Economics of Tobacco

Modelling the Market for Cigarettes in Ireland

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Padraic Reidy and Keith Walsh.

Research and Analytics Branch, Planning Division, Revenue Commissioners.

Contact: Keith Walsh; Email: keithw@revenue.ie; VPN: 21417; DD: 01 4251417.

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Table of Contents

List of Figures

List of Tables

Executive Summary

This report is motivated by a desire to better understand the market for cigarettes in Ireland through the application of economic tools and analysis. A model that links consumption of cigarettes with a number of key economic determinants of smoking is assembled and tested econometrically. The model identifies the factors that determine cigarette consumption and tests the degree of influence of those factors. Time series analysis is used over the period 2002 to 2009.

Numerous explanatory variables of cigarette consumption are explored but the only factors that are found to be statistically significant in the most efficient econometric regression are: price, income, the introduction of the smoking ban, EU enlargement and the point of sale advertising ban. Of these, the most important effect is from price. The model suggests a price elasticity of -3.6, i.e., a 1 per cent increase in price results in a 3.6 per cent reduction in cigarette consumption.

This price elasticity is extremely high compared to other estimates for the Irish market, most suggest a figure of between 0.5 and 1. A price elasticity of -3.6 is too high to be realistic, for example it would imply that a 10 per cent increase in price reduces smoking by 36 per cent. Previous experience in Ireland shows this is not the case. Therefore another factor must be at play.

The consumption variable in this study is the consumption of taxed cigarettes.[1] So the price elasticity estimated refers to taxed cigarettes: a 1 per cent increase in price leads to a 3.6 decrease in consumption of taxed cigarettes. The most reasonable theory to explain such a large decrease in taxed consumption is that only part of the reduction is caused by lower smoking levels, the remainder must be caused by smokers switching to substitute cigarettes.

The most likely substitutes in the case of taxed cigarettes are non-Irish taxed cigarettes (i.e., purchased legally outside Ireland and brought into the country) or untaxed cigarettes (produced in or smuggled into Ireland and purchased illegally).

[1] Cigarettes on which VAT and excise duty are paid in Ireland.

It is recognised that the consumption of untaxed cigarettes has become an increasingly important issue. Revenue estimates that currently around 20 per cent of cigarettes consumed in Ireland are not Irish taxed and this figure has been increasing in recent years. It is driven by several factors but the main cause is the price differential between cigarettes on the Irish market and elsewhere.

Given the current high cigarette price level in Ireland, the incentive for substitution to untaxed tobacco is greater in Ireland than it otherwise would be. This probably explains the high price elasticity estimate – higher prices will likely increase untaxed consumption.

Although limited by the data and requirements of the model, further analysis finds some evidence that cigarette tax levels have moved beyond a critical point at which increases in tax rates lead to lower, rather than higher, tax revenue. Further tax (price) rises will reduce smoking somewhat but they will also greatly encourage more untaxed consumption.

Increasing the taxation of cigarettes in Ireland no longer carries the combined benefits of better public health and higher revenue for the public finances that would have arisen from such increases in the past. At the very least, these benefits are severely weakened by the substitution of untaxed for taxed consumption.

This suggests that taxation increases are no longer the optimum tool for reducing smoking in Ireland. This is further supported by the significance in the model results of the effect of the smoking ban. Such non-price measures are shown to reduce taxed consumption and do not carry the same incentive to switch to untaxed cigarettes as higher rates of taxation.

The findings in this report are significant and clearly have important consequences for policy-makers. Irish research on this topic to date is extremely limited but this report addresses this shortcoming. This analysis follows the international literature and adapts it for Irish market. The econometric model and results are statistically robust.

1 Introduction

1.1 Aim of the Research

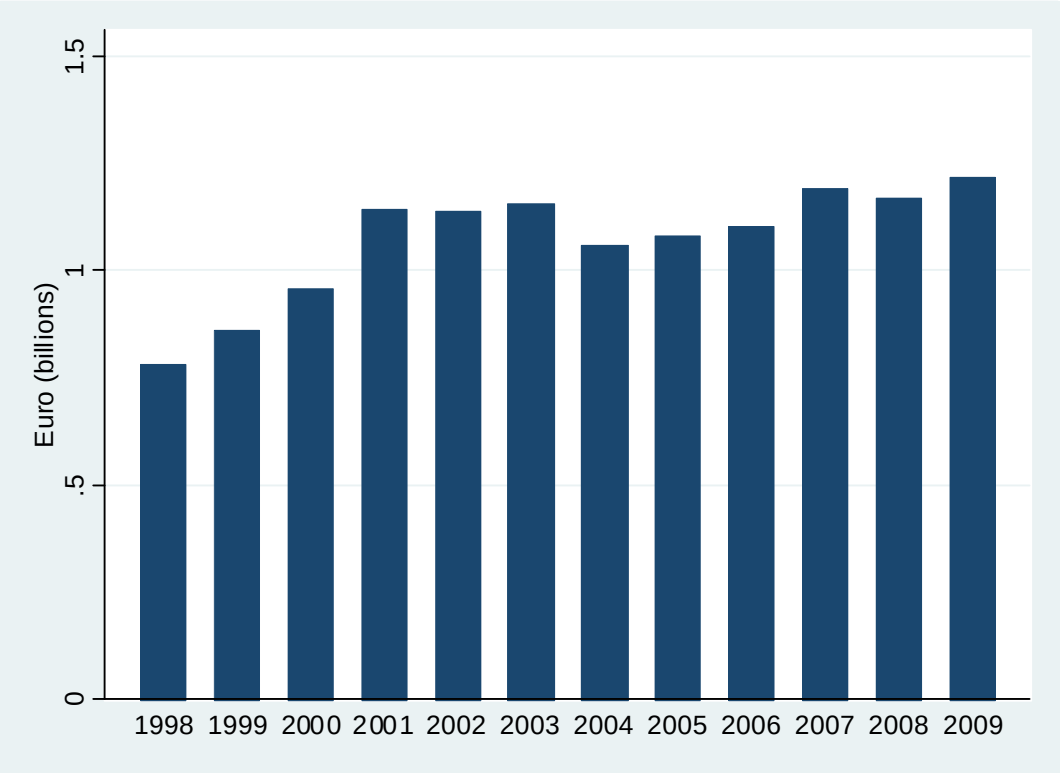
The research in this report is motivated by a desire to better understand the market for cigarettes in Ireland through the application of economic tools and analysis. The focus is on the demand side of the market – cigarette consumption. This report creates an econometric model of consumption of cigarettes in Ireland. The model identifies the key economic factors that determine cigarette consumption and tests the degree of influence of those factors on consumption.

