the demand for specific products. Thus, in the context of this analysis we have tested the influence of maximum, mean and minimum temperature, precipitation, sunshine duration and relative humidity on the sales of bottled water and non-alcoholic beverages. The monthly values of these parameters are the average (for temperature, relative humidity and sunshine duration) or the sum (for precipitation) of the corresponding daily figures.

To investigate the impact of climate change for the period 2021–50, the daily meteorological data at the same location were derived by interpolating the results provided by the regional climate model for the four nearer grid points of the computational grid of the model (grid analysis 25 km $\times$ 25 km). Then, a typical meteorological year for the period 2021–50 was formulated on the basis of the approach presented in Estimation of Future Regional Climate and finally the monthly values of the selected parameters were calculated from the corresponding daily figures.

The socio-economic parameters included in the developed regression models comprise private consumption of households and the number of overnight tourist stays; the relevant data derived from the National Statistical Service of Greece. The number of overnight tourist stays was available on a monthly basis for the entire period under examination. Data on the private consumption of households were available on a quarterly basis. To disaggregate them on a monthly basis, first it was assumed that consumption is equally spread within each 3-month period. On the assumption that the monthly values obtained stand for the private consumption at the second month of each quarter, the consumption of the third month of the quarter n and the first month of the quarter $n+1$ derived from a linear interpolation of the consumption estimated for the second month of the quarters n and $n+1$.

Results

Sensitivity of Product Sales to Weather Conditions

Using $n=114$ monthly observations (covering the period from January 2002 up to June 2011) several multiple regression models were developed, correlating the volume of sales for each product category in question with a number of explanatory variables presented in The Demand Model. Table 1 shows, for each product category examined, the models presenting the highest adjusted coefficient of determination (R^2), the significant independent variables included and other indices related to the performance of the models. It is worth mentioning that the selected models present a satisfactory to very high predictive power, with R^2 ranging from 70 to 90%, with somewhat lower values (*c.* 55%) for small containers of less than 500 ml, meaning that the independent variables included in each model explain a corresponding percentage of sales fluctuations for the relevant product category. According to the results of the analysis, in all models the private consumption of households is statistically very significant. In some models, additional economic parameters are statistically significant, namely the overnight stays of tourists as well as the linear time variation (see for example the equations modeling the sales of soft drinks and juices), identifying a long-term development of the corresponding markets and/or the activity of the specific company which provided the relevant sales data. In addition, some models selected incorporate as statistically significant independent variables one or more weather parameters, namely the mean monthly maximum temperature, the mean relative humidity or the mean apparent temperature. Finally, for all the products examined, the corresponding models include a number of dummy variables, identifying a seasonal or monthly variation of product sales not attributed to weather variability.

Despite the fact that the multiple regression models developed in the context of this study present a satisfactory to high R^2, many of them still show large serial correlation, violating one of the basic assumptions of the regression analysis. The Durbin–Watson statistic is widely used for testing the serial correlation or the independence of

DOI: 10.1002/bse

Model	Significant Independent Variables	Adjusted R^2	Significance F	Durbin–Watson
Bottled mineral water				
Total volume of sales	T_{max}, PC, S_2, S_3	0.724	8.1×10^{-29}	2.397
Sales in packs < 500 ml	T_{max}, PC, S_2, S_3	0.538	2.1×10^{-17}	2.227
Sales in packs > 500 ml	T_{max}, PC, S_2, S_3	0.717	3.2×10^{-28}	2.475
Carbonated water				
Total volume of sales	T_{max}, PC, S_2, S_3	0.733	1.5×10^{-29}	2.206
Sales in packs < 500 ml	T_{max}, PC, S_2, S_3	0.722	1.2×10^{-28}	2.075
Sales in packs > 500 ml	T_{max}, PC, TRSM, S_4	0.759	7.9×10^{-32}	2.208
Soft drinks				
Total volume of sales	T_{app}, PC, t, M_{Aug}, M_{Dec}	0.706	3.4×10^{-28}	0.755
Sales in packs < 500 ml	T_{max}, RH, PC, t, M_{Aug}, M_{Dec}	0.587	8.5×10^{-20}	0.545
Sales in packs > 500 ml	T_{app}, PC, t, M_{Aug}, M_{Dec}	0.730	3.4×10^{-30}	0.889
Juices				
Total volume of sales	T_{max}, RH, PC, t, M_{Aug}	0.901	1.3×10^{-53}	1.390
Sales in packs < 500 ml	T_{max}, PC, t, M_{Aug}	0.847	2.1×10^{-44}	1.120
Sales in packs > 500 ml	T_{max}, RH, PC, t, M_{Aug}	0.894	5.3×10^{-52}	1.562

Table 1. Independent variables and overall performance of multiple regression models selected for analyzing the sales of bottled mineral water and non-alcoholic beverages. All models are structured on a monthly basis, incorporating the following independent variables: T_{max}, mean maximum temperature; RH, mean relative humidity; T_{app}, mean apparent temperature; PC, private consumption of households; TRSM, number of tourist overnight stays; S_2, S_3 and S_4, dummy variables indicating the season of the year (i.e. 2 for spring, 3 for summer and 4 for autumn); M_{Aug} and M_{Dec}, dummy variables indicating correspondingly the months August and December; t, time in months showing the long-term trends in sales

residuals at lag 1 in regression models; it ranges in value from 0 to 4, with an intermediate value of 2, which indicates the absence of autocorrelation at lag 1. As clearly depicted in Table 1, for several models developed in the context of this study the Durbin–Watson statistic deviates significantly from this central value, which casts doubt on the validity of the *F*- and *t*-tests and confidence intervals (Makridakis *et al.*, 1998). One of the common methods for reducing the serial correlation observed in econometric regression is the incorporation of an autoregressive structure in the error term (Makridakis *et al.*, 1998).

In the context of this paper, autoregressive structures were incorporated in all models presenting a Durbin–Watson index higher than 2.3 or lower than 1.7 (facts that show a significant serial correlation problem in the corresponding models). All the other independent parameters remained unchanged. Tables 2–5 present the final models selected for each product category and the corresponding estimated coefficients. Notably, the incorporation of autoregressive structures in the models resulted in increased R^2 values, indicating an improvement of their predictive power. The inclusion of autoregressive structures in the models examined does not affect significantly the importance of weather parameters. In all cases of products examined, the maximum ambient temperature is a statistically significant independent variable, affecting positively the volume of product sales. The humidity, either directly or in combined form (T_{app}) has been included only in a limited number of models and seems to be less significant. As regards the economic parameters, the inclusion of autoregressive structures seems to weaken the significance of the private consumption of households in some models. This is reasonable as the autoregressive structures reflect in a way the economic activity. The additional presence of tourists in the models does not seem to influence sales either of water (except for carbonated water in large containers) or of the other non-alcoholic beverages. Possible explanations are the relatively small percentage of their numbers in comparison to the total population in the Athens area and the similarity of their choice behavior to the local residents.

As the maximum temperature was found to be the meteorological parameter with the most significant influence on the level of sales of non-alcoholic beverages, Figure 2 shows the changes in total sales for all products examined attributable to a uniform increase of the mean monthly maximum temperature by 1 °C for all months of the year. For the case of soft drinks in large containers where T_{app} is included instead of T_{max}, the value of T_{app} to be used in the demand equations resulted from Eq. (2) with a 1 °C increase in T_{max} and the relative humidity constant (RH).

DOI: 10.1002/bse

Variable	Total volume of sales		Sales in packs < 500 ml		Sales in packs > 500 ml	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
c	1.659	0.028	0.089	0.949	1.770	0.017
T_{max}	0.163	0.011	0.206	0.061	0.144	0.023
RH						
T_{app}						
PC	1.227	0.000	1.442	0.000	1.177	0.000
TRSM						
t						
S_2	0.116	0.000	0.125	0.000	0.111	0.000
S_3	0.240	0.000	0.212	0.000	0.251	0.000
S_4						
M_{Aug}						
M_{Dec}						
AR (1)	−0.213	0.033			−0.251	0.011
R^2	0.746		0.538		0.744	

Table 2. Values of the independent coefficients of the final models selected for analyzing the sales of bottled mineral water. See text and Table 1 for definitions of variables; c, constant of the model; AR(1), autoregressive structure at lag 1

Variable	Total volume of sales		Sales in packs < 500 ml		Sales in packs > 500 ml	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
c	−2.409	0.016	−4.171	0.000	6.364	0.000
T_{max}	0.427	0.000	0.462	0.000	0.432	0.002
RH						
T_{app}						
PC	1.825	0.000	2.235	0.000	−0.671	0.007
TRSM					0.153	0.002
t						
S_2	0.106	0.000	0.099	0.000		
S_3	0.150	0.000	0.130	0.000		
S_4					−0.200	0.000
M_{Aug}						
M_{Dec}						
R^2	0.733		0.722		0.759	

Table 3. Values of the independent coefficients of the final models selected for analyzing the sales of carbonated water. See text and Table 1 for definitions of variables; c, constant of the model

As a general remark, the results obtained indicate that as the temperature increases, the demand for bottled mineral water and other non-alcoholic drinks tends to be higher; on an annual basis this increase ranges from approximately 0.9% for bottled mineral water and soft drinks up to 2.2 and 2.3% for carbonated water and juices, respectively. Yet, the estimated changes attributable to a +1 °C increase in the mean monthly maximum temperature are seasonally not uniform. Specifically, on a percentage basis, the projected increases are more significant in the winter period (i.e. December to February), which is above 1.2% for bottled mineral water and soft drinks, reaching up to 3.7% for carbonated water and 4% for juices. On the other hand, the level of sales during the summer period (i.e. May to September) seems to be less affected by an increase in mean monthly maximum temperature by 1 °C and ranges between 0.5 and 0.7% for bottled mineral water, 1.3 and 1.8% for carbonated water, 0.4 and 0.7% for soft drinks and 0.8 and 3.1% for juices.

DOI: 10.1002/bse

	Total volume of sales		Sales in packs < 500 ml		Sales in packs > 500 ml	
Variable	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
c	9.763	0.000	8.208	0.000	10.399	0.000
T_{max}			0.243	0.000		
RH			−0.077	0.171		
T_{app}	0.164	0.000			0.136	0.000
PC	−0.214	0.472	0.021	0.924	−0.391	0.204
TRSM						
t	0.001	0.000	0.001	0.203	0.001	0.000
S_2						
S_3						
S_4						
M_{Aug}	−0.059	0.000	−0.052	0.000	−0.061	0.000
M_{Dec}	0.199	0.000	0.103	0.000	0.218	0.000
AR (1)	0.733	0.000	0.638	0.000	0.664	0.000
AR (2)			−0.186	0.095		
AR (3)			0.474	0.000		
R^2	0.846		0.881		0.838	

Table 4. Values of the independent coefficients of the final models selected for analyzing the sales of soft drinks. See text and Table 1 for definitions of variables; c, constant of the model; AR(1) - AR(3), autoregressive structures at lag 1–3

	Total volume of sales		Sales in packs < 500 ml		Sales in packs > 500 ml	
Variable	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
c	9.325	0.000	9.186	0.000	9.562	0.000
T_{max}	0.401	0.000	0.254	0.000	0.420	0.000
RH	−0.108	0.079			−0.179	0.005
T_{app}						
PC	−0.227	0.199	−0.385	0.166	−0.281	0.132
TRSM						
t	0.002	0.000	0.003	0.000	0.002	0.000
S_2						
S_3						
S_4						
M_{Aug}	−0.096	0.000	−0.137	0.000	−0.087	0.000
M_{Dec}						
AR (1)	0.219	0.035	0.382	0.001	0.140	0.150
AR (2)	0.057	0.566	0.157	0.136	0.101	0.274
AR (3)	0.391	0.000			0.339	0.001
R^2	0.923		0.886		0.916	

Table 5. Values of the independent coefficients of the final models selected for analyzing the sales of juices. See text and Table 1 for definitions of variables; c, constant of the model; AR(1) - AR(3), autoregressive structures at lag 1–3

A possible explanation for this differentiation is that the consumption of bottled mineral water and non-alcoholic beverages during the summer period is already high and therefore there is not much room for a substantial further growth in sales as a result of higher temperatures. Also, at extremely high temperatures people limit their outdoor activities, remaining at home.

DOI: 10.1002/bse

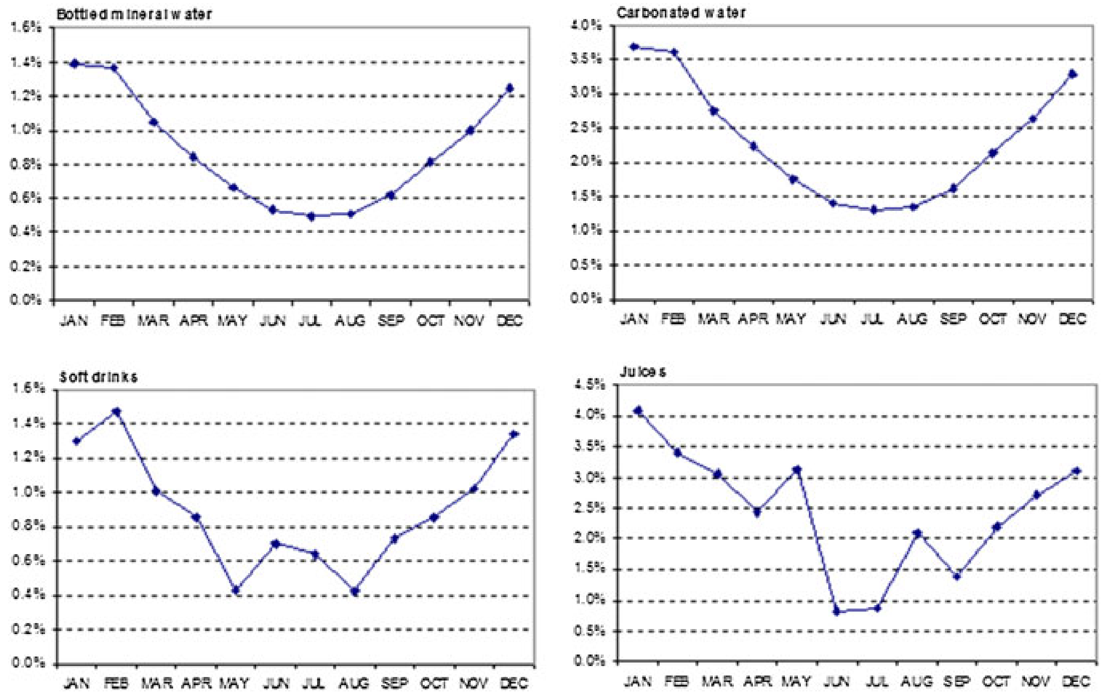

Figure 2. Estimated change of sales of bottled mineral water and non-alcoholic beverages as a result of a +1 °C change in the average monthly maximum temperature

Climate Projections for Greece

As already mentioned, changes in climatic conditions in Greece during the upcoming decades (i.e. 2021–50) compared with historic climate (1961–90) are examined in the context of the A1B Scenario of the IPCC. The data set developed for the historic and future climate comprises daily values for the selected meteorological parameters for a 30-year period (1961–90 and 2021–50). TMY are defined on the basis of the above-mentioned data sets according to the Sandia National Laboratories method.

In view of the results of the previous section, after the FS statistics were computed for all 30 years of the historical (1961–90) and future (2021–50) periods as described in Step 2 of the TMY methodology above, the following weighting factors (Table 6) have been utilized to compute the weighted sum of FS statistics (Step 3 of the TMY methodology). The weighting factors are in line with the sales sensitivity for non-alcoholic beverages to the meteorological parameters identified in the regression analysis. The regression analysis shows that maximum temperature and in some cases relative humidity are the most relevant meteorological parameters. Therefore, weights assigned to temperature-related parameters were set to 50%, for relative humidity to 30% while the remaining 20% accounts for the other parameters (sunshine duration, wind speed and precipitation).

As mentioned, the final selection of typical months is based on the simpler process introduced by Pissimanis *et al.* (1988). Since maximum temperature represents the key determining meteorological parameter, the RMSD of maximum temperature is calculated for the five candidate years (Table 7). Years finally selected per month are presented in bold.

	Maximum temperature	Minimum temperature	Mean temperature	Precipitation	Relative humidity	Wind speed	Sunshine duration
Weight	30%	10%	10%	10%	30%	5%	5%

Table 6. Weighting factors used for the development of the typical meteorological years for historic and future climate

DOI: 10.1002/bse

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Historic climate											
3.2371	2.5820	3.5492	3.4458	2.6304	2.4000	3.6287	2.9602	3.1059	4.0684	2.3279	3.2379
1984	1982	1977	1988	1984	1988	1977	1986	1977	1970	1965	1974
2.5232	3.0443	3.3555	2.9314	3.1291	3.1661	2.9129	3.6161	**2.5628**	3.9097	2.6612	2.5408
1964	1983	1976	1986	1977	1981	1967	1963	**1969**	1975	1969	1978
3.4405	2.8763	**2.3954**	3.4494	2.7303	3.2687	2.8282	2.8647	3.4863	3.8832	**1.8644**	**2.2017**
1972	1988	**1969**	1990	1966	1975	1974	1987	1967	1980	**1987**	**1971**
2.6263	2.9217	3.3276	3.3719	3.3759	2.8757	2.7767	**2.7039**	2.6516	3.0020	2.6280	2.3136
1961	1987	1963	1968	1979	1984	1985	**1964**	1975	1976	1961	1986
4.0935	**1.8709**	3.7459	**2.9051**	**2.6128**	**1.8589**	**2.4831**	3.5020	3.6046	**2.8898**	2.6772	4.5677
1978	**1973**	1982	**1976**	**1986**	**1990**	**1975**	1972	1963	**1965**	1968	1984
Future climate											
2.7317	3.1920	3.0589	**1.9417**	**1.7007**	3.0831	3.2969	**1.9610**	2.7650	**2.0328**	2.6879	4.0741
2047	2048	2025	**2045**	**2036**	2030	2040	**2036**	2041	**2046**	2031	2048
2.7038	4.2281	3.5996	4.5810	3.0275	2.8154	2.5816	2.9921	**2.0654**	2.1960	2.2300	3.3410
2039	2021	2034	2022	2041	2024	2033	2041	**2047**	2047	2044	2038
3.2718	4.2537	3.0287	2.4963	4.0578	2.6121	2.5964	3.8993	2.7687	2.4307	**1.9985**	3.1612
2025	2047	2036	2021	2046	2045	2039	2034	2027	2036	**2036**	2025
2.2027	**2.7438**	**3.0285**	3.6412	1.8015	2.8977	**2.3518**	2.7192	3.4011	2.0899	3.7143	**1.8509**
2036	**2040**	**2028**	2042	2050	2032	**2048**	2039	2028	2030	2049	**2024**
2.3067	3.1585	3.7659	2.8572	3.3510	**2.2411**	3.4347	2.5085	2.4827	4.1670	2.7890	2.6672
2048	2033	2031	2037	2039	**2042**	2025	2033	2023	2045	2024	2029

Table 7. Root mean square difference values for maximum temperature in historic and future climate and years selected per month

Figure 3 presents the monthly values of maximum temperature and relative humidity for the historic and future climate calculated from the corresponding daily values of the TMYs developed. On average, mean annual maximum temperature is expected to increase under the future climate by 1.4 °C compared with the historic climate. On a monthly basis, temperature increases are more pronounced during autumn periods and particularly in October, when the maximum temperature is projected to increase by 3.0 °C. During winter, spring and summer, maximum monthly temperature increases, on average, by 0.8, 1.5 and 1.5 °C, respectively. Changes of minimum and mean temperature between historic and future climate follow a similar profile, while minor changes are observed for the remaining parameters (e.g. relative humidity shown in Figure 3b).

Impacts of Climate Change on Product Sales

The empirical relationships developed using historic data in order to estimate the effect of weather conditions on the demand for bottled water and the other non-alcoholic beverages in question have been utilized to estimate the potential implications of future climate change for the level of product sales.

Table 8 presents the projected future monthly and annual changes in sales of bottled mineral water and other non-alcoholic beverages attributable to the anticipated climate change in Greece for the period 2021–50 compared to sales under the historic climate (1961–90). For all products examined, future climate (as simulated under the A1B global GHG emissions scenario) will result in an increase in annual sales of all products examined. Specifically, the total volume of sales is projected to increase by 1.1% for bottled mineral water, 2.9% for carbonated water, 1.2% for soft drinks and 3.1% for juices. On a seasonal basis, the most significant increases in demand are expected in autumn for bottled mineral water, carbonated water and soft drinks, and in spring for juices. On the other hand, the total volume of sales in summer seems to be less affected by climate change.

DOI: 10.1002/bse

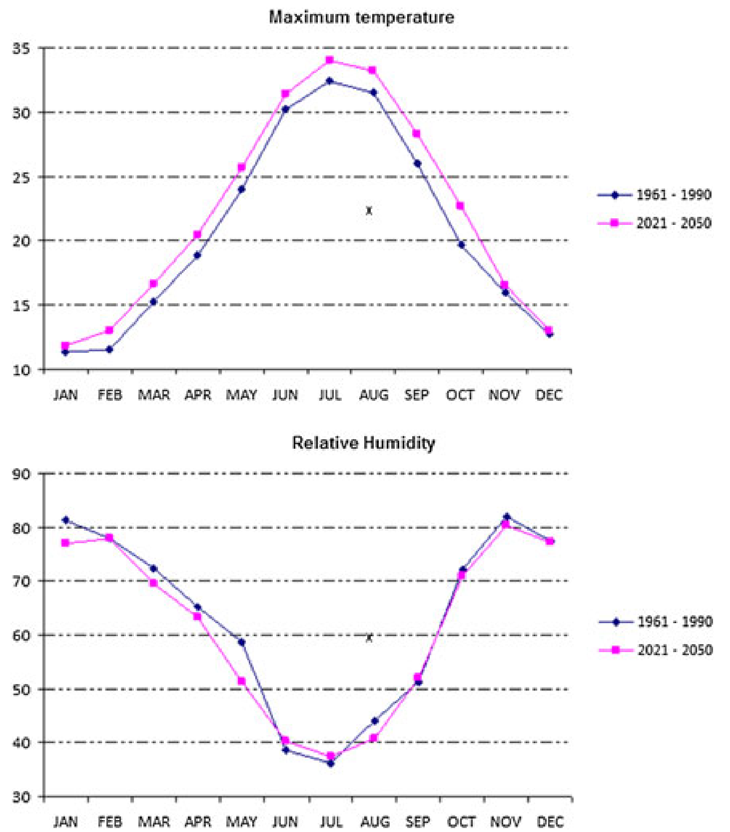

Figure 3. Monthly maximum temperature (a) and relative humidity (b) under historic and future climate on the basis of the typical meteorological year developed

Regarding the behavior of different product types, the results of the analysis show that the sales of bottled mineral water and soft drinks available in packages of less than 500 ml are most sensitive to weather conditions; this leads to a higher expected growth of sales under future climate than for larger packages of the same products. This trend can be explained by the fact that future climate is very likely to favor more outdoor activities, while the expected higher temperatures will increase the demand for bottled mineral water and soft drinks in individual packs. Consumption of bottled mineral water and soft dinks in family packages is also positively related to temperature increases, but to a lesser extent than individual packs. On the other hand, the increased sales of carbonated water under the future climate seem to be irrelevant to the type of packaging. Finally, sales of juices in family packs seem to be more sensitive to weather conditions compared with individual packs. As juice consumption mainly takes place within the home, future climatic conditions will result in increased consumption of juices mainly in the form of family packs.

Some Conclusions

In this study, the potential impacts of the upcoming climate change in 2021–50 on consumer goods sales, and specifically on the sales of bottled water and other non-alcoholic beverages, has been investigated and applied to Greece as a case study. To this end, a methodological framework was developed comprising demand equations derived from long-term existing data that incorporate economic, social and climate parameters, and a special purpose TMY for future and historic climate constructed from the outcome of a high-spatial-resolution regional climate model taking into account the significance of various meteorological parameters as per the demand equations. The use of special purpose TMY and the estimation of monthly values from the corresponding daily

DOI: 10.1002/bse

	Bottled mineral water			Carbonated water			Soft drinks			Juices		
	Total volume of sales	Sales in packs <500 ml	Sales in packs > 500 ml	Total volume of sales	Sales in packs < 500 ml	Sales in packs > 500 ml	Total volume of sales	Sales in packs < 500 ml	Sales in packs > 500 ml	Total volume of sales	Sales in packs < 500 ml	Sales in packs > 500 ml
Jan	0.8	1.0	0.7	2.1	2.2	2.1	0.7	1.6	0.5	2.6	1.2	3.1
Feb	2.0	2.5	1.8	5.3	5.8	5.4	2.1	3.0	1.8	5.0	3.1	5.2
Mar	1.4	1.8	1.2	3.7	4.0	3.7	1.4	2.4	1.2	4.0	2.2	4.4
Apr	1.3	1.6	1.1	3.4	3.7	3.4	1.3	2.2	1.1	3.5	2.0	3.9
May	1.1	1.4	1.0	2.9	3.1	2.9	0.9	2.7	0.7	4.2	1.7	5.3
Jun	0.7	0.9	0.6	1.8	1.9	1.8	0.9	0.6	0.7	1.2	1.1	0.9
Jul	0.8	1.0	0.7	2.1	2.2	2.1	1.0	0.9	0.8	1.6	1.2	1.4
Aug	0.9	1.1	0.8	2.3	2.5	2.3	0.8	1.9	0.7	3.0	1.4	3.7
Sep	1.3	1.7	1.2	3.6	3.9	3.6	1.6	1.9	1.3	3.2	2.1	3.3
Oct	2.3	2.9	2.0	6.2	6.7	6.3	2.6	3.6	2.1	6.0	3.6	6.4
Nov	0.6	0.8	0.6	1.6	1.8	1.7	0.6	1.1	0.5	1.8	1.0	2.0
Dec	0.4	0.5	0.4	1.1	1.2	1.1	0.4	0.6	0.4	1.0	0.6	1.1
Total	1.1	1.4	1.0	2.9	3.1	2.9	1.2	1.9	1.0	3.1	1.8	3.3

Table 8. Estimated percentage increase of sales of bottled mineral water and non-alcoholic beverages attributable solely to climate change under A1B scenario for the period 2021–50 compared with historic climate (i.e. 1961–90)

DOI: 10.1002/bse

figures rather than using average monthly values for the entire period under consideration also enhanced the accuracy of the results.

The results of the analysis clearly show that future sales for bottled water and non-alcoholic beverages in Greece for the period 2021–50 could increase considerably under the future warmer climate associated with the A1B global GHG emissions scenario of IPCC. Specifically, on an annual basis, the increase in the total sales volume attributed solely to climate was estimated at 1.1% for bottled mineral water, 2.9% for carbonated water, 1.2% for soft drinks and 3.1% for juices. It is also worth mentioning that for all products examined these changes are not seasonally uniform, and in some months exceed 6%. The increase is more pronounced in autumn and spring rather than summer, possibly because during summer the consumption of bottled water and non-alcoholic beverages is already high and therefore there is not much room for substantial further growth in sales. The expected rate of sales change depends also on the type of beverage packaging. Thus, the sales of bottled mineral water and soft drinks in smaller packaging (i.e. 330 ml cans) seem to be more weather-sensitive compared with family packs, while the opposite was found for juices. From the results of the analysis it is obvious that future climate change is expected to affect positively the demand for bottled mineral water and non-alcoholic beverages, creating new business opportunities. Compared with historic climate (1961–90), future warming in Greece during 2021–50 under the A1B global GHG emissions scenario is expected to average over 2 °C and could result in an increase due to solely climatic conditions of the present (2010) annual turnover by €3.0 million for bottled mineral water, €0.4 million for carbonated water, €6.8 million for soft drinks and € 8.5 million for juices.

A large number of retail sales as well as other commercial activities will be influenced, mostly adversely, by climate change. Others, such as the water and soft drinks industry, could be affected positively. It is important to continue examining and quantifying the effect of climate change in all business activities, above and beyond the clearly important ones of energy, if we want to provide better estimates of the impact in economic terms of climate change, to be juxtaposed with the cost of mitigation. To this end, it is important for enterprises and business associations to develop:

- capacity for understanding the diverse impacts of climate change on the economy at both micro- and macro-level. The identification of the climatic parameters that influence a specific activity, the nature of impacts, their severity, the temporal and spatial scale at which they will occur, the way they influence businesses (directly or indirectly), the uncertainties associated with climate research, etc., are important aspects that businesses need to understand before developing adaptation strategies as well as short-to-medium business plans.
- analytical historic data collection and recording capacity at company level and appropriate tools that will allow investigation of the potential impacts of climatic parameters on businesses in quantitative terms and at an appropriate level of analysis. In this context, the existence of short term or even daily data regarding the level of sales for different products per size of package, region of sale, etc., together with local meteorological parameters as well as other economic parameters (e.g. expenditures in advertising campaigns) could provide a sound basis for improving and taking advantage of models aiming at quantifying the influence of various parameters on the demand for the products in question. This could result in adjusting the levels of production for specific products, enhancing the stocks, implementing appropriate pricing policies, production of new products, etc.

Acknowledgement

The authors would like to thank the two (anonymous) Greek companies which provided the sales data for bottled mineral water and non-alcoholic beverages.

References

Agnew MD, Thornes JE. 1995. The weather sensitivity of the UK food retail and distribution industry. *Meteorological Applications* **2**: 137–147.

Argiriou A, Lykoudis S, Kontoyiannidis CA, Asimakopoulos D, Petrakis M, Kassomenos P. 1999. Comparison of methodologies for TMY generation using 20 years data for Athens, Greece. *Solar Energy* **66**(1): 33–45.

Bahng Y, Kincade D. 2012. The relationship between temperature and sales: Sales data analysis of a retailer of branded women's business wear. *International Journal of Retail & Distribution Management* **40**(6): 410–426.

DOI: 10.1002/bse

Beverage Council of Ireland [BCI]. 2009. The glass is half full - The 2009 Republic of Ireland Soft Drinks Market Review. BCI, Dublin, 40 p., available at: www.beveragecouncilofireland.ie

Blom J-E. 2009. Hedging revenues with weather derivatives - A literature review of weather derivatives & a case study of Ringnes AS. MSc. Thesis, Norges Handelshøyskole, Bergen, June, 114 p.

British Soft Drinks Association. 2008. A changing climate - The 2008 UK Soft Drinks Report. BSDA, London, 31 p., available at: www.britishsoftdrinks.com

British Soft Drinks Association. 2009. Trusted Innovation - The 2009 UK Soft Drinks Report. BSDA, London, 36 p., available at: www.britishsoftdrinks.com

CCSP. 2008. Climate Models: An Assessment of Strengths and Limitations. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Bader D.C., C. Covey, W.J. Gutowski Jr., I.M. Held, K.E. Kunkel, R.L. Miller, R.T. Tokmakian and M.H. Zhang (Authors)]. Department of Energy, Office of Biological and Environmental Research, Washington, D.C., USA

Dubé J-P. 2004. Multiple discreteness and product differentiation: demand for carbonated soft drinks. *Marketing Science* **23**(1): 66–81.

Hall I, Prairie R, Anderson H, Boes E. 1978. Generation of typical meteorological years for 26 SOLMET stations. SAND78-1601, Sandia National Laboratories, Albuquerque, NM.

Hansen J, Sato M, Ruedy R. 2012. Perception of climate change, PNAS early edition, 29 March 2012.

IPCC. 2000. *Special report on emissions scenarios. Intergovernmental Panel of Climate Change*. Cambridge University Press.

Jiang Y. 2010. Generation of typical meteorological year for different climates of China. *Energy* **35**: 1946–1953

Makridakis S, Wheelwright S, Hyndman R. 1998. *Forecasting methods and applications*, 3rd Edition. John Wiley & Sons Inc.: New York

Meijgaard E, Ulft B, Berg WJ, Bosveld FC, Hurk B, Lenderink G, Siebesma AP. 2008. The KNMI regional atmospheric climate model RACMO, version 2.1, KNMI technical report, TR-302.

Murray KB, Finn A, Leszczyc P, Di Muro F. 2010. The Effect of weather on consumer spending. *Journal of Retailing and Consumer Services* **17**: 512–520.

Pissimanis D, Karras G, Notaridu V, Garva K. 1988. The generation of a typical meteorological year for the city of Athens. *Solar Energy* **40**: 405–411.

Ramanathan U, Muyldermans L. 2010. Identifying demand factors for promotional planning and forecasting: A case of a soft drink company in the UK. *International Journal of Production Economics* **128**: 538–545.

Sawaqed NM, Zurigat YH, Al-Hinai, H. 2005. A step-by-step application of Sandia method in developing typical meteorological years for different locations in Oman. *International Journal of Energy Research* **29**: 723–737.

Skeiker K. 2007. Comparison of methodologies for TMY generation using 10 years data for Damascus, Syria. *Energy Conversion and Management* **48**: 2090–2102.

Steadman R. 1984. A universal scale of apparent temperature. *Journal of Climate and Applied Meteorology* **23**: 1674–1687.

Weather Trends International [WTI]. 2009. Identifying and Quantifying How Weather Influences Consumer Behavior. WTI, April, 13 p., available at: www.wxtrends.com/wp-content/uploads/2012/03/identify_and_quantify_weather_influences_on_human_behavior.pdf

Wedawatta G, Ingirige B, Jones K, Proverbs D. 2011. Extreme weather events and construction SMEs: vulnerability, impacts, and responses. *Structural Survey* **29**(2): 106–119.

Weinhofer G, Busch T. 2012. Corporate strategies for managing climate risks. *Business Strategy and the Environment*, Published online in Wiley Online Library. DOI: 10.1002/bse.1744

Winn M, Kirchgeorg M, Griffiths A, Linnenluecke M, Gunther E. 2011. Impacts from climate change on organizations: a conceptual foundation. *Business Strategy and the Environment* **20**: 157–173. DOI: 10.1002/bse.679

Xu J, Sun N. 2011. The impact of meteorological factors on manufacturing economy: a quantitative analysis based on trans-log production fuction. Paper presented in International Conference on Remote Sensing, Environment and Transportation Engineering (RSETE), 2011.