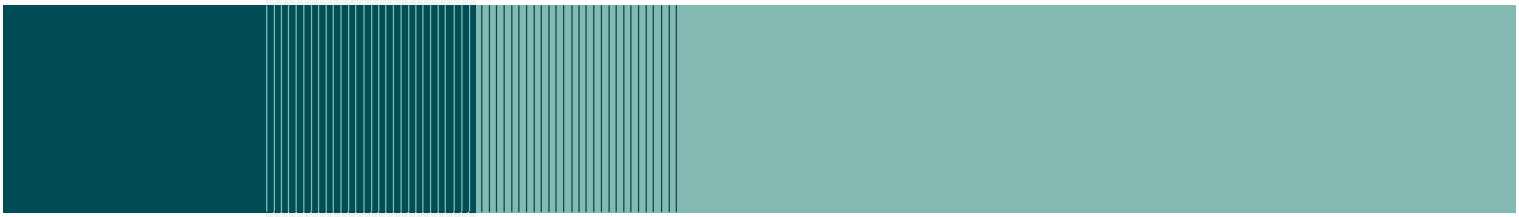
27 November 2007

Non-Residential Demand for Water in the Bristol Water Region

A Report for Bristol Water



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Contents

1. Introduction

This report presents forecasts of non-residential demand for water in the Bristol Water (BWL) area from April 2007 until April 2020. The methodology that we used to develop our water demand forecasts can be summarised as follows:

- We received annual consumption data for 26,754 BWL non-domestic customers for the period 2001 to 2007 (the sample period);
- We purchased historic macroeconomic (output and employment) activity data for the period 2001-2007 and forecast macroeconomic data for the period 2008-2020 from *Experian Business Services.* This data was provided to us at a detailed local authority level breakdown to enable us to analyse consumption and economic relationships more accurately*;*
- We obtained data on tariffs charged by BWL to non-domestic customers from Ofwat's annual publication '*Water and Sewerage Charges*' (various years);
- We divided BWL's non- domestic customer base into two distinct groups, the Sample and the Residual. The sample consists of all non-residential customers whose average consumption was greater than 5 M/l per year over the period 2001 to 2007 and the residual constitutes all other customers;
- We classified each of the sample customers by one of six industrial sector classifications;
- We excluded a number of customers from the sample dataset used to generate our final regression models where these customers had unusual consumption patterns. ;
- We attached price and macroeconomic activity variables to the annual consumption observations of each of the sample customers;
- We estimated dynamic regression models of water demand growth rates against price and macroeconomic activity variables and time trends specific to each industrial sector. The models were estimated using consumption data from customers included in the sample. We used data for the period 2001 to 2007 to estimate our models; and
- We used our regression models to forecast water demand over the period 2007-2020 (the forecast period). We produced individual forecasts for each customer within the sample and aggregate forecasts by industrial classification for the residual customers. We also produced separate forecasts for each of the customers excluded from the sample dataset.

The remainder of this report is structured as follows:

- Section 2 describes the data we have used in our analysis and the methodology we have adopted to generate the forecasts presented in this report;
- Section 3 presents our regression models; and
- Section 4 presents and discusses our forecasts for non-residential demand in the BWL area.

2. Data Issues

This section describes the data that we have we have used for our analysis. We have constructed two datasets: 1) the sample dataset which we use to estimate our regression models and to produce consumption forecasts for sample customers; and 2) the residual dataset which we use to produce consumption forecasts for residual customers.

2.1. Sample Dataset

We constructed the sample dataset by first identifying customers whose average consumption during the sample period was greater than 5M/l per year. Of the 26752 non-domestic customers for which we had consumption data 606 of these customers had average consumption of greater than 5M/l per year. The customers in the sample were then classified into one of six industrial classifications on the basis of their standard industrial classification (SIC) code. We also identified the local authority area where each customer was located on the basis of their postcodes. For each customer each year between 2001 and 2020 was assigned a macroeconomic activity value and a marginal price value. The sample dataset consists of:

- Annual consumption observations for each customer in the sample between 2001 and 2007;
- An industrial sector classification identifier for each customer in the sample;
- A local authority location identifier for each customer in the sample;
- An actual macroeconomic activity value for each customer in the sample for the years 2001-2007;
- A forecast macroeconomic activity variable for each customer in the sample for the years 2008-2020
- The actual marginal price faced by each customer in the sample for the year 2001-2007;
- A forecast marginal price that will be faced by each customer in the sample for the years 2008—2020.

We excluded a number of unusual consumption observations from the sample dataset where we felt that these would lead to bias in the regression models or the forecasts. After we had excluded these observations we had a complete sample dataset for 590 non-domestic customers.

Industrial Sector Classifications

We have grouped the sample customers into six industry sectors based upon their SIC code. The sector groupings are defined so that the customers within them have similar technology and processes. The sector classifications are:

1. Primary products and metals (SICs 1-15, 25-29);

2. Food, drink and tobacco (SICs 15-16);
3. Chemicals, oil and manufacturing (SICs 17-25, 29-37.2);
4. Public services (SICs 50-75,);
5. Other services (SICs 50-75, 90-99); and
6. Other sectors (SICs 40-45.5).

Macroeconomic activity

We purchased macroeconomic activity data from *Experian Business Strategies* (EBS). The dataset consisted of the value of real output in each local authority area either wholly or partly located in the BWL region. These local authorities are: Bath & North East Somerset, City of Bristol, Cotswold, Mendip, North Somerset, North Wiltshire, Sedgemoor, South Gloucestershire, South Somerset, Stroud and West Wiltshire. For each local authority area the EBS dataset provides a value for output and for employment for each of the following industrial categories:

Agriculture, Forestry & Fishing
Oil & Gas Extraction
Other Mining
Food, Drink & Tobacco
Textiles & Clothing
Wood & Wood Products
Paper, Printing & Publishing
Fuel Refining
Chemicals
Rubber & Plastics
Minerals
Metals
Machinery & Equipment
Electrical & Optical Equipment
Transport Equipment
Other Manufacturing
Gas, Electricity & Water
Construction
Wholesaling
Retailing
Hotels & Catering
Transport
Communications
Banking & Insurance
Business Services
Other F&Bs
Public Admin. & Defence
Education
Health
Other

We aggregated the EBS values so that for each local authority we have a figure for the value of output and the number of people employed that corresponds to the six industrial classifications that we use to classify customers in the sample. Each customer was assigned a macroeconomic activity variable for each year between 2001 and 2020 based on their industrial classification and on which local authority they are located in.

The values for the period 2001 to 2007 is actual data based on measured output and employment figures. The values for the period 2007 to 2020 are forecast values produced by EBS.

Prices

For each year of customer consumption data in the sample we assigned a marginal price per m^3 of water for each year between 2001 and 2020.

For the years 2001 to 2007 we sourced actual marginal prices from Ofwat's annual publication '*Water and Sewerage Charges*' (various years). Non-domestic customers face different marginal prices based on the volume of water they consume. We assigned marginal prices to each year of data for each sample customer on the basis of the volume of water that they consumed in that year.

For the years 2008 to 2020 we assumed that real price growth for each customer was equal to BWL annual K-factor (where one was available) or 1.5%. K factors are available for the remainder of the current regulatory control period. We chose 1.5% as a value for real price growth thereafter after discussions with BWL. The assumed average annual rate of real price growth that is implicit in our forecast is 1.2%. This compares with an average annual growth rate over the sample period of 3.5%.

Table 2.1
Real Price Growth Assumptions

Year	Assumed real price growth	Basis of assumption
2007/08	1.50%	K-Factor
2008/09	0.70%	K-Factor
2009/10	-2.30%	K-Factor
2010/11	1.50%	Assumption
2011/12	1.50%	Assumption
2012/13	1.50%	Assumption
2013/14	1.50%	Assumption
2014/15	1.50%	Assumption
2015/16	1.50%	Assumption
2016/17	1.50%	Assumption
2017/18	1.50%	Assumption
2018/19	1.50%	Assumption
2019/20	1.50%	Assumption

Excluded consumption data

Our guiding principle in deciding which consumption observations to exclude from the sample dataset was to keep in as much data as possible. In the estimation of the regression model the greater the number of consumption observations is in the sample the greater the

number of degrees of freedom will be available. The larger the number of degrees of freedom that are available the fewer constraints will be placed on the estimation of the regression models. Consequently the greater the number of consumption observations the more statistically robust the regression models will be.

In such a large dataset there are always likely to be a number of consumption observations which are unusual and extreme. We remove such observations from the dataset to minimise any bias in the estimation of the regression models. We discuss the issue of how unusual consumption observations may cause bias in the regression models further in Section 3.2.

Unusual consumption observations can also lead to forecasts that do not make intuitive sense. Given the regression model that we use to generate the forecasts this is particularly the case where the customers are large, and where the consumption observations suggest that there are very large increases or decreases in consumption between 2006 and 2007. We discuss how unusual consumption patterns of this type affect forecasts of consumption further in section 3.2.

We excluded unusual consumption observations from the sample dataset in two ways:

- Using a programmed rule to identify annual consumption data that was unusually high or low relative to other annual consumption data for a particular customer; and
- We examined the consumption data manually to identify customers with unusual consumption patterns.

We programmed a rule that excluded certain annual consumption observations. Consumption observations were excluded from the sample dataset if:

- The level of consumption by a customer in any year was 50% *higher* than it was in both the preceding *and* the following years; and
- The level of consumption by a customer in any year was 50% *lower* than it was in both the preceding *and* the following years.

Our manual examination of the consumption data was intended to identify consumption patterns that were unusual and which had a significant impact on the estimation of the regression models and generation of forecasts.

After undertaking these procedures we exclude 16 customers from the original sample. Details of these customers can be found in Appendix A. We obtain separate forecasts for each of these customers.

Final sample

After the exclusion from the sample of unusual consumption observations the final sample is reduced from 606 customers to 590 customers. These 590 customers account for 48% of total non-domestic water consumption in 2007.

2.2. Residual Dataset

The residual dataset comprises all customers whose consumption averaged less than 5M/l per year during the period 2001-2007 plus the aggregate consumption of the excluded customers. We do not use consumption data from the residual customers to estimate our regression models. We use our regression models to forecast consumption for the residual customers over the period 2008 to 2020. To achieve generate these forecasts we constructed a dataset for the residual customers that consisted of:

- Total consumption by residual customers by industrial sector classification in 2007;
- Actual aggregate macroeconomic activity for each industrial sector for 2007;
- Forecast macroeconomic activity values for each industrial sector for the period 2008 – 2020;
- Actual marginal prices for the period 2001 to 2007; and
- Forecast marginal prices for residual customers for the period 2008 -2007.

To determine the total consumption for residual customers by sector we first aggregated consumption by all residual customers for whom we had SIC code data by industrial sector classification. We only had data on the SIC codes of approximately 60% of the residual customers. We assumed that the consumption of the remaining 40% of customers was distributed between industrial sectors in exactly the same way as it was for the 60% of customers for whom we knew SIC codes. This assumption allowed us to arrive at an aggregate figure for consumption by industrial sector for all residual customers.

The forecast macroeconomic activity values for industrial sectors for the whole BWL region were taken from the EBS dataset.

All customers in the residual have average consumption of below 5M/l per year during the sample period therefore the marginal price they faced in 2007 was assumed to be the standard volumetric change per m^3 published in the 2006/07 edition of the Ofwat '*Water and Sewerage Charges Report*'. The forecast marginal prices for the period 2008-2020 were obtained by applying the same real price growth assumptions outlined in Table 2.1 to the 2007 prices.

3. Estimation of Regression Models

3.1. Baseline Forecasting Model

We use regressions of historic consumption by the sample customers on a number of explanatory variables as the basis for our water demand forecasts. The baseline model for our demand forecasts is:

$$\log C_{it} = a \log C_{it-1} + b \log X_{it} + g \log P_{it} + s_{jt} t + e_{it}$$

where

C_{it} is the consumption of customer i in year t;

X_{it} is an index of economic activity of customer i in year t;

P_{it} is an index of the real marginal volumetric tariff paid by customer i in year t;

σ_{jt} is a time trend in consumption for customers in group j at time t; and

ε_{it} is an error term.

In this model non-domestic water consumption is a function of consumption in the previous year (lagged consumption), macroeconomic activity, price, and a time trend. This set of variables are the 'explanatory variables'.

The technique that we use to estimate our regression models requires that the growth rate or differences in these variables are used. The basic equation that we use to estimate our regression models is:

$$\Delta \log C_{it} = a \Delta \log C_{it-1} + b \Delta \log X_{it} + g \Delta \log P_{it} + s + n_{it}$$ [1]

A more detailed presentation of this model and our econometric technique for estimating it is given in Appendix D.

We include an economic activity variable and a marginal price variable as explanatory factors in the models as this is consistent with the economic theory.[2] Ideally we would have an economic activity variable that was specific to each customer as our economic activity variable, however because of data constraints we use a macroeconomic activity variable at a local level. We would expect there to be a positive relationship between water consumption and macroeconomic activity and a negative relationship between consumption and price.

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[1] Δ indicates that we are using a change or difference in the variable, for example $\Delta \log C_{it} = \log C_{it} - \log C_{it-1t}$.

[2] A detailed description of how the economic theory of production and input demand applies to demand for water by commercial and industrial customers can be found in chapter 4 of Renzetti (2002): 'The Economics of Water Demand', Kluwer Academic Publishers.

In the model we include lagged consumption as an explanatory factor since there is likely to be a degree of persistence in customers' consumption. That is, consumption in the current year for a given customer is likely to be influenced by their consumption in the previous year.

We include an underlying time trend in this model, which we allow to be different across groups of customers. The time trend effectively captures regularities over time in underlying water use behaviour by specified groups once the affects of macroeconomic activity and price have been taken into account.

The regression models estimate how consumption by non-domestic customers varies with the explanatory variables. Values of α, ß , γ and σ (the regression coefficients) are estimated by our regression models. The specification of the model means that α, ß and γ can be interpreted as elasticities[3] whereas σ can be interpreted as a growth rate.[4]

3.2. Empirical Issues

Treatment of unusual consumption observations

In section 2.1 we discuss our process for removing unusual consumption observations from the sample dataset. In this section we discuss the empirical issues raised by the unusual consumption observations.

Unusual consumption observations can lead to bias in the estimation of the regression models. Where there are large changes in consumption by customers and these changes are spuriously related to changes in the explanatory variables then this can upwardly or downwardly bias the estimated regression coefficients.

In some cases unusual consumption observations can result in unrealistic consumption forecasts. This problem occurs mainly when there are large customers who experience very large increases or decreases in demand between 2006 and 2007. It occurs because (as we outlined in section 3.1) our regression model assumes that a change in annual consumption is dependent on the change in lagged consumption. For example the regression model assumes that the change in consumption for a customer between 2004 and 2005 is dependent on the change in the customers' consumption between 2003 and 2004. When we use our regression model to forecast consumption for individual customers in the sample this means that the forecast change in consumption for a customer between 2007 and 2008 is dependent on the change in consumption that customer experienced between 2006 and 2007. Similarly, forecasts changes for 2008-2009 depend on forecast changes for 2007-2008 and so on. Therefore the change in consumption experienced by a customer between 2006 and 2006 will influence the annual forecast for that customer for the entire forecast period.[5] If the customer

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[3] In this context these values can be interpreted as the percentage increase in water consumption that results from a one percent change in either lagged consumption, economic activity or marginal price.

[4] The coefficient on a time trend for a specific group of customers can be interpreted as the underlying growth rate in consumption by those customers once output and price effects have been taken into account. The growth rate represents the annual percentage change.

[5] Changes in consumption before 2006/07 will not affect the forecast because the specification of our regression model imposes the restriction that water consumption is dependent on only one lagged difference in consumption.

is a very large customer then these extreme consumption observations can have a significant affect on the overall forecasts.

Customers that are excluded from the sample due to unusual consumption patterns are described in Appendix A. Forecasts for these customers are derived using sector trends from the regression model.

Treatment of residual customers

The sample of customers in the dataset we use to estimate our regression models does not contain all those that contribute to total non-residential water use. We do not use data from all non-domestic customers to estimate our regression models. We outline our reasons for this below.

We consider consumption by small non-residential water customers to be significantly more volatile (proportionately) than consumption by larger customers. Furthermore, we consider that consumption by smaller customers is likely to vary more with idiosyncratic factors that are not captured by the explanatory variables than is the case with large customers. However, if this variation in consumption by small customers is spuriously correlated with the explanatory factors then including small customers in the regression models could bias the estimates of the regression coefficients. We find that more reliable estimates of the regression coefficients can be obtained using data from large customers only.

We choose the cut off point between those customer that we include in the sample ("large customers") and those customers that we include in the residual ("small customers") to ensure that we have sufficient numbers of consumption observations in our dataset to ensure that our regression model are statistically robust. We also have to balance the need for statistical robustness with the potential effect that the increased volatility of smaller customers on the estimates of our regression model. We have used a cut off point of average consumption of 5M/l between 2001 and 2007 for inclusion in our sample.

Treatment of large customers

We identify a group of large customers within the sample. We define a 'large' customer as being one whose average consumption over the sample period is greater than 100 ML per year. We identify large customers so that we are able to capture potential scale effects within our regression models.

Within the sample there are 16 customers who satisfy our definition of a large customer. In 2007 these 16 customers accounted for 25% of the total water consumption of the sample customers. In Table 3.1 below consumption by large customers in 2006 is presented disaggregated by sector.

Table 3.1
2006 Water Consumption by Large Customers Disaggregated by Sector

Sector	Total 2006 consumption of large customers (M/l)	Percentage of total 2006 sector consumption by sample customers
Primary products and metals	882.46	36.30%
Food, drink and Tobacco	260.13	37.00%
Chemicals and oil refining and other manufacturing	136.26	15.98%
Public services	170.59	7.80%
Other services	799.23	19.01%
Other sectors	330.05	58.85%

3.3. Estimation of Model

Model specification

In Table 3.2 below, we present the econometric models that we used to forecast water consumption in the Bristol Water area. We present two models, both of which were estimated using consumption data from the sample of 590 large non-household customers.

Model A models historic water consumption as a function of customer consumption in the previous year, a macroeconomic activity variable[6], marginal price, a sector specific time trend and an additional sector specific time trend that applies to customers who have average consumption of greater than 100Ml per year over the period 2001-2007. This model is applied to the consumption of all of the customers included in the sample to produce forecasts for each customer in the sample.

Model B models historic water consumption as a function of customer consumption in the previous year, a macroeconomic activity variable[7], marginal price, and a sector specific time trend. This model is applied to the aggregate sector consumption of all of the customers included in the residual to produce aggregate sector forecasts for these customers. The model does not include time trends for large customers because there are no large customers included in the residual consumption.

Model estimation

Our regression models provide us with estimates of the relationship between the explanatory variables and water consumption. We present these estimates in Table 3.2. The coefficients for lagged consumption, macroeconomic activity and price presented in Table 3.2 can be interpreted as elasticities (i.e. they indicate the percentage change in water consumption that will occur given a one percentage change in the relevant explanatory variable). The

[6] The macroeconomic activity variable is the value of output for a customer's industrial sector classification in the local authority area in which the customer is located.

[7] The macroeconomic activity variable is the value of output for a customer's industrial sector classification in the local authority area in which the customer is located.

coefficients on the time trends can be interpreted as annual growth rates.[8] We use separate models to forecast water demand for the sample and for the residual customers.

Table 3.2
Econometric Models of Historic Water Consumption

	Model A: Sample Model			Model B: Residual Model	
	Coefficient	Probability that coefficient is zero		Coefficient	Probability that coefficient is zero
Consumption in previous year	0.38	0.00		0.41	0.00
Macroeconomic activity	0.19	0.17		0.19	0.20
Marginal price	-0.24	0.04		-0.24	0.05
trend sector 1	-0.06	0.11		-0.05	0.15
trend sector 2	-0.05	0.21		-0.04	0.35
trend sector 3	-0.07	0.09		-0.06	0.10
trend sector 4	-0.06	0.13		-0.05	0.19
trend sector 5	-0.08	0.03		-0.07	0.04
trend large sector 1	-0.06	0.19			
trend large sector 2	0.00	0.95			
trend large sector 3	-0.30	0.00			
trend large sector 4	-0.06	0.25			
trend large sector 5	-0.05	0.15			
trend large sector 6	-0.12	0.00			
constant	0.05	0.14		0.04	0.22

Source: NERA Analysis

The results from the econometric models indicate that:

- Output elasticity is 0.19 suggesting that an increase in the rate of growth in output will tend to have a positive, but proportionately lower, effect on the rate of growth of water consumption;

[8] However, the raw coefficient cannot of itself be taken to be the growth rate as the constant term must be taken into account. We present the actual growth rates in Table 3.3.

- Real price elasticity is -0.24 suggesting that an increase in the rate of growth in real prices will tend to have a negative, but proportionately lower, effect on the rate of growth of water consumption;

- Water consumption by a customer in any given year is strongly dependent on consumption in the previous year. The implication of this is that for our consumption forecasts the changes in consumption between 2006 and 2007 will have an impact forecast consumption, particularly in the short term; and

- The underlying trends in consumption over time have generally been negative with the trends tending to be more negative for large customers. We present the underlying growth rates in water consumption implied by the coefficient estimates from our regression model in Table 3.3.

Table 3.3
Implied Underlying Growth Rates in Water Consumption

Sector	Model A (customers with average consumption of less than 100M/l)	Model A (customers with average consumption of more than 100M/l)	Model B
1	-0.53%	-6.71%	-0.84%
2	0.19%	0.36%	0.40%
3	-1.33%	-31.49%	-1.96%
4	-0.43%	-6.23%	-0.55%
5	-2.65%	-7.65%	-2.81%
6	5.33%	-6.63%	3.99%

The estimated values of price elasticity and output elasticity produced by our regression models are within the range of values for the elasticity of water consumption with respect to price contained with the published literature.

We would expect water consumption in any year to be strongly dependent on water consumption in the previous year. This is because the ability of customers to change their consumption is constrained by decisions that they have made in the past.

The aggregate consumption data for the Bristol Water region shows that consumption by non-domestic customers in the Bristol Water region has generally been declining, especially since 2004. We would expect this to be reflected in the estimated sector trends from our regression models. The main exception to this general trend has been sector 6 ('Other Sectors') where the consumption trend over time (for customers with average consumption of less that 100M/l per year) has been positive.

Sensitivity testing

We subject the model specifications that are presented in Table 3.2 to a number of sensitivity checks. In particular we looked at:

- A model specification that allowed for sector specific real price and output elasticities;
- A model specification which allowed for real price and output elasticities that were specific to large customers; and
- A model specification with a narrower group of time trends. We excluded from our model the sector specific time trends that applied only to large customers, instead we included only a single large customer time trend.

Our approach to determining the final specification of the regression models followed the general principle of starting with a general model and working towards a more specific model. We started with a very general model specification (i.e. including a wide range of variables to allow all important effects to be identified) and then we worked towards a more specific model (i.e. one with fewer variables but which captures the only the important effects).

The criteria that we used to decide upon of final forecasting model were statistical validity and an intuitive economic sense check. Statistical validity criteria involved checking the overall performance of regression models and individual coefficient estimates against standard tests for statistical significance. Where models demonstrated similar statistical validity we applied a parsimony criteria, where fewer variables were preferred to more variables, this criteria is based upon the fact that statistical theory suggests that the fewer coefficients that are estimated with a given set of data the more certain the estimates will be. The other important criterion was that the specification of the forecasting model must conform with economic theory.

Using the above criteria we selected the specification of the forecasting equations presented in Table 3.2. We also examined the level of consumption predicted by model specifications that we rejected using our criteria and found that there was limited variation in the forecast levels of water consumption between models. We are, therefore, confident that our model specification contains the real price, macroeconomic activity and time trend variables that are the important influences on non-residential water consumption.

4. Demand Forecasts

This section presents our forecasts for non-residential water use in the BWL area.

In section 4.1 we explain how we generate the forecasts. In section 4.2 we present our overall projections for total non-residential consumption. In section 4.3 we examine in detail our forecasts for each industrial sector for customers included in the sample. In section 4.4 we present our forecasts of consumption for customers included in the residual.

We present tables containing all of the forecast data in Appendix B.

4.1. Forecasting methodology

We produce our forecasts using the regression models presented in section 3.3 and forecast values of the explanatory variables. The regression models estimate the relationship between annual changes in water consumption and annual changes in the explanatory variables between 2001 and 2007. As we explain in section 2 we have constructed a dataset that includes forecast values of the explanatory variables over the period 2008 to 2020. Our forecasts assume that the relationship between changes in water consumption and explanatory variables between 2008 and 2020 will be as it was between 2001 and 2007. On this basis we use the forecast values of the explanatory variables to generate a forecast of water consumption during the period 2008 to 2020.

As we explain in section 3.2 our regression models are estimated using data only from customers whose average consumption is greater than 5M/l between 2001 and 2007. This allows us to obtain the best estimates of the relationship between consumption and the explanatory variables in the BWL region. In obtaining the residual forecast we are therefore applying coefficient estimates obtained in regressions on data from only large customers to generate forecasts for small customers After estimating the regression models we are confident that we have obtained robust estimates of the elasticity of non-domestic water consumption in the BWL region with respect to lagged consumption, real price and output. Given that these are the best estimates of these values that can be obtained given the data then we are confident that we can use these values to generate reasonable forecasts for residual customers.

We did not apply the underlying sector time trends consumption to generate the forecasts for the residual customers. This is because there is a marked contrast in recent trends in consumption growth between customers included in the sample and the consumption growth of residual customers. This is demonstrated in Table 4.1 below

Table 4.1
Growth Rates in Water Consumption Between 2004-2007

Sector	Sample customers average annual consumption growth	Residual customers average annual consumption growth
1	-1.02%	-1.30%
2	-0.90%	-2.86%
3	-6.30%	1.62%
4	-3.13%	0.10%
5	-3.49%	0.24%
6	-3.52%	-0.94

Table 4.1 shows that aggregate sector consumption growth for sample customers between 2004 and 2007 has been significantly different from consumption growth for residual customers. In general the consumption growth of sample customers has been significantly more negative than that of residual customers. This negative growth amongst sample customers is reflected in the estimated time trends from the regression models. However if we were to use these time trends to generate forecasts for residual customers they would be underpinned by a significant underlying negative growth rate that would seem unlikely to be realised. Consequently when we generate our residual customer forecasts we do not use the time trends from the regression model. We generate these forecasts using only our estimates of the elasticity of lagged consumption, price and output and the forecast values of price and output.

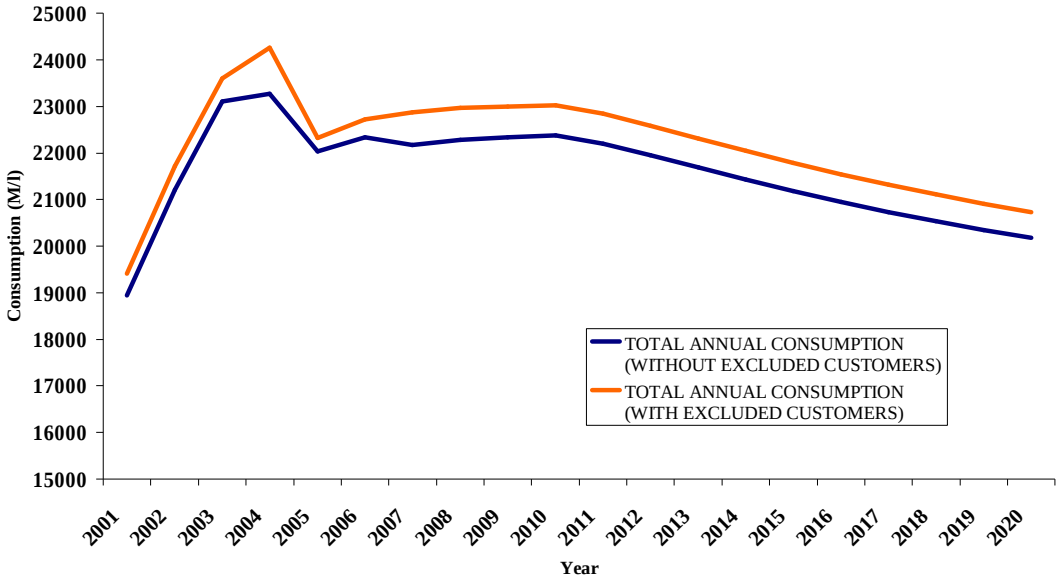
As we discuss in section 3.2 a number of customers are excluded from the sample because they have extreme consumption patterns which leads to bias in our regression models and/or unrealistic consumption forecasts. The consumption of a number of the excluded customers exhibits a very large increase or decrease in consumption between 2006 and 2008. The dynamic specification of our regression model means that this pattern of consumption can adversely affect the forecasts for these customers if we use our full regression model to obtain the forecasts. Instead of applying the full regression model to obtaining forecasts for the excluded customers we produce forecasts of future consumption by these customers by assuming that their consumption will grow over the period 2008 to 2020 at a rate equal to the time trend corresponding to their industrial sector classification from regression model A.

4.2. Overall Demand Projections for Bristol Water

Figure 4.1 displays the projected consumption path for total consumption by all non-domestic customers in the Bristol Water region. There are two total consumption forecasts presented, one takes into account the separate forecasts that we generated for customers who were excluded from the sample and one does not.

Figure 4.1

Total Non-domestic Water Consumption in the Bristol Water Region



In the remainder in this section we describe our consumption forecasts in the context of recent aggregate trends both in water consumption and in the explanatory variables.[9] We also explain our forecast with reference to the estimated coefficients from our regression models and to predicted changes in the explanatory variables over the period 2007 to 2020.

Over the period 2004 to 2007 total consumption in the BWL region fell from 24265.42 M/l to 22869.56 M/l at an average growth rate of -1.96% per year. Between 2006 and 2007 consumption increased by 0.66%. Between 2004 and 2007 the value of output in the region increased by 2.69% per year and real prices grew at an average rate of 3.5%.

During the period 2007 to 2020 output is forecast to grow by 3.45% and real prices to grow at 1.22%. Our forecast assumes that for customers in the sample, in addition to output and real price effects, there will be an underlying time trend in their water consumption based on the customers' industrial classification and size.

As we discussed in section 3 we would expect the rate of growth in consumption between 2006 and 2007 to have an impact on the forecast change in consumption between 2007 and 2008. Increases in output growth will have a positive effect on forecast consumption growth. Contrastingly increases in real price growth would be expected to have a negative effect on consumption growth. As the values in Table 3.3 indicate the time trends estimated by our regression models can be expected to have a generally negative effect on water consumption over time.

[9] Our examination of aggregate trends focuses on the period after 2004 because before this year aggregate consumption figures are distorted because there are a smaller number of consumption observations.

Water consumption is forecast to grow by 0.23% per year between 2007 and 2010. This forecast short spell of consumption growth can be attributed to a continuation of the short term trend of growth between 2006 and 2007.

Over the full forecast period to 2020, water consumption is forecast to decline by -0.75% per year. This is a continuation of the trend over the sample period. This forecast rate of growth is lower than the recent trend which is consistent with higher rate of forecast output growth and lower rate of forecast real price growth over the period 2008 to 2020 than occurred during the period 2004 to 2007.

4.3. Demand Forecasts for Sample Customers by Sector

In this section we present consumption forecasts for non-domestic customers included in the sample by industrial sector.

4.3.1. Primary Products and Metals – Sample Customer Forecast

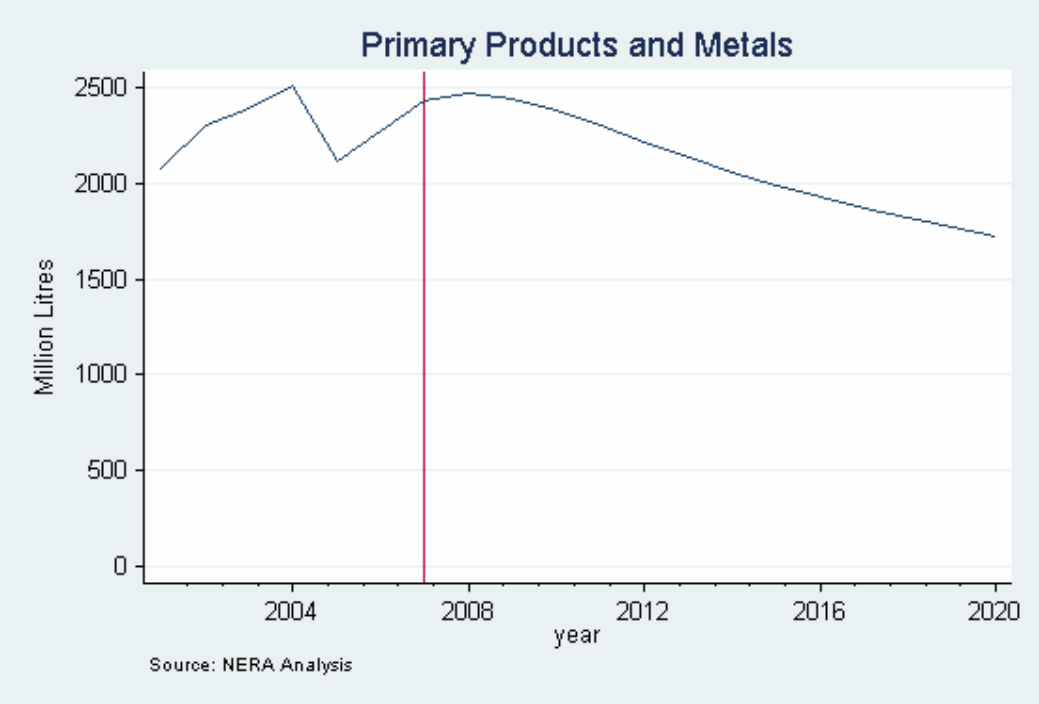


Table 4.2
Primary, Products and Metals
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-1.02%	0.39%	3.50%
Forecast: 2007-2020	-2.53%	0.38%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being in the primary products and metals industrial sector declined by 1.02% per year. Between 2006 and 2007 water consumption in this sector increased by 7.1%, the vast majority of which can be attributed to a substantial increase in consumption by Chanson Foods. If the consumption of Chanson Foods is excluded from the figures then water consumption declined at a rate of 3.85% per year between 2004 and 2007. During this period real prices were increasing by 3.5% per year on average and output was increasing by 0.39% per year.

The decline in water consumption in this sector (excluding Chanson Foods) over the period 2004 to 2007 was strongly negative and consistent with this our regression model identifies a negative underlying trend in consumption once price and output affects have been taken into account.

Between 2007 and 2008 water consumption by sample customers in this sector is forecast to increase by 1.8% before declining throughout the rest of the forecast period. Over the whole forecast period water consumption is forecast to fall by 2.53% per year. The short term increase in consumption is a result of the substantial change in consumption at Chanson foods between 2006 and 2007 being projected forward into the forecast change in consumption between 2007 and 2008. Over the course of the period 2008 to 2020 the strong negative underlying trend in consumption is forecast to continue.

4.3.2. Food, Drink and Tobacco – Sample Customer Forecast

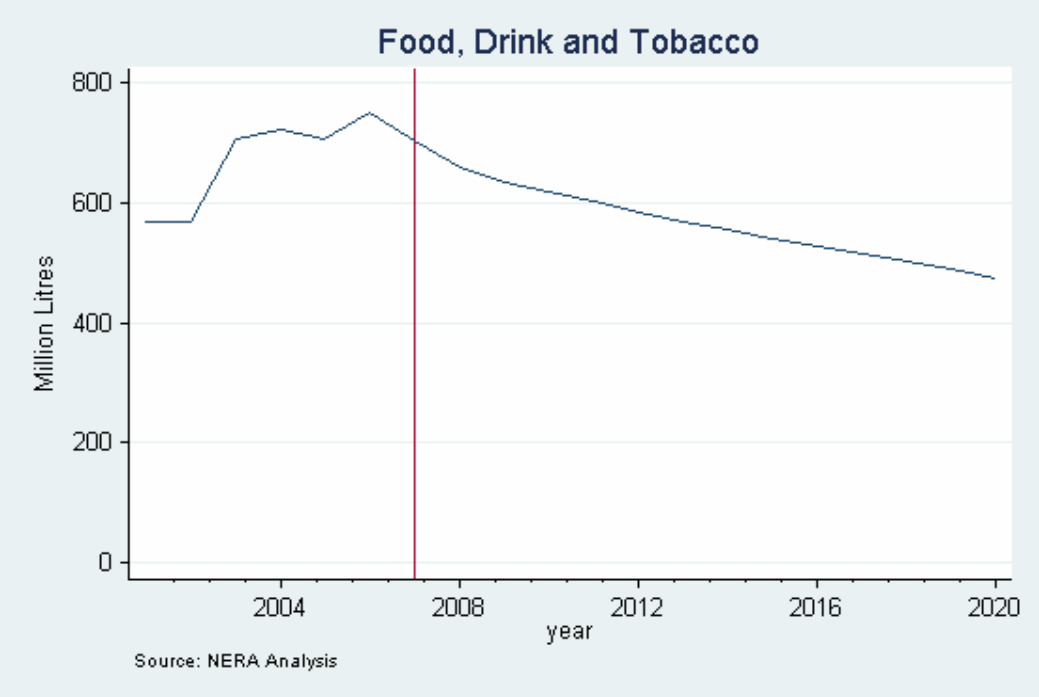


Table 4.3
Food, Drink and Tobacco
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-0.90%	-4.19%	3.50%
Forecast: 2007-2020	-2.25%	-3.58%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being in the food, drink and tobacco sector declined by 0.9% per year. Between 2006 and 2007 water consumption in this sector declined by 6.12%. During this period real prices were increasing by 3.5% per year on average and output was declining by 4.19% per year. In the case of this sector the trend in output between 2004 and 2007 is slightly misleading in terms of the output trend over the full sample period. Between 2001 and 2007 output declined at a rate of 1.9% per year.

The decline in water consumption in this sector over this period was slightly negative and explained largely by negative output growth and positive real price growth. Consequently our regression model estimates a slight positive underlying time trend in consumption in this sector.

Over the period 2007 to 2020 output growth in this sector is forecast to be -3.58% whilst real prices are forecast to grow at 1.22%. Output growth is forecast to be more strongly negative towards the end of the forecast period with growth predicted to be -4.74% between 2015 and 2020.

Between 2007 and 2008 water consumption by sample customers in this sector is forecast decrease by 2.25% per year. This rate of decline is greater than during the period 2004 to 2007. The increase in the rate of consumption decline can be attributed to: 1) the short run impact of the substantial fall in consumption between 2006 and 2007; and 2) the forecast greater rate of output decline in the sector between 2007 and 2008 (compared with the whole sample period).

4.3.3. Chemical, Oil Refining and Other Manufacturing – Sample Customer Forecast

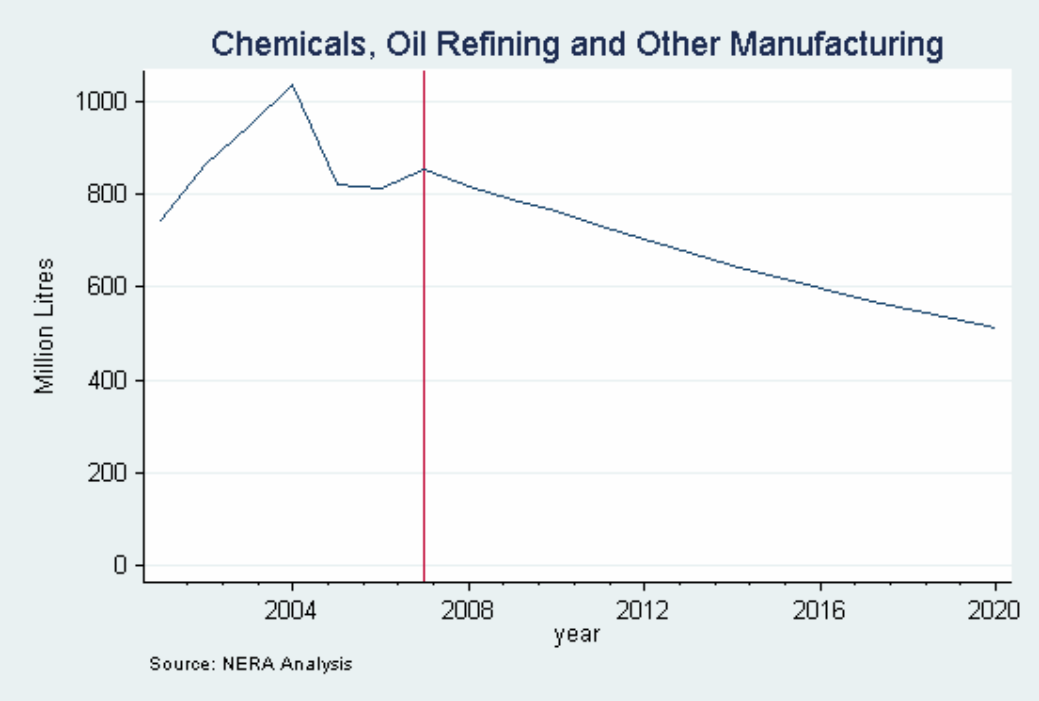


Table 4.4
Chemicals, Oil Refining and Other Manufacturing

Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-6.30%	-2.58%	3.50%
Forecast: 2007-2020	-3.45%	1.67%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being in the chemicals, oil refining and other manufacturing industrial sector declined by 6.30% per year. Between 2006 and 2007 water consumption in this sector increased by 5.0%. During this period real prices were increasing by 3.5% per year on average and output was decreasing by 2.58% per year.

The decline in water consumption in this sector over the period 2004 to 2007 was strongly negative and consistent with this our regression model identifies a negative underlying trend in consumption once price and output affects have been taken into account.

Over the period 2007 to 2020 real price growth is forecast to be 1.22% per year and output growth is forecast to be 1.67% per year.

Between 2007 and 2020 water consumption by sample customers in this sector is forecast to decrease by an average of 3.45% throughout the rest of the forecast period. Growth in water consumption in this sector is forecast to continue to be negative but the rate of growth will be less negative than was observed during the period 2004 to 2007. The reasons for this are: 1) positive output growth is forecast in this sector in contrast with an observed decline in output over the period 2004-2007; and 2) price growth over the forecast period is predicted to be lower than it was during the period 2004 to 2007.

4.3.4. Public Services – Sample Customer Forecast

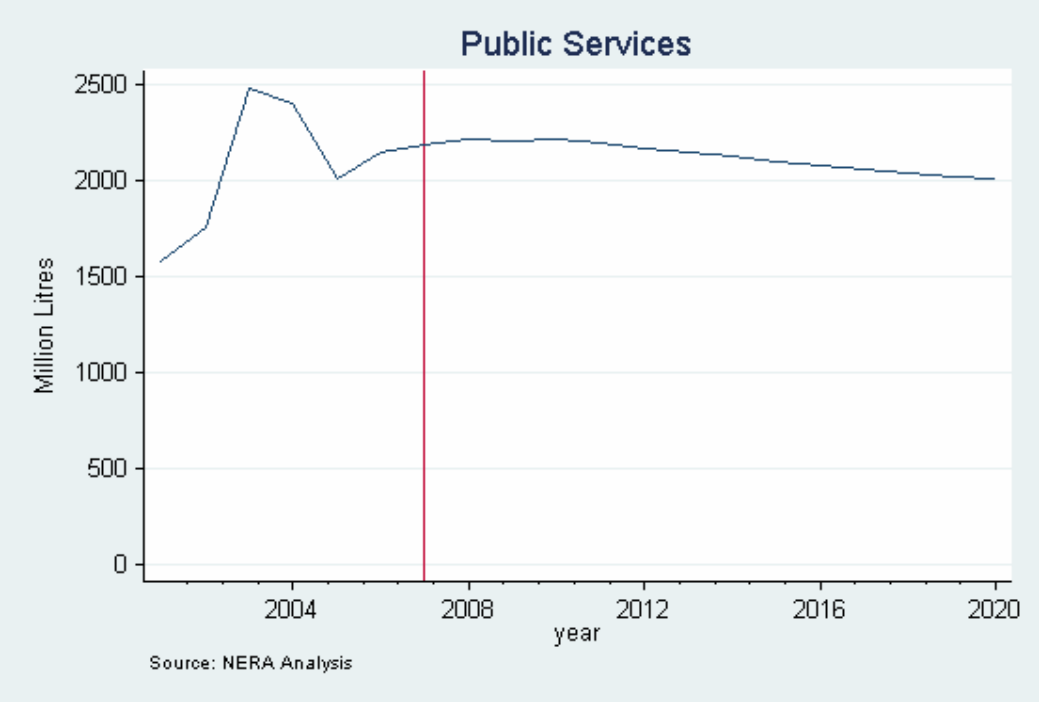


Table 4.5
Public Services
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-3.13%	2.05%	3.50%
Forecast: 2007-2020	-0.68%	1.60%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being in the public services industrial sector declined by 3.13% per year. However, this rate of decline is significantly exaggerated by a very large decline in consumption at one Ministry of Defence site. If data from this site is excluded there was actually a slight rise in consumption during

the period 2004 to 2007. Between 2004 and 2007 real prices were increasing by 3.5% per year on average and output was increasing by 2.05% per year.

Over the period 2007 to 2020 real price growth is forecast to be 1.22% per year and output growth is forecast to be 1.60% per year.

Over the whole period 2007 and 2020 water consumption by sample customers in this sector is forecast to decline slightly by 0.68%. This forecast decline is a consequence of the lower output growth predicted in this sector (compared with 2004-2007) and the negative underlying time trend.

4.3.5. Other Services – Sample Customer Forecast

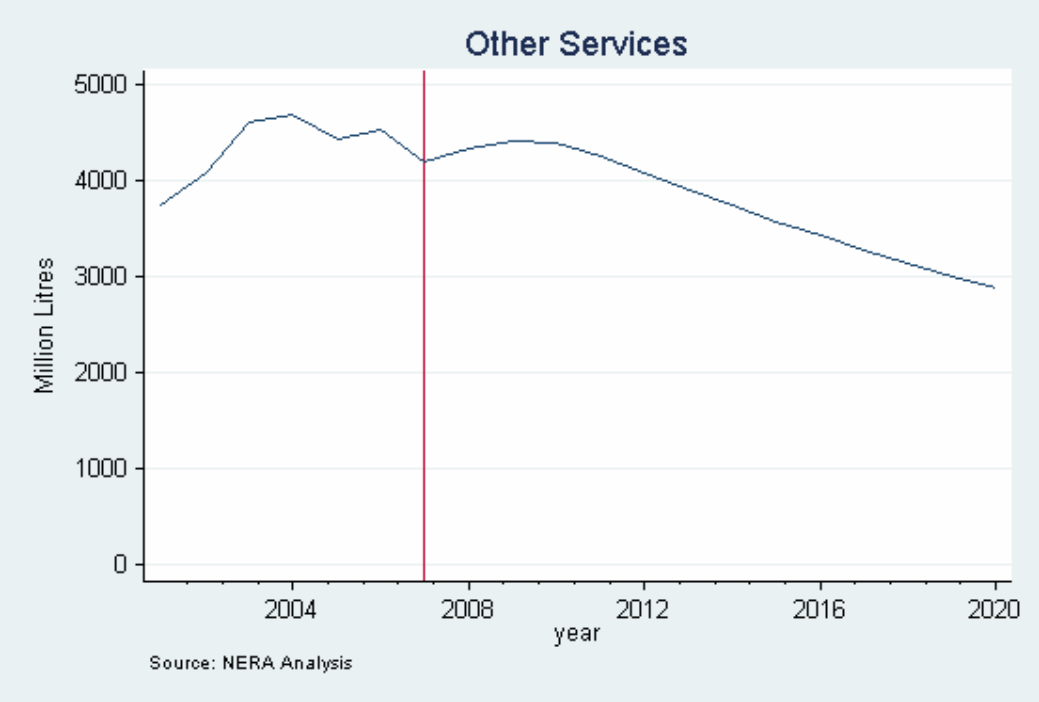


Table 4.6
Other Services
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-3.49%	3.86%	3.50%
Forecast: 2007-2020	-2.79%	3.95%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being in the other services industrial sector declined by 3.49% per year. Between 2006 and 2007 the average growth rate in consumption amongst customers in this sector consumption was

2.1%.[10] Between 2006 and 2007 real prices were increasing by 3.5% per year on average and output in this sector was increasing by 3.86% per year.

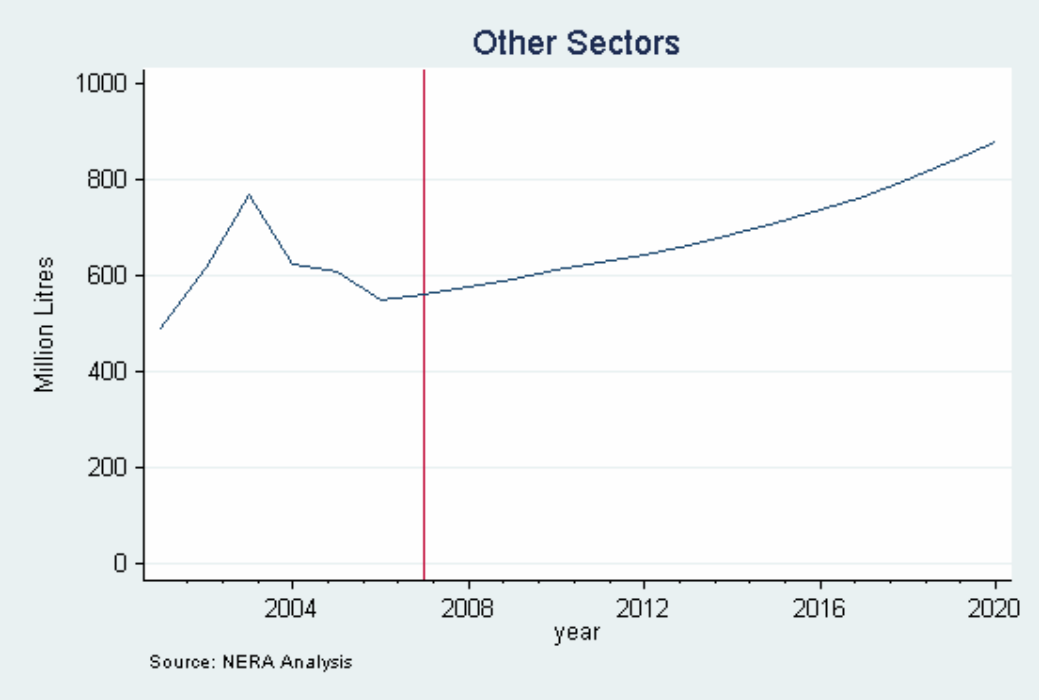
The decline in water consumption in this sector over the period 2004 to 2007 was strongly negative despite strong output growth. Our regression model identifies a negative underlying trend in consumption once price and output affects have been taken into account.

Over the period 2007 to 2020 real price growth is forecast to be 1.22% per year and output growth is forecast to be 3.95% per year.

Between 2007 and 2010 water consumption by sample customers in this sector is forecast to increase by 2.79% per year. Water consumption is forecast to increase in the short term as a consequence on the short term increases in consumption experienced by most of the customers in this sector between 2006 and 2007. Output is forecast to grow at a similar rate to the period 2004 to 2007 and real price growth is forecast to be lower than during 2004-2007.

Over the whole forecast period water consumption is forecast to decline at an average annual rate of 2.79%. The rate of growth in consumption is forecast to be slightly less negative than the rate observed between 2004 and 2007. This can be attributed in part to the forecast of lower real price growth.

4.3.6. Other Sectors – Sample Customer Forecast



[10] This calculation excluded data from Royal Insurance which experienced a very large decline in consumption between 2006 and 2007.

Table 4.7
Other Sectors
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	-3.52%	2.57%	3.50%
Forecast: 2007-2020	2.72%	2.98%	1.22%

Between 2004 and 2007 water consumption by sample customers classified as being 'other sectors' declined by 3.52% per year. However, if we exclude consumption observations from Wessex Water the growth rate in consumption is 1.36% per year. During the period 2004 to 2007 real prices were increasing by 3.5% per year on average and output was increasing by 2.57% per year.

The increase in consumption experienced by the majority of customers in the sector is explained to a large extent by strong output growth. However, our regression model indicates that there is also a positive underlying trend in consumption in this sector once price and output effects have been taken into account.

Over the period 2007 to 2020 real price growth is forecast to be 1.22% per year and output growth is forecast to be 2.98% per year.

Between 2007 and 2008 water consumption by sample customers in this sector is forecast to increase by 2.72%. This forecast is a continuation of the increasing consumption seen between 2004 and 2007 (excluding Wessex Water). The rate of increase is forecast be higher than during the period between 2004 to 2007. The higher forecast growth rate in consumption is consistent with a higher forecast rate of output growth and a lower forecast rate of real price growth.

4.4. Demand Forecast for Residual Customers by Sector

In this section we present our forecasts of water consumption for residual customers by sector. These forecasts are generated using our estimates of price and output elasticity from our regression models and the forecasts of real price growth and aggregate sector output growth described in section 2.2. The forecasts are also a function of the change in aggregate sector consumption by residual customers between 2006 and 2007. As we explain in section 4.1 we do not use the estimated sector time trends from our regression models in generating our forecasts for residual customers.

4.4.1. Primary Products and Metals – Residual Customer Forecast

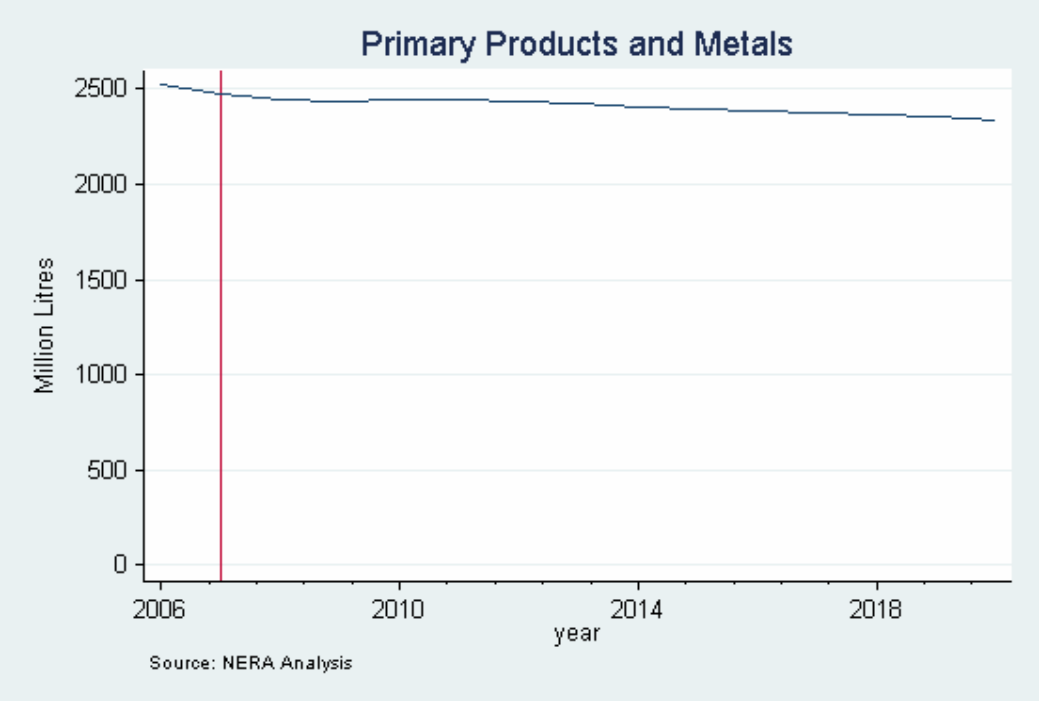


Table 4.8
Primary, Products and Metals
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	0.39%	3.50%
Forecast: 2007-2020	-0.22%	0.38%	1.22%

Water consumption for residual customers in this sector is forecast to decline at an average rate of 0.22% per year. This is consistent with low output growth and growth in real prices at a faster rate than output growth. A change in aggregate consumption between 2006 and 2007 of -1.96% will also be a component in the forecast consumption decline.

4.4.2. Food, Drink and Tobacco –Residual Customer Forecast

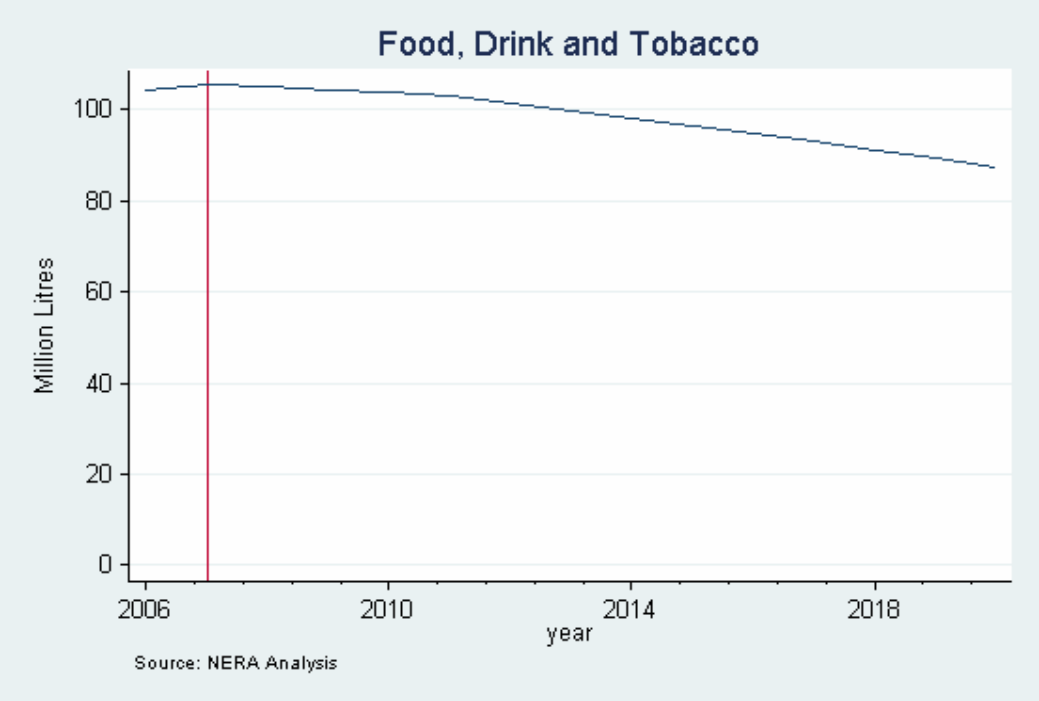


Table 4.9
Food, Drink and Tobacco
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	-4.19%	3.50%
Forecast: 2007-2020	-1.16%	-3.58%	1.22%

Water consumption for residual customers in this sector is forecast to decline at an average rate of 1.16% per year. This is consistent with forecast output decline and real price growth.

4.4.3. Chemical, Oil Refining and Other Manufacturing – Sample Customer Forecast

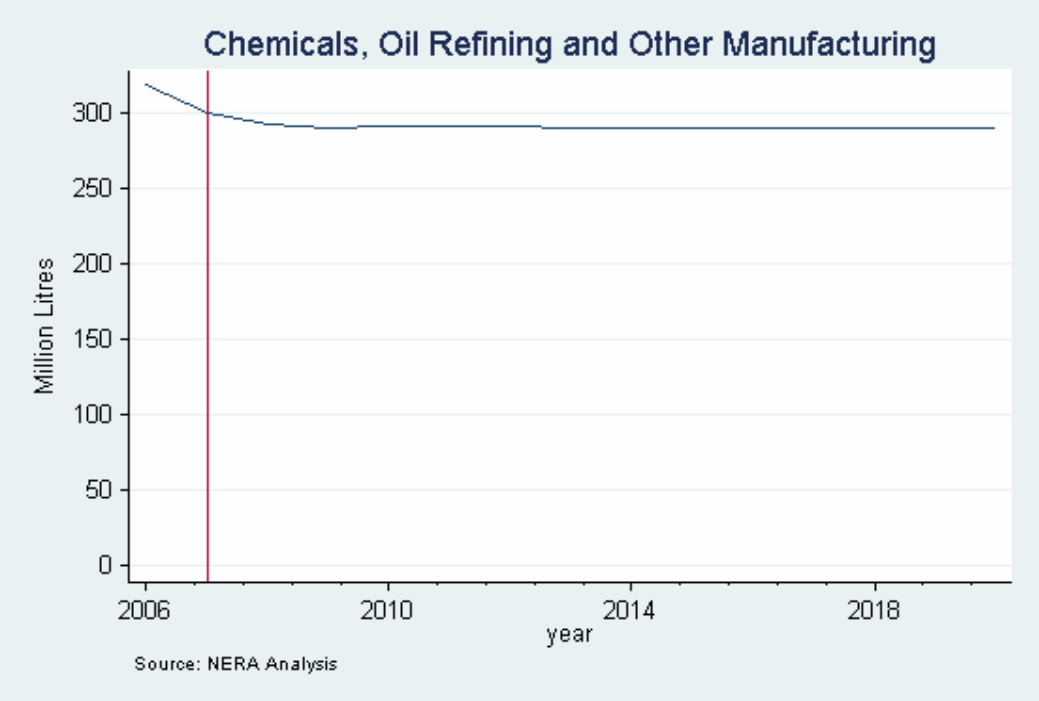


Table 4.10
Chemicals, Oil Refining and Other Manufacturing

Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	-2.58%	3.50%
Forecast: 2007-2020	-0.71	1.67%	1.22%

Water consumption for residual customers in this sector is forecast to decline at an average rate of 0.71% per year. This is consistent with low output growth and growth in real prices at a faster rate than output. A change in aggregate consumption between 2006 and 2007 of -5.97% will also be a component in the forecast consumption decline.

4.4.4. Public Services – Sample Customer Forecast

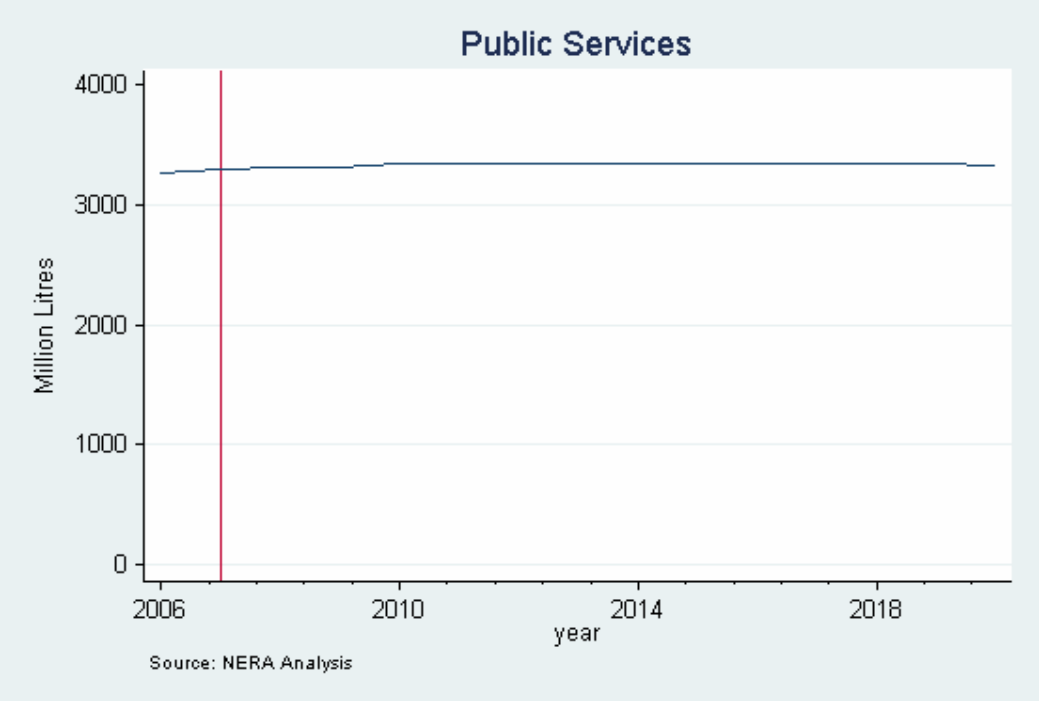


Table 4.11
Public Services
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	2.05%	3.50%
Forecast: 2007-2020	-0.02%	1.60%	1.22%

Water consumption in this sector is forecast to increase by -0.02% per year between 2007 and 2008. In this sector the effect of the forecast output growth and forecast real price growth virtually cancel each other out.

4.4.5. Other Services – Sample Customer Forecast

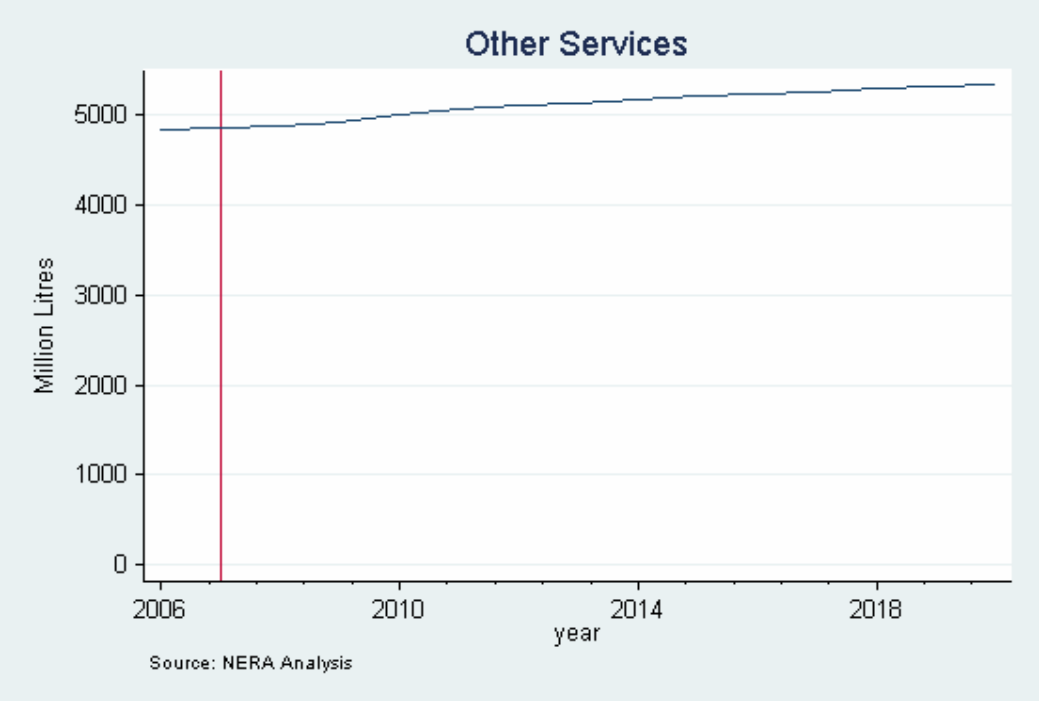


Table 4.12
Other Services
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	3.86%	3.50%
Forecast: 2007-2020	0.75	3.95%	1.22%

Between 2007 and 2020 consumption in this sector is forecast to increase by an average of 0.75% per year. This is consistent with the strong output growth in this sector.

4.4.6. Other Sectors – Sample Customer Forecast

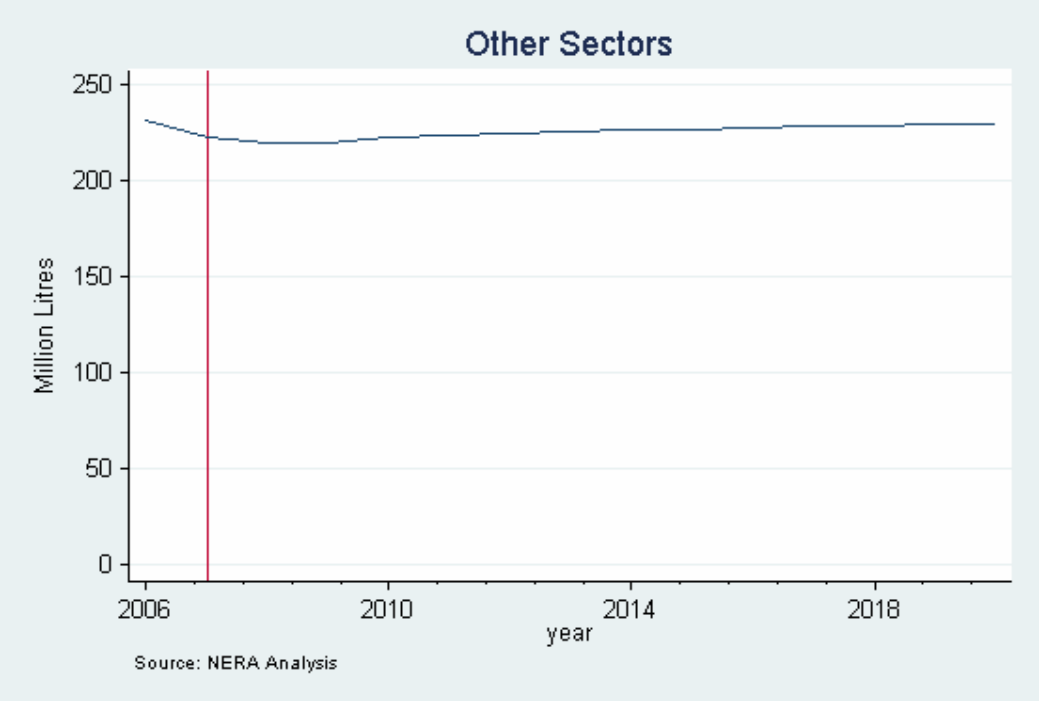


Table 4.13
Other Sectors
Consumption, Output and Real Price Growth Rates pre and post 2007

	Consumption growth p.a.	Output growth p.a.	Real price growth p.a.
Actual: 2004-2007	N/A	2.57%	3.50%
Forecast: 2007-2020	-0.05%	2.98%	1.22%

Consumption growth in this sector is forecast to be -0.05% per year between 2007 and 2020. This is consequence of the strong output growth effect being cancelled out by the effects of real price growth and the short term trend produced by the change in aggregate consumption in this sector of -3.92% between 2006 and 2007.

Appendix A. Excluded Customers

Table A.1
Customers Excluded from the Sample

NAME	SIC	SECTOR	POSTCODE	LOCAL AUTHORITY	CONSUMPTION (M/I)						
					2001	2002	2003	2004	2005	2006	2007
MERLONI ELETTRODOMESTICI U K LTD	29.71	3	BS37 5HR	South Gloucestershire	9.591	5.284	5.405	6.031	6.28	11.602	7.554
CROUDACE PROPERTIES LTD	70.32	5	BS8 2PN	Bristol, City of	5.495	7.375	6.69	4.753	5.025	17.936	0.788
KODAK PROCESSING COMPANIES	74.81	5	BS20 7BX	North Somerset	5.89	13.304	13.259	12.31	1.212	0.005	0.011
SOUTH WEST REGIONAL DEV	75.22	4	BS24 7AA	North Somerset	18.053	24.615	72.361	14.831		6.48	
AIRBUS UK LIMITED	35.3	3	BS34 xxx	South Gloucestershire	16.023	16.023	16.023	16.023	5.641	28.519	5.885
AMCOR FLEXIBLES WINTERBOURNE LTD	21.21	3	BS34 6PT	South Gloucestershire	13.97	23.57	23.971	12.608	11.45	22.541	8.459
SEVALCO LTD	28.95	1	BS11 0YU	Bristol, City of	13.135	13.135	13.135	13.135	4.208	1.054	2.873
FRAMPTONS LIMITED	15.5	2	BA4 5PD	Mendip					13.594	21.77	9.331
LLOYDS BANK PLC	65.12	5	BS1 5LL	Bristol, City of	5.654	9.045	8.157	9.814	12.386	11.561	283.699
SEABANK POWER LTD	31.1	3	BS11 xxx	Bristol, City of	305.671	317.52	277.319	281.964	208.721	257.608	240.107
B M C LTD	27.42	1	BS4 5LQ	Bristol, City of	34.394	32.612	28.51	34.971	9.56	0.013	0.075
RHODIA UK LTD	24.66	3	BS11 9YF	Bristol, City of	13.509	13.509	13.509	13.509	0.111	0.002	
J J SAUNDERS LTD DAIRY & CHEESE	15.51	2	BA3 4SA	Bath & North East Somerset	12.608	11.388	9.297	6.206	0.891	0.575	0.552
DEAN & DYBALL CONSTRUCTION SW	45.21	6	BS10 7SJ	Bristol, City of				566.7	0.476	0.155	0.203
J G LAND & ESTATES LIMITED	15.88	2	BA5 1TP	Mendip	7.357	17.268	8.208	3.153	1.324	0.78	0.94
MR S W HOWES	1.3	1	GL12 8JY	South Gloucestershire	2.27	1.179	1.518	1.669	2.072	1.801	131.485
TOTAL					463.62	505.827	497.362	997.677	282.951	382.402	691.962

Appendix B. Consumption Forecasts

Table B.1
Consumption Forecasts for Sample Customers (M/l per year) by Sector

Year	Primary products and metals	Food, drink and tobacco	Chemicals, oil and manufacturing	Public services	Other services	Other sectors
2007	2431.19	702.97	852.85	2186.08	4203.87	560.83
2008	2476.19	669.19	794.85	2211.32	4337.21	561.65
2009	2449.06	651.91	751.77	2209.91	4433.08	558.88
2010	2397.83	644.85	721.39	2211.29	4424.35	561.46
2011	2321.08	637.54	693.54	2195.62	4305.39	563.60
2012	2240.87	627.45	669.18	2174.20	4143.91	569.22
2013	2162.66	616.03	648.45	2151.17	3971.04	579.49
2014	2086.72	606.63	630.31	2128.12	3800.46	594.63
2015	2018.54	594.92	613.44	2105.19	3634.66	614.65
2016	1954.74	582.80	597.35	2083.15	3475.33	639.61
2017	1896.90	569.29	582.29	2061.63	3322.90	669.73
2018	1842.62	555.73	567.47	2041.04	3177.78	705.58
2019	1792.11	541.11	553.23	2020.74	3040.13	747.38
2020	1742.39	522.90	540.03	2001.14	2908.86	795.19

Table B.2
Consumption Forecasts for Residual Customers (M/l per year) by Sector

Year	Primary products and metals	Food, drink and tobacco	Chemicals, oil and manufacturing	Public services	Other services	Other sectors
2007	2475.88	105.62	299.79	3291.50	4844.77	222.24
2008	2447.28	105.01	292.15	3302.74	4869.73	219.23
2009	2437.96	104.12	289.37	3310.91	4916.48	219.28
2010	2448.17	104.02	290.81	3340.68	5005.08	222.05
2011	2446.13	103.13	291.34	3351.96	5065.50	223.64
2012	2440.62	101.69	291.38	3356.31	5112.83	224.86
2013	2430.70	100.10	291.31	3357.29	5152.99	225.92
2014	2419.03	98.61	291.42	3356.83	5189.58	226.87
2015	2407.06	96.90	291.31	3355.17	5222.85	227.67
2016	2394.64	95.19	291.16	3353.51	5252.93	228.30
2017	2383.53	93.36	291.03	3351.47	5280.99	228.81
2018	2372.61	91.58	290.73	3349.64	5307.81	229.34
2019	2361.78	89.71	290.57	3347.10	5333.51	229.86
2020	2349.95	87.68	290.62	3344.53	5358.89	230.35

Table B.3
Consumption Forecasts for Excluded Customers (M/l per year)

NAME	SECTOR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MERLONI ELETTRODOMESTICI U K LTD	3	7.55	7.45	7.35	7.26	7.16	7.06	6.97	6.88	6.78	6.69	6.60	6.52	6.43	6.34
CROUDACE PROPERTIES LTD	5	0.79	0.77	0.75	0.73	0.71	0.69	0.67	0.65	0.64	0.62	0.60	0.59	0.57	0.56
KODAK PROCESSING COMPANIES	5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SOUTH WEST REGIONAL DEV	4	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AIRBUS UK LIMITED	3	5.89	5.81	5.73	5.65	5.58	5.50	5.43	5.36	5.29	5.22	5.15	5.08	5.01	4.94
AMCOR FLEXIBLES WINTERBOURNE LTD	3	8.46	8.35	8.23	8.13	8.02	7.91	7.80	7.70	7.60	7.50	7.40	7.30	7.20	7.10
SEVALCO LTD	1	2.87	2.86	2.84	2.83	2.81	2.80	2.78	2.77	2.75	2.74	2.72	2.71	2.70	2.68
FRAMPTONS LIMITED	2	9.33	9.35	9.37	9.39	9.40	9.42	9.44	9.46	9.48	9.49	9.51	9.53	9.55	9.57
LLOYDS BANK PLC	5	283.70	276.19	268.89	261.77	254.85	248.11	241.54	235.15	228.93	222.88	216.98	211.24	205.65	200.21
SEABANK POWER LTD	3	240.11	236.91	233.75	230.63	227.55	224.52	221.52	218.57	215.66	212.78	209.94	207.14	204.38	201.65
B M C LTD	1	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
RHODIA UK LTD	3	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
J J SAUNDERS LTD DAIRY & CHEESE	2	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.57
DEAN & DYBALL CONSTRUCTION SW	6	0.20	0.21	0.23	0.24	0.25	0.26	0.28	0.29	0.31	0.32	0.34	0.36	0.38	0.40
J G LAND & ESTATES LIMITED	2	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.96	0.96	0.96	0.96	0.96
MR S W HOWES	1	131.49	130.79	130.10	129.41	128.72	128.04	127.36	126.69	126.02	125.35	124.69	124.03	123.37	122.72
TOTAL		691.96	680.26	668.81	657.61	646.64	635.90	625.40	615.11	605.05	595.19	585.54	576.09	566.85	557.79

Table B.4
Consumption Forecasts for Sample and Residual BWL Customers (M/l per year) by Sector

Year	Primary products and metals	Food, drink and tobacco	Chemicals, oil and manufacturing	Public services	Other services	Other sectors	Total consumption (without excluded customers)
2007	4907.07	808.59	1152.64	5477.58	9048.64	783.06	22177.60
2008	4923.47	774.20	1087.00	5514.07	9206.94	780.88	22286.54
2009	4887.01	756.03	1041.14	5520.82	9349.57	778.15	22332.73
2010	4845.99	748.87	1012.20	5551.97	9429.43	783.51	22371.98
2011	4767.21	740.68	984.88	5547.58	9370.89	787.24	22198.48
2012	4681.49	729.15	960.56	5530.51	9256.75	794.08	21952.54
2013	4593.36	716.13	939.76	5508.46	9124.03	805.41	21687.15
2014	4505.75	705.24	921.73	5484.95	8990.04	821.50	21429.22
2015	4425.61	691.83	904.75	5460.36	8857.51	842.32	21182.38
2016	4349.38	677.99	888.51	5436.66	8728.26	867.91	20948.71
2017	4280.43	662.65	873.32	5413.11	8603.89	898.54	20731.95
2018	4215.22	647.31	858.20	5390.68	8485.59	934.93	20531.93
2019	4153.89	630.81	843.81	5367.84	8373.64	977.24	20347.22
2020	4092.35	610.58	830.65	5345.67	8267.75	1025.54	20172.54

Table B.5
Consumption Forecasts for All BWL Customers (M/l per year) by Size

Year	Customer Size Category				
	<5M/l	**>5M/l <15M/l**	**>15M/l <50M/l**	**>50M/l <100M/l**	**>100M/l**
2008	11539.62	3032.94	2513.72	2494.34	3386.19
2009	11611.70	2987.54	2413.49	2565.73	3423.08
2010	11764.28	2894.57	2539.08	2399.49	3432.16
2011	11848.65	2861.09	2519.19	2284.12	3332.06
2012	11887.72	2869.20	2514.30	2124.80	3192.42
2013	11960.53	2805.37	2626.81	1873.54	3046.29
2014	12015.65	2724.11	2661.21	1637.62	3005.73
2015	12062.76	2718.62	2673.00	1541.79	2791.25
2016	12091.05	2683.26	2678.30	1402.58	2688.72
2017	12127.61	2683.03	2542.53	1463.66	2500.66
2018	12171.80	2584.90	2553.58	1855.82	1941.92
2019	12203.48	2525.39	2439.45	1849.39	1896.37
2020	12247.81	2437.28	2539.49	1654.19	1851.56

Appendix C. Macroeconomic Data and Forecasts

Figure C.1 presents actual and forecast output and employment data for the whole BWL area, Figure C.2 presents this data disaggregated by sector.

Figure C.1
Actual and Forecast Macroeconomic Activity for Whole Bristol Water Region

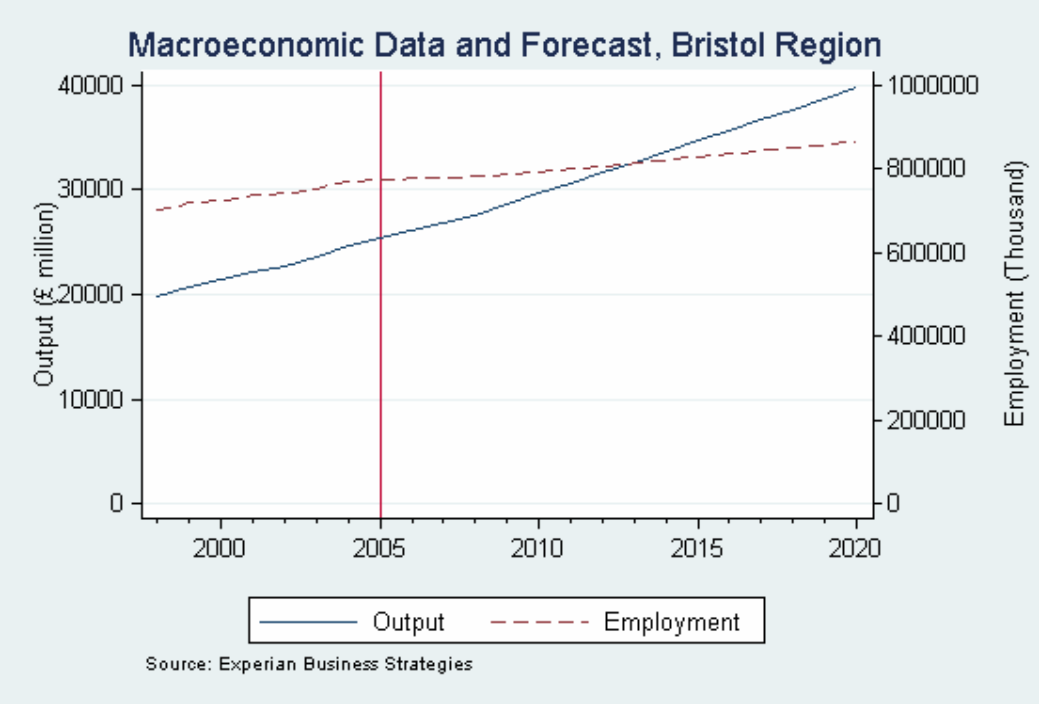
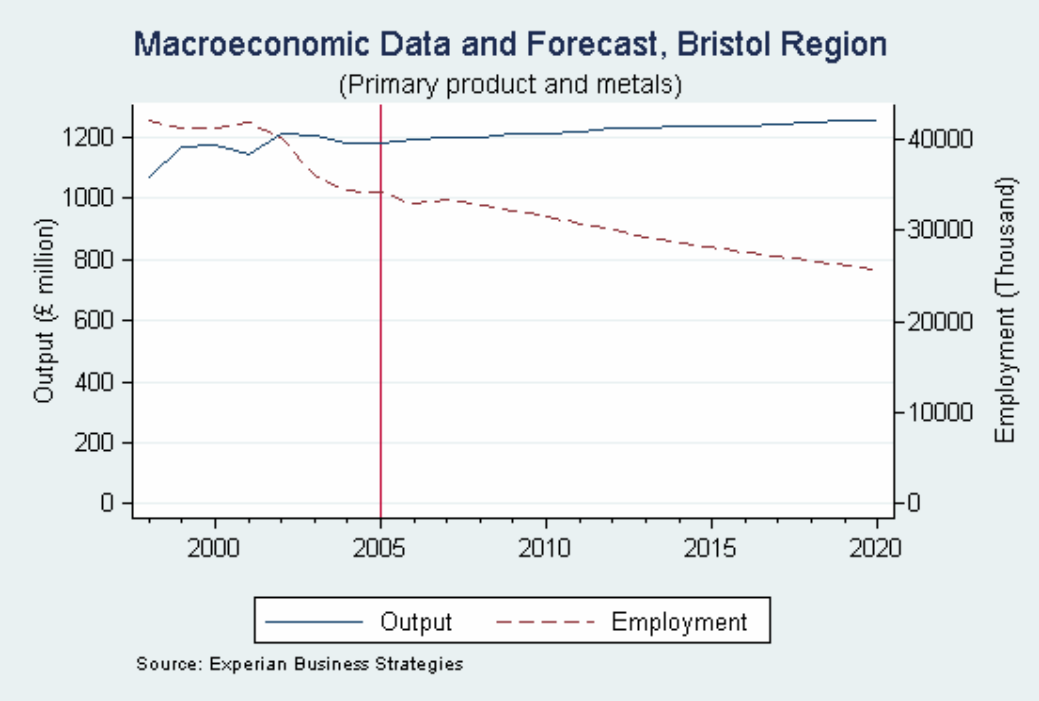
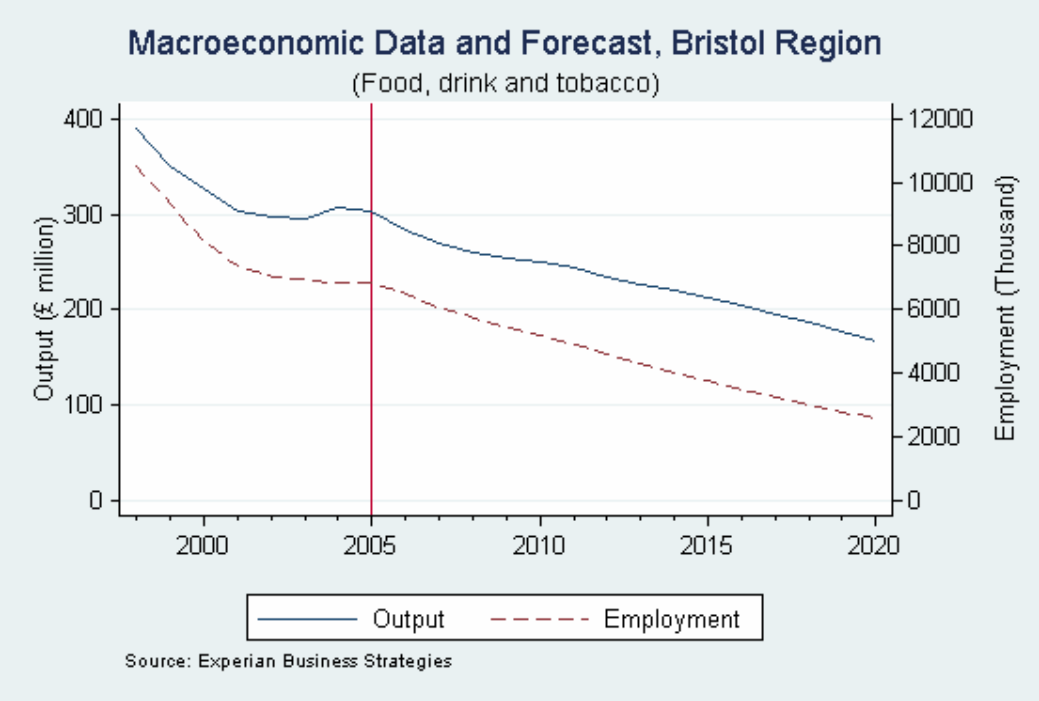
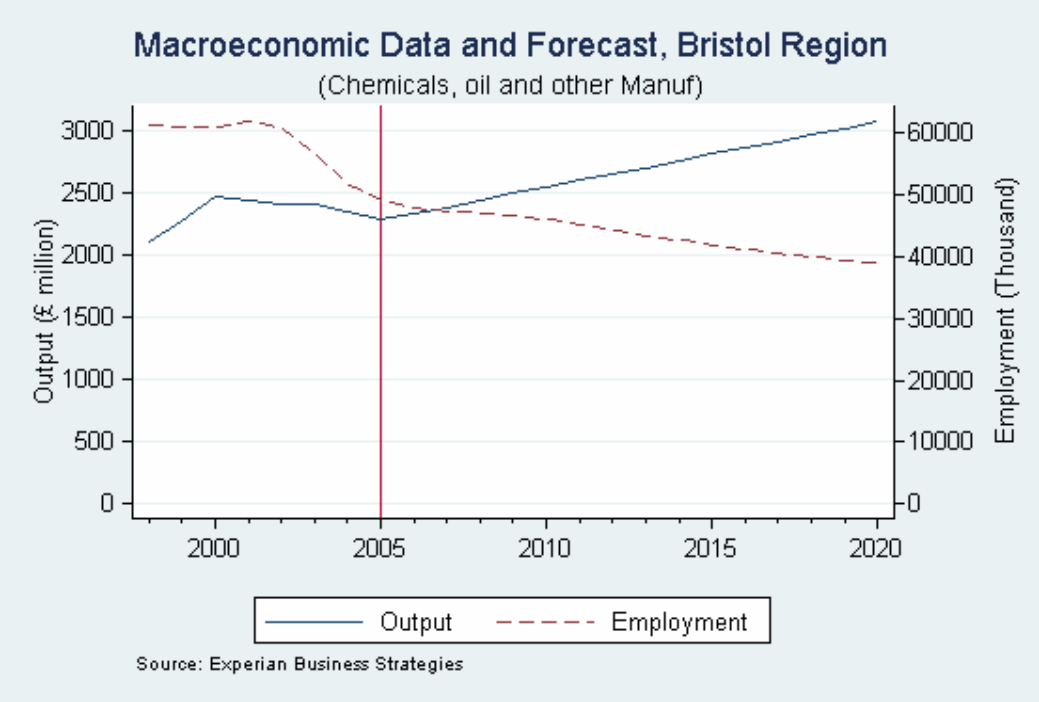
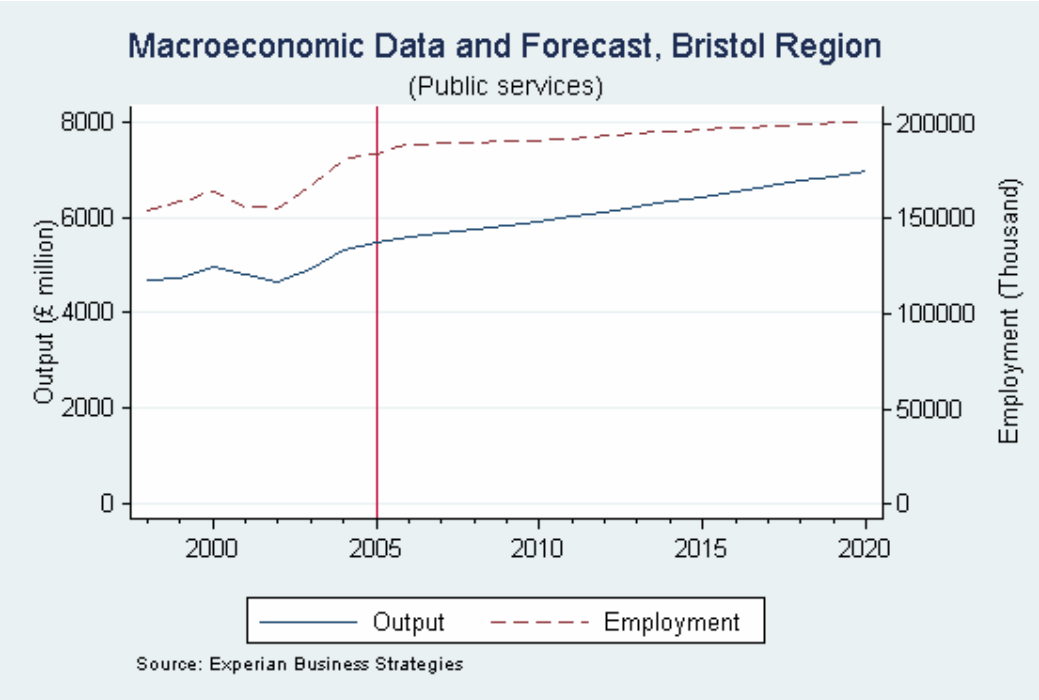


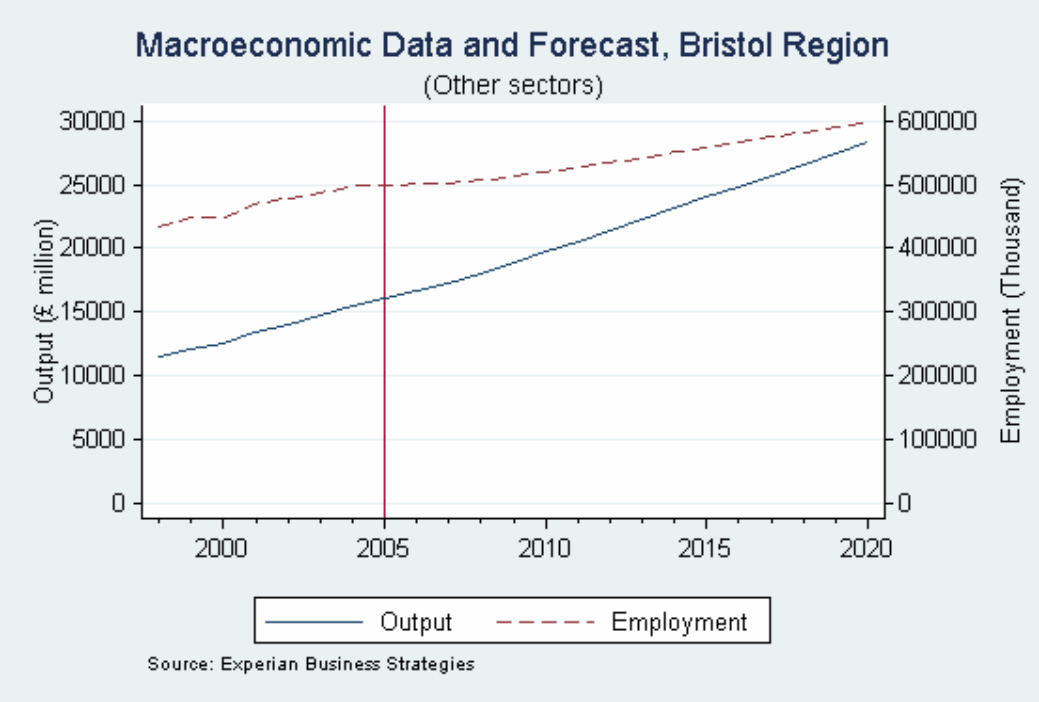
Figure C.2
Actual and Forecast Macroeconomic Activity Disaggregated by Sector






Macroeconomic Data and Forecast, Bristol Region
(Chemicals, oil and other Manuf)
Output (£ million)
Employment (Thousand)
3000
2500
2000
1500
1000
500
0
60000
50000
40000
30000
20000
10000
0
2000
2005
2010
2015
2020
Output
Employment
Source: Experian Business Strategies


Macroeconomic Data and Forecast, Bristol Region
(Public services)
Output (£ million)
Employment (Thousand)
8000
6000
4000
2000
0
200000
150000
100000
50000
0
2000
2005
2010
2015
2020
Output
Employment
Source: Experian Business Strategies


Macroeconomic Data and Forecast, Bristol Region
(Other sectors)
Output (£ million)
Employment (Thousand)
30000
25000
20000
15000
10000
5000
0
600000
500000
400000
300000
200000
100000
0
2000
2005
2010
2015
2020
Output
Employment
Source: Experian Business Strategies

Appendix D. Econometric Model of Non-Residential Demand

The baseline model for our demand forecasts is

$$\log C_{it} = a \log C_{it-1} + b \log X_{it} + g \log P_{it} + s_{jt} t + e_{it}$$

where

C_{it} is the volume of water consumed by consumer i in period t;

X_{it} is an index of the economic activity of consumer i in period t; we used employment as the preferred index of economic activity;

P_{it} is an index of the real volumetric price paid by consumer i in period t;

σ_{jt} is a time trend in consumption for consumers in group j at time t; and

$\varepsilon_{it} = \mu_i + v_{it}$ is the error term which may contain a fixed effect for consumer i (μ_i) and an error that varies with both time and consumer but may be autocorrelated over time.

By taking the difference between the equation in periods t and t-1 this yields the following dynamic specification

$$\Delta \log C_{it} = a \Delta \log C_{it-1} + b \Delta \log X_{it} + g \Delta \log P_{it} + s + n_{it}$$

which can be estimated using the Arellano-Bond dynamic panel GMM estimator with tests for autocorrelation of the residuals and the Sargan test for the validity of using lagged values as instruments in the estimation.

In this model the coefficients β and γ are the short run elasticities of consumption with respect to economic activity and price, while the long run elasticities are obtained by multiplying the short run elasticities by 1/(1-α).

Since we do not have specific data on the output or employment of the individual consumers, which comprise our sample, we have used indices of employment and output for the sector and region in which the consumer operates as alternative measures of economic activity.

The coefficients of the final forecasting model using Δlog (Consumption[t]) as the dependent variable are given in section 3.3 together with their estimated p-values. These estimates were obtained using the Arellano-Bond two-step estimation procedure, which should produce more reliable estimates of the coefficients than the one-step procedure.

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