1.2 Motivation and Context

Excise revenue is an important source of tax revenue in Ireland. This tax has not been as badly impacted by the recession as some other taxes. Excise revenue decreased from €6.0 billion in 2007 to €4.9 billion in 2009, a reduction of about 18 per cent. During the same period, total tax revenue decreased by 30 per cent. Excise duty is payable on products such alcohol, tobacco and motor fuel. By their nature, demand for these goods tends to be quite inelastic so increases in prices or reductions in incomes will have less of a negative impact on quantity purchased.

As Figure 1 shows, tobacco has consistently been a significant source of excise revenue, with over €1bn paid in each year from 2000 onwards. VAT is also paid on tobacco consumption. The amount of revenue has been quite stable over the years despite changes in excise and VAT duty rates on tobacco and important social, economic and demographic changes. Cigarettes are the largest contributor to excise revenue from tobacco. For example, in 2008 excise revenue from cigarettes was €1,132 million while revenue from other tobacco products (cigars and cut tobacco mainly) was €39 million.

Figure 1: Excise Revenue from Tobacco



Source: Revenue data.

Research on cigarettes, in Ireland (and elsewhere) often focuses on the causes of smoking, the consequent costs on society due to the health costs and the effectiveness of measures to reduce smoking. However, it is important to note that cigarettes remain a sizeable source of exchequer funding. While it may be desirable from a public health perspective to abolish smoking, the €1bn in excise revenue from tobacco would be a significant loss from the fiscal perspective.

Changes in tax rates and duties are often seen as a tool to change smoker behaviour but tobacco is also a source of excise revenue for the Irish exchequer. The primary motivation of this research is to assess and measure the economic factors that underlie the market for cigarettes in Ireland to improve Revenue's understanding of an important part of the tax base.

An additional motivation for this study arises from the issue of untaxed cigarettes. In recent years there has been increased attention on the problem of cigarette smuggling. There is a perception that the availability of untaxed cigarettes is increasing and this poses a threat to the tax base and the Irish Exchequer. Revenue has greatly increased its

efforts and resources to tackle this problem, often in a successful and high profile manner.[2] Analysing the market for tobacco should help to better understand the problem of tobacco smuggling.

1.3 Background Research

There has been extensive research focusing on the determinants of consumer demand both nationally and internationally in the last number of decades. However, the extension of this type of analysis to include addictive goods (such as tobacco) has only happened relatively recently. The literature is reviewed in detail in the following section but as a brief introduction, it is worth noting some important aspects in relation to the rationale for this study.

The study is a time series demand analysis for taxed cigarettes in Ireland using aggregated data. This is notable because there is a lack of recent literature using a similar analytic approach. There is an array of similar studies focusing on individual level survey data, but in relation to research using data over time, this analysis is timely in the Irish context.

Internationally, this type of study is more common and the data and methodology will draw on the most applicable of these papers but ultimately, the focus of the study is on Irish cigarette consumption and how changes in the pricing and legislative environment affect this consumption.

1.4 Structure of the Report

The report is organised as follows. The next section introduces the literature that informs the analysis on which this report builds. Section 3 discusses the data collected to conduct the analysis. The methodology of the research is then outlined and the results of the data analysis explained in Section 4. Section 5 contains a detailed discussion of the estimated relationship between cigarette prices and consumption. The final section concludes.

[2] For example, see http://www.revenue.ie/en/press/2010/pr-280710-results-cigarette-smuggling.html

2 Literature Review and Expected Results

2.1 Introduction and Context

The economic effects and determinants of tobacco consumption have been widely studied and modelled in recent years. There are numerous reasons for this.

First, *"It was believed at one time that cigarette smoking and other addictive behaviour was not rational and so not suitable for conventional economic analysis"* but this has changed in recent years: *"There is now a substantial body of literature to testify that the demand for cigarettes clearly responds to changes in prices and other factors. The limited range of Irish studies are still in line with international evidence indicating that consumption is price sensitive. Thus Irish smokers appear to be rational in terms of their response to tax and price increases."* (Madden 2002). The development of new and more powerful econometric tools has also driven recent analyses of tobacco consumption along with increases in data collection and quality.

Second, in recent years there have been wide ranging commitments by national governments and international organisations such as the World Bank and the World Health Organisation (WHO) to reduce the amount of people who smoke tobacco products. This drive to curb smoking has been driven by research into the health effects of tobacco use, effects that were not always made clear by the tobacco industry (WHO 2007). Stemming from this research has been the implementation of instruments by governments designed to reduce the population of tobacco users and the numbers of people taking up smoking. Instruments such as tax increases over inflation, advertising restrictions and restrictions on smoking in public places have formed part of the attempt by governments to reduce tobacco use.

Third, methodology guides, discussed in more detail below, have been provided by the World Bank specifically on the topic of the economics of tobacco. They provide guidelines relating to data collection and variable choice, model specification, dealing with the design and administration of tobacco taxes, tobacco related employment, tobacco control relating to poorer sections of society and the issue of smuggling. These publications provide a starting point for modelling the economics of tobacco.

2.2 Economic Analysis in Ireland

With changes in policy have come studies, both national and international, seeking to monitor their effects. Most recently in Ireland, Power (2009) sets out the rationale for a €2 increase in taxation on a packet of 20 cigarettes: "*Such an initiative would have the dual effect of raising between €380 million and €420 million in extra tax revenues, while at the same time leading to a reduction of up to 10 per cent in tobacco consumption*".

There is no source cited in the paper for the extra revenue generation figures, nor is there an explicit source justifying the 10 per cent reduction in tobacco consumption provided for by the tax increase. However, from reading the paper, it is possible that this figure is taken from Jha and Chaloupka (1999) where it is estimated that a 10 per cent increase in the price of tobacco in developed countries leads to a 4 per cent reduction in demand in the short term and a 10 per cent reduction in the long run. The issue with this figure is that it is a generic one. Every country is different and the justification for its use in a policy context may not be easily argued. A more specific study is needed to attain the exact effects on tobacco demand in Ireland resulting from an increase in price, something the research undertaken in this report provides.

Power (2009) does not allow for the possibility that the tax revenue collected on tobacco may fall off at higher rates of taxation. In the case of tobacco, an increase in tax rates could lead to a combination of reduced cigarette consumption and the increased consumption of untaxed tobacco.

In other analysis in Ireland, Layte and Whelan (2004), using regression analysis on Central Statistics Office (CSO) and Eurostat data *"argue that the social structuring of smoking rates suggests that social and economic processes may have a major role in starting and quitting behaviour. … that measures of disadvantage and deprivation help to explain half of the differential of class smoking"*. Reinforcing these findings, Murphy (2007) analyses the socio-economic factors and influences on smoking in Ireland using CSO data. Murphy (2007) finds clear commonalities between smokers: *"The model revealed positive relationships between age, males, medical card eligibility, employment and being married and the expected number of cigarettes smoked daily …while higher educational attainment had a negative relationship with the expected number of cigarettes smoked daily"*.

Madden has published extensively on the subjects of tax, education and tobacco use. Madden (2003), using a survey of women's knowledge, understanding and awareness of their lifetime health needs, investigates tobacco taxes and starting and quitting smoking. The paper finds that taxes do influence the starting and quitting of smoking. The results for quitting suggest the greatest effects for women with the lowest level of education.

Madden (2002), using a variety of sources, examines the issues involved in setting the appropriate tax on cigarettes in Ireland. The paper, using individual level data, compares Irish tax rates with those in other EU countries and then examines the external costs of cigarette consumption in Ireland concluding that, on a comparative basis, Ireland has a relatively high tax rate and even higher retail price. Madden (2003) also posits that *"the estimates suggest that higher taxes do delay the period before starting (smoking), with estimated elasticities of 1.0 but the results are sensitive to various aspects of model specification and so cannot be regarded as entirely robust".*[3] Madden (2001) has also researched the factors influencing female smoking and drinking in Ireland and finds the decision to smoke and drink and how much to smoke and drink are not independent.

Other Irish studies include an overview of the existing published literature with regard to the economics and marketing of tobacco by Layte, Russell and McCoy (2002), an examination of models of tobacco consumption by Conniffe (1995) and an elasticity analysis of tobacco demand in Ireland (O' Riordan 1969).

Madden (2003) summarises that *"these studies have produced broadly comparable results with a median estimate for the price elasticity of tobacco in the region of –0.5, which is in line with results from elsewhere in the world".* The Office of Tobacco Control (OTC, 2002) suggests a price elasticity of demand for cigarette consumption of -0.6 per cent, that is, a one per cent increase in the price corresponds to a 0.6 per cent fall in demand. This again is in line with international estimates. These figures in some cases are now nearly ten years old and therefore the rationale for the analysis in this report is immediately evident.

[3] Elasticity is discussed in more detail below. As an economic concept, the elasticity of demand to price measures the percentage change in demand in response to a 1 per cent change in price. There are many other elasticities (e.g., the income elasticity of demand measures the responsiveness of demand to changes in income).

2.3 Economic Analysis in the UK

Cullum and Pissarides (2004) model demand for tobacco products in the UK. The paper reports the results of the estimation of a tobacco demand model that attempts to improve on previously inadequate models of demand. They use various modelling approaches to estimate price elasticities between –0.5 and –0.87 for the UK market.

Reed (2010), using a cost benefit analysis approach, argues that a *"tobacco price rise of 5% results… economic benefits in the first five years of the policy are around £270m per year on average. The analysis also shows a positive effect of the policy on the public finances, with a net revenue gain to the government of around £520m per year in the first five years on average.* The analysis in this paper follows that of Townsend (1996) where the effects of price on consumption are analysed in a health context.

Townsend**,** Roderick and Cooper (1994) find a range of elasticities of demand for smoking through regression analysis of a random population sample. Townsend *et al.* (1994) state *"men and women in lower socioeconomic groups are more responsive to changes in the price of cigarettes and less to health publicity. Women of all ages appear to have been less responsive to health publicity than have men but more responsive to price. Real price increases in cigarettes could narrow differences between socioeconomic groups in smoking and the related inequalities in health".*

2.4 Economic Analysis Internationally

One of the most prolific authors on the economics of tobacco internationally is Chaloupka. His work includes tobacco control expenditure analysis (2003) with Farrelly and Pechacek, tobacco control policies (1995) with Wechsler, the effects of tobacco advertising on consumption (2000) with Saffer, the economics of smoking (1999) with Warner, the determinants of smoking cessation (1999) with Tauras, and the effects of prices and tobacco-control policies on the demand for tobacco products (1999).

Chaloupka also contributes several chapters to the World Bank *Economics of Tobacco Toolkit* (Yurekli and de Beyer, 2000). This lays out a recommended methodology for applying economic tools to the analysis of tobacco in a number of areas. The chapters of the toolkit on data preparation (Ciecierski and Chaloupka, 2000) and demand modeling (Wilkins, Yurekli and Hu, 2000) are used extensively in this report. In particular, the analysis undertaken in the later sections is based on Wilkins *et al.* (2000).

Other sources that provide research on the demographics of tobacco demand include Pampel's (2009) discussion on education disparities and smoking using a logistic regression model to analyse twenty-four surveys from the US. Pampel finds that *"changes in prices and restrictions thus far have done little to reduce educational disparities"*.

Fichtenberg and Glantz (2002) research the effects of smoke-free workplaces on smoking behaviour: *"totally smoke-free workplaces are associated with reductions in prevalence of smoking of 3.8 per cent. …to achieve similar reductions tax per pack would have to increase to $1.11 (in the US) and £4.26 (in the UK)"*.

On a lesser scale, there are other research projects that warrant mentioning although they do not relate directly to the Irish case. Ross and Nabilla (2007), Pekurinen (2006), Tiezzi (2005) and Galbraith and Kaiserman (1998) all focus on demand analyses of tobacco consumption in Malaysia, Finland, Italy and Canada respectively.

Ross and Nabilla (2007) using time series data in Malaysia find *"Income was positively related to cigarette consumption: A 1 per cent increase in real income increased cigarette consumption by 1.46 per cent. The model predicted that an increase in cigarette excise tax from Malaysian ringgit (RM) 1.60 to RM2.00 per pack would reduce cigarette consumption in Malaysia by 3.37 per cent"*.

Pekurinen (2006) uses four time series models in his analysis of addictive substances. *"The price of cigarettes is the most important single determinant of the demand for tobacco products. The demand for cigarettes is twice as sensitive to falling prices (elasticity –0.94) than to rising prices (elasticity –0.49). The demand for cigarettes is also responsive to changes in real income"*.

Tiezzi (2005) uses a rational addiction approach and finds that *"announcements of future price changes may be effective in curbing tobacco demand"* while Galbraith and Kaiserman (1998) analyse cigarette consumption and taxation to produce elasticities of demand. They conclude by saying, *"the sensitivity of total cigarette sales to taxation is much lower than it would appear from sales of taxed cigarettes alone"*.

2.4 Literature on the Consumption of Untaxed Cigarettes

The incentive for smokers to switch consumption to untaxed cigarettes is noted in some of the previous literature. Cullum and Pissarides (2004) find that "*The increased complexity of the market for tobacco products means that earlier studies of the UK duty-paid segment of the market… struggle to predict the impact of price changes on demand. Normally, price increases would lead to reduced consumption. However, more recently the effects of higher prices have become more uncertain as consumers may switch their consumption to other sources or lower quality cigarettes".*

More broadly, there is evidence that price is the main driver in the decision to substitute towards untaxed cigarettes (PWC, 2010) and that tobacco taxes a key determining factor in the establishment of markets in untaxed cigarettes (Gabler and Katz, 2010). Gabler and Katz (2010) find in Canada that "*Contraband cigarettes are perceived to be a near-perfect substitute for lawfully purchased cigarettes. As such, contraband tobacco use neutralizes the deterrent effect of higher taxes. Moreover, the tobacco tax revenues sought by politicians shrink when the contraband market enables smokers to evade taxation".*

Geis (2005), in an Australian study, notes that although previous World Bank research suggests that *"even at high rates, tax increases bring greater increase in revenues and reduce smoking …rather than foregoing tax increases, the appropriate response to smuggling is to crack down on criminal activity"* it leaves *"unanswered questions about the consequences for smuggling… what results might ensue if the tax reached what the public believes is an unacceptable level".* Geis (2005) does not accept *"…the logic of those who downplay the contribution of the excise tax to an illegal tobacco market. They may follow this observation with the 'proof' that countries such as Spain, which had a very low excise tax on cigarettes, nonetheless suffered from high levels of tobacco smuggling"* and concludes *"Current excise taxes are a major contributing force to the [illicit] market".*

2.5 Summary

Given the literature, it is clear that price (tax) is an essential determinant of tobacco demand along with income and a range of demographic factors (age, gender and education). Other important factors include smoking restrictions, anti-smoking advertising and health information.

This study builds on the above literature. While the focus on Ireland, the international literature provides a view of the expected results and informs the model choice.

3 Data

3.1 Introduction

This section discusses the data variables that are included for analysis in this report. It outlines the specification (and the limitations) of the data and reasons why the variables are chosen.

The Choice of Time Series for the Analysis

Taking into account the nature of this type of study, it was clear that aggregated time series data would be used in the analysis. While studies have used individual level data (often collected from surveys), this approach is not sufficient given the ultimate aims of this report. The report seeks to explain the determinants of tobacco consumption over a seven-year period from 2002 to 2009 (using quarterly data for all variables). This approach requires the use of aggregated data. The use of individual level datasets, while extremely useful for research similar in nature to this, merely provides a snapshot in time, as individual level data over time are not available (so panel analysis is not possible). Accordingly, in attempting to analyse trends in consumption behaviour over time, the use of aggregated data is appropriate.

The CSO is the primary source of data. However a number of other sources, including the Revenue Commissioners, the OTC, the WHO and the UK's Office of National Statistics (ONS) are also used.[4]

The Choice of Variables

The decision as to what variables are included in the analysis was initially informed by the aims of the analysis for Revenue (to better understand the market for cigarettes in Ireland) and was supplemented by the literature review outlined in Section 2. Previous research suggests that the main determinants of cigarette consumption are price, income, education, smoking restrictions and health information.

The variables in the dataset are described individually below. In most cases, it is self-evident what relationship is expected between consumption (the variable the analysis is

[4] Most of the data used are available on the websites of these organisations.

seeking to explain) and the explanatory variables. For example, price should be negatively related to consumption (higher prices would be expected to decrease consumption) while income should be positively related.

3.2 Variables

Consumption

The aim of this report is to model cigarette consumption in Ireland. The dependent variable in the model is the volume of cigarettes consumed per quarter – shown in Figure 2. A number of qualifications must be made from the outset.

Figure 2: Cigarette Consumption Per Quarter in Ireland

Source: Revenue data.

First, direct consumption or sales data are not readily available on a quarterly basis in Ireland. This shortcoming arises in similar studies in many countries.[5] Instead, a proxy in the form of cigarette clearance data provided by the Revenue Commissioners is used. This is essentially a measure of the payments of excise duty on cigarettes. Tobacco

[5] Even when detailed consumption data are available, there are often problems with the data. For example, survey data are often used but this tends to underestimate the level of smoking in a population, as a common feature of survey responses is a tendency of smokers to underestimate their consumption.

companies pay excise at the point of warehouse clearance. The data show a clear element of seasonality (Figure 2), as tobacco companies tend to take large volumes of cigarettes from excise warehouses prior to Budget day (in anticipation of excise duty increases). Therefore clearance data do not provide a perfect proxy for tobacco consumption by smokers but the use of quarterly rather than monthly data does to some extent mitigate this effect.

Second, by its nature, data from Revenue clearances can only include Irish taxed cigarettes. It does not capture consumption of cigarettes not taxed in Ireland (either cigarettes that are taxed and legally purchased elsewhere or the purchase of illegal untaxed cigarettes). The importance of this effect will depend on the level of cross border purchases of cigarettes and smuggling.

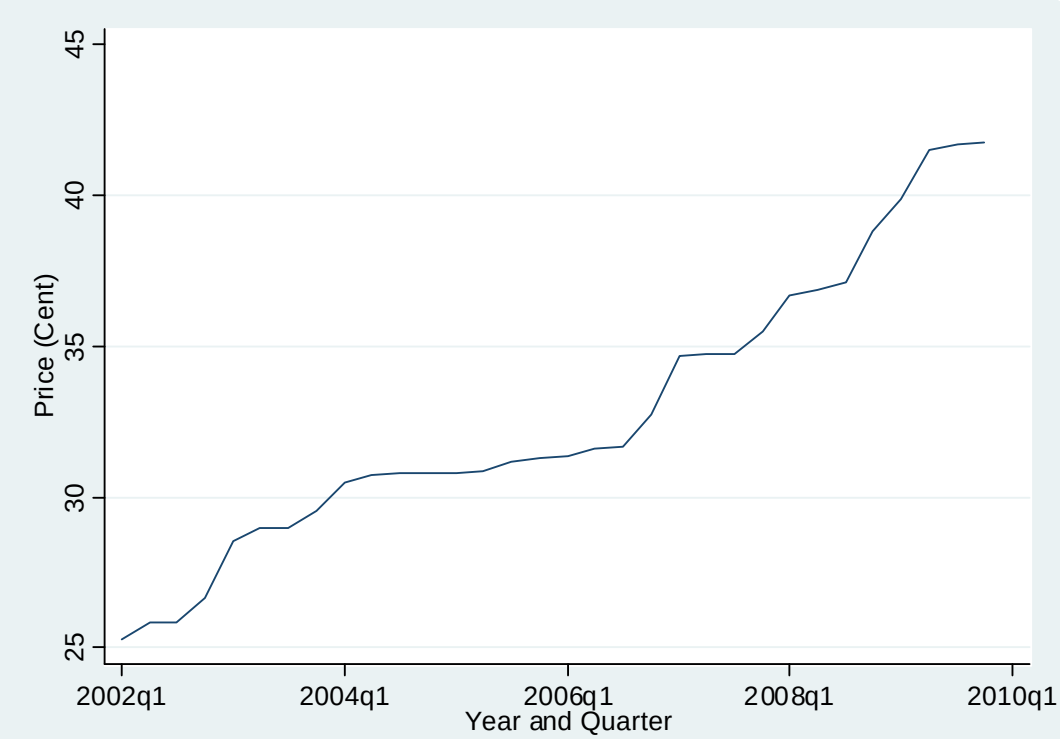
Third, a per capita consumption figure is derived for the population of adults (over 15 years of age) within the Irish population. Population data from the CSO Quarterly National Household Survey are used.[6]

Price

The first explanatory variable is the price of cigarettes. The nominal price variable (tax inclusive) is provided by the CSO and shown in Figure 3. To convert the price to real terms (i.e., taking into account the rate of inflation), a CSO tobacco Consumer Price Index (CPI) measured in 2001 prices is used. In many cases of economic analysis, it is preferable to work with real, rather than nominal, prices. The inflation rate of tobacco prices is considerably higher than that of a normal basket of goods. This is as a result of numerous tax increases on the price of tobacco over the years in question (2002-2009). A similar trend in tax increases is seen internationally, born of a desire by governments, non-governmental organisation and international institutions to discourage smoking.[7]

[6] 15 years is used as the threshold, it is based on the data available and is consistent with the literature on the topic.
[7] In addition, in relation to the base year, 2001 is close to the beginning of the sample period used the report.

Figure 3: Nominal Price Per Cigarette



Source: CSO data.

One limitation with regard to price must be noted. The data available from the CSO are the price of a twenty pack of cigarettes. Thus there is no distinction between 20 packs and 10 or 15 packs (now banned). A binary variable is included for introduction of the restriction on the sale of 10 and 15 packs (discussed below). On top of this, price data for hand rolling tobacco are not available in Ireland therefore restricting the analysis to 20 packs of cigarettes. The price variable included in this report is the real price per cigarette and is calculated by dividing the CSO figures by twenty. Because of difficulties during the modelling stage, the nominal (as opposed to real) price of a single cigarette is also used to provide for a more consistent estimation.

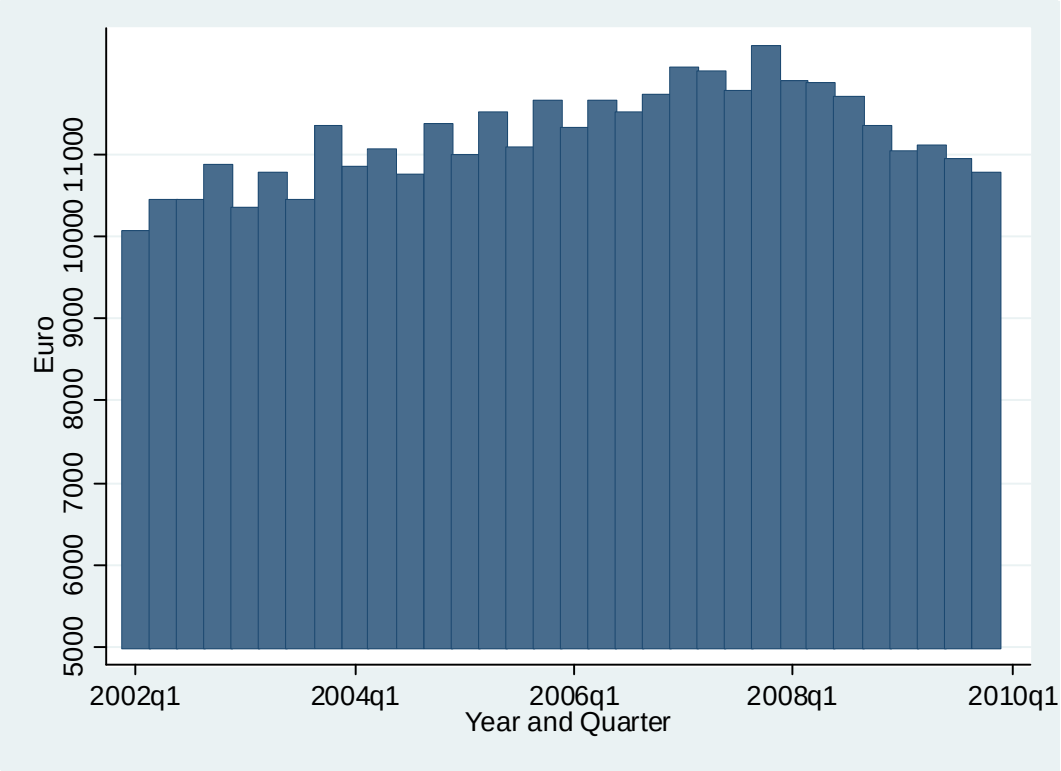
Gross Domestic Product

GDP per capita is included as a measure of income in the Irish economy. GDP per capita is used as a substitute for the preferred measure, disposable income per capita, which is not available on a quarterly basis. The nominal value of GDP (shown in Figure 4) was deflated to real terms using a CPI measure based in 2006.[8] Per capita GDP is

[8] An overall CPI is used here, rather than the restrictive tobacco CPI used to estimate the real price above.

calculated by dividing the GDP by the number of adults (older than 15 years of age) in the population. Both the quarterly GDP data and the CPI are sourced from the CSO.

Figure 4: Nominal Gross Domestic Product Per Capita



Source: CSO data.

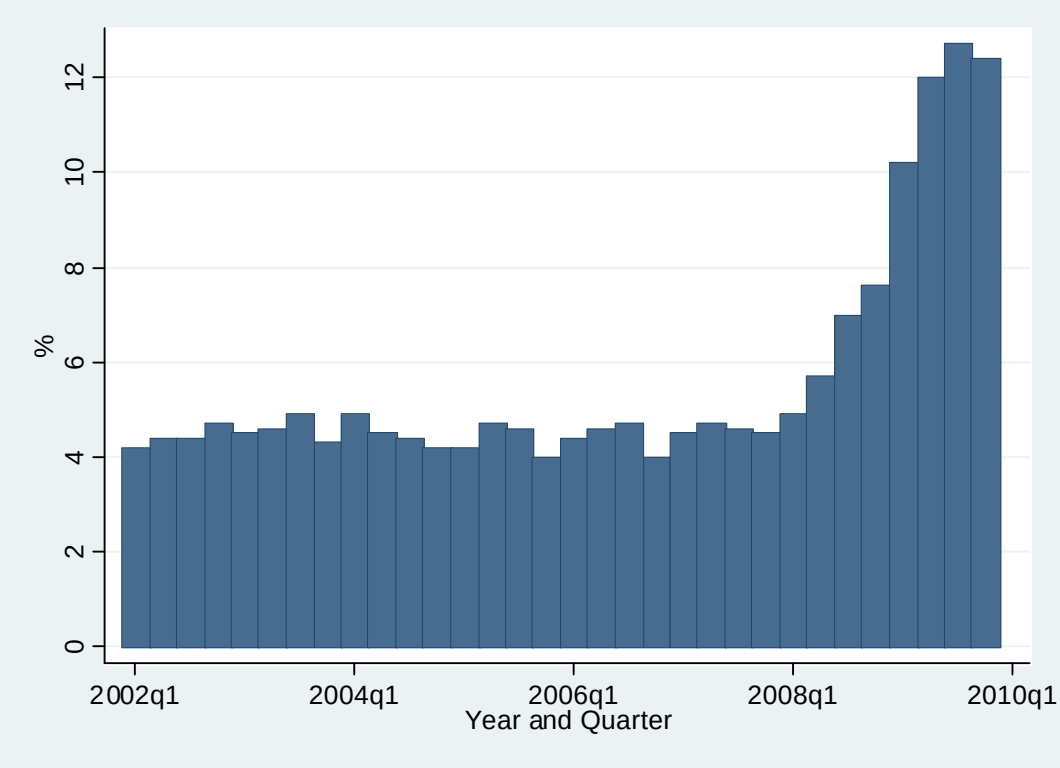
The GDP per capita variable also acts to an extent as a proxy for education level. The inclusion of a variable to measure the education level of the population was considered but not included. The justification for this is the widespread research that links education to income level. Educational attainment is often employed in studies using individual level data but the intuitive sense of inclusion of an education variable is lost when the data are aggregated. Previous studies, as outlined in the preceding section, have focused on education but this study is mainly interested in the effects of other variables on tobacco consumption thus the necessity to include education explicitly is diminished.

Finally, a limitation apparent in this variable comes from the fact that a better measure of personal disposable income is either inadequate or unavailable. However, the measure included should provide for suitably robust analysis. Ciecierski and Chaloupka (2000) support the use of GDP per capita as a valid proxy for disposable income.

The Unemployment Rate

The literature suggests the inclusion of the unemployment rate as a variable in the analysis (Figure 5). This tests to see if there exists any effects on tobacco demand from increases or decreases in unemployment. The data source for this variable is the CSO Quarterly National Household Survey.

Figure 5: Unemployment Rate



Source: CSO data.

Smoking Restrictions[9]

From reviewing the legislation in Ireland on smoking restrictions, summarised by the WHO (2010), that there are three distinct stages to the development of restrictions in Ireland, one outside the sample time period, two within.

In the first stage, there were limited restrictions before 2002 including both direct and indirect advertising and smoking in public places such as hospitals and buses. However, because of the scarcity of consumption data (the dependent variable), it was necessary to restrict the sample timeline to 2002 onwards. Therefore the earliest set of tobacco restrictions will not be captured in the analysis.

[9] This variable and the others discussed below are binary in nature, they take a value of either zero or one.

In the second stage, 2002 saw the introduction of the Public Health Act increasing restrictions on advertising, smoking in public places and restrictions on the sale of certain products.

The third stage of restrictions is the Public Health (Amendment) Act 2004 which introduced bans on advertising, more severe restrictions on the sale of tobacco products and, most notably, the workplace smoking ban.

A binary variable for smoking restrictions is set 0 prior to 2004 and 1 from 2004 onwards. Essentially, this variable indicates the introduction of the smoking ban in Ireland. Further binary variables on other smoking restrictions are discussed below.

EU Enlargement

A binary variable is introduced to account for EU enlargement in May 2004. This enlargement consisted of a 10-country accession to the European Union, countries which for the most part are situated in Eastern Europe. Ireland was one of the few existing EU members to fully open its labour market to workers from the new member states. This, combined with a buoyant Irish economy at the time, encouraged a relatively large flow of migration from Eastern Europe to Ireland.

The rationale for this variable is the increase in immigration to Ireland that occurred as a result of enlargement. This changed the population of tobacco users. The demographic profile of migrants was notable: many were young, male and found work in the construction sector. These characteristics are all associated with smoking, thus capturing these effects is important, as are the consequent effects on demand. The decision to include the enlargement as a binary variable and not as a share of the population that migrated to Ireland from the accession states was again necessitated by data availability.

One caveat for this variable is concerned with its timing. Only one quarter separates EU enlargement (Q2 2004) and the introduction of the Public Health Act 2004 (Q1 2004). One possible hypothesis is that the effects of the workplace smoking ban on cigarette consumption may have been mitigated by the increase in immigrants to Ireland from the new European states therefore separating these effects may provide interesting results.

Further Binary Variables on Smoking Restrictions

Three more binary variables are specified. The first binary variable specified is an adverting restriction, which came into force in Q1 of 2009. This variable captures the effects of a ban on the point of sale advertising of cigarette products by tobacco companies.

The second binary variable captures the effects of the easing of the purchase and personal transportation allowance of duty free cigarettes in the EU. In general, travellers within the EU face no restriction on the amount of cigarettes that can be brought from state to state as long as it can be proven that they are for personal consumption. Legislation, introduced in December 2008, eased rules that placed limits on the personal transportation of cigarettes from several member states that joined the EU in 2004.

The third binary variable included is another piece of legislation banning the sale of ten and fifteen packets of cigarettes in Ireland in Q2 2007.

3.3 Summary

Table 1 summarises the main descriptive statistics of the data for the continuous (non-binary) variables above: including the number of observations, their mean and standard deviation (a measure of the dispersion of the observations) as well as minimum and maximum values.

Table 1: Summary Statistics

Variable	Units	Observations	Mean	Standard Deviation	Minimum	Maximum
Consumption per Capita	Number of Cigarettes	32	423.88	97.31	285.15	674.16
Price per Cigarette	Cent	32	32	4.67	25.27	41.775
GDP per capita	Euro	32	11,228	559	10,086	12,329
Unemployment Rate	%	32	5.64	2.52	4.0	12.7

Source: authors' calculations. Note: all data are nominal values and quarterly; binary variables not shown.

4 The Model and Results

4.1 The Objective

The aim of the research in this report is to understand the demand for cigarettes in Ireland. Consumption of cigarettes is the variable to be analysed. Several economic factors are identified that would be expected to influence consumption, these are the variables discussed the above Section 3.

This section describes the econometric model and results that measures the relationship between cigarette consumption and the explanatory variables. The model assesses, in a statistically robust manner, whether these variables affect cigarette consumption and the strength and direction of that effect. An econometric model such as this is designed to indicate, for example between consumption and price, if there is a relationship (does price affect consumption), the direction (does a price increase lead to an increase or decrease in consumption) and the strength of the relationship (if price changes by X per cent, does consumption change by more or less than X per cent).

The sections below focus on discussing the results from the model. The Appendix contains a more detailed and technical description of the model, the specification of the variables and some other econometric issues that arise during the research.

4.2 Overview

Table 2 shows the results of the two models that perform best given the post-estimation testing. Following a brief review of the results table, a detailed discussion is provided describing more aspects of the data, the rationale for the types of analyses shown and the final results. This discussion is preceded by brief outline of the roll of lags and addiction in economics.

In Table 2 all the explanatory variables are regressed on total consumption and the estimated coefficients are shown for each. The figures for each explanatory variable indicate the influence of that factor on consumption. The asterisks next to estimated

coefficients indicate which are found to be statistically significant.[10] The interpretation of the results is discussed in detail below.

Table 2: Model Results

Dependent Variable: Consumption	(1) OLS	(2) Stepwise OLS
Lag of Consumption	-0.132 (-0.89)	
2nd Lag of Consumption	-0.211 (-1.92)	-0.208** (-2.09)
Price	0.0134 (0.01)	
Lag of Price	-3.885*** (-3.35)	-3.583**** (-3.84)
GDP per capita	1.883**** (4.38)	2.109**** (6.00)
Unemployment Rate	-0.0123 (-0.37)	
Smoking Restriction	-0.388**** (-4.09)	-0.408**** (-4.77)
EU Enlargement	0.113 (1.12)	0.163* (1.99)
Advertising Ban	-0.0231 (-0.24)	
Traveller Allowance Restrictions	-0.160 (-1.98)	-0.166**** (-3.85)
Constant term	0.745**** (8.08)	0.673**** (13.70)
Number of observations	30	30
R-Squared	0.8894	0.8824
R-Squared Adjusted	0.8312	0.8517

Source: authors' model. Note: t statistics in parentheses; p<0.10*, p<0.05**, p<0.01***, p<0.001****

4.3 Lags and Addiction

The first of the models is estimated using a basic econometric method known as OLS. During the preparation of the variables, and given the time series nature of the data, lagged versions of consumption, price and GDP are generated. Gujarati (2003) provides a rationale for the use of lags: *"the dependence of a variable Y on another variable X is rarely instantaneous. Very often, Y responds to X with a lapse of time. Such a lapse of time is called a lag"*. The lag of a variable is the value of that variable in the previous time period, the second lag is the value in the period before that. Gujarati (2003) identifies the three reasons for lags in economics: psychological (as a result of a force of habit or inertia), technological

[10] A statistically significant result is one that is not likely to have occurred by chance. Varying levels of statistically significance are used (10%, 5%, 1% and 0.1%). The lower the level, the less likely the result has occurred by chance. The more asterisks next to a coefficient, the more significant the result.

(including a price change of a substitute in relation to a related good) and institutional factors (including contractual obligations of firms to suppliers). The rationale for the use of lags in this report is the importance of psychological factors related to smoking.

Cigarettes contain addictive ingredients, most notably nicotine.[11] The model must take account of the fact that consumption of addictive goods is likely to be affected by previous consumption because of this psychological factor. This is provided for by using two lagged consumption variables. These are a one-quarter lag of consumption and a two-quarter lag of the same variable.

This use of lags is extended to price also to provide an insight into the decisions of the cigarette consumer.[12] By allowing the price of a cigarette in a previous quarter to affect consumption at the current time, it assesses how consumers of cigarettes react to changing conditions or variables. For example, in the OLS column (Column 1) of Table 2, the price in the current quarter does not statistically significantly affect consumption in the current quarter; however, the price in the previous quarter does have a statistically significant effect on consumption this quarter. This indicates that decisions to change consumption habits are not instantaneous. Human decisions are subject to inertia, in this case from the addictive nature of cigarettes, and so the reported results are consistent with previous literature and, more importantly, they are consistent with reality.

4.4 OLS Results

The OLS results (Column 1 in Table 2) are broadly in line with initial expectations. However, starting from the top of the column, the one-quarter lag of consumption and the two-quarter lag of consumption are exceptions to these expectations. It would be expected, given the addictive nature of cigarettes, that previous consumption would positively effect consumption today. However, both coefficients carry negative signs.

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[11] OTC (2010) provides a brief discussion of why. *"Nicotine, one of more than 4,000 chemicals found in the smoke from tobacco products, is the primary component in tobacco that acts on the brain. Since nicotine was first identified in the early 1800s, it has been studied extensively and shown to have a number of effects on the brain and the body. Through inhaling smoke, the average smoker takes 1 to 2 mg's of nicotine per cigarette, which reaches the brain within ten seconds. However, the acute effects of nicotine dissipate in a few minutes, causing the smoker to continue dosing frequently throughout the day to maintain the drug's pleasurable effects and prevent withdrawal.*

[12] A lag was also provided for the GDP per capita variable. As noted previously, our GDP variable is used as a proxy for disposable income in the model and the expectation before the analysis was for a positive and significant coefficient on the variable. While these expectations were met across all our models, the same was not the case for the lagged specification of GDP, which is not reported as a significant determinant of consumption so it does not appear in the above specifications.

Importantly, neither variable is statistically significant in the OLS model (as denoted by the lack of asterisks next to those coefficients). This implies that, although a relationship was found between consumption and lagged consumption, it is not a statistically significant result.

Price in the current quarter is not a statistically significant variable but the one-quarter lag of price is statistically significant at the 1 per cent level of significance. An elasticity interpretation sees an increase in price of 1 per cent reducing consumption in the next quarter by 3.8 per cent. Compared to the existing literature, this is a very high figure (from the previous literature it would be expected that the elasticity would lie between –0.2 and –0.9). Section 5 discusses factors that may account for this high figure.

The next variable modelled is GDP per capita – the proxy for disposable income. The reported coefficient on GDP in this model is 1.883 and is statistically significant at the 1 per cent level of significance. This represents an income elasticity of demand of 1.9, i.e., a 1 per cent increase in income will lead to a 1.8 per cent increase in consumption. As would be expected, an increase in income allows smokers to consume more cigarettes.

The last of the continuous variables, the unemployment rate, has a negative coefficient as expected. This indicates that an increase in unemployment will reduce consumption. However, the result is not statistically significant.

The final four variables in the model are the binary variables. The first of these variables (Smoking Restriction) accounts for the Public Health Act 2004, which introduced, among other laws, the workplace smoking ban in Ireland. The coefficient is –0.388 therefore the introduction of the smoking ban resulted in a reduction in consumption of just over a third of a percent. This is statistically significant at the 1 per cent level of significance and is broadly in line with expectations.

The second binary variable captures EU enlargement in Q2 2004. This variable turns out to be insignificant in the OLS. However, it does carry the expected (positive) sign, as discussed in Section 3.2 enlargement is believed to have increased cigarette consumption.

The final two variables in this model are the point of sale advertising ban of Q3 2009 and the measures to further ease of the personal consumption allowances for travellers between certain EU states introduced from Q4 2008. While both variables have the expected (negative) sign, neither is statistically significant.

Overall, this model does a good job at explaining variation in the dependent variable. While there are some surprising results, most of the variables act as expected.

4.5 Stepwise Results

Column (2) in Table 2 shows the results of the model when stepwise regression, rather than simple OLS, is used.[13] Essentially, stepwise regression assesses all the possible explanatory variables in the dataset and tests which variables should be included in the model. Most research involves doing this process in a manual fashion but the use of stepwise regression automates the procedure. This procedure optimises the model, compared to the OLS model, as indicated by the R squared adjusted that indicates the fit of the model.[14]

Using this stepwise procedure a full model is specified with all possible explanatory variables in the dataset. Given the entry level to the model, the variables omitted, because of insignificance are the lag of consumption, the price in the current quarter, the unemployment rate, advertising ban and the ban on the sale of ten packets of cigarettes. This leaves a model with six statistically significant variables.

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[13] Gujarati (2003) describes the method of stepwise regression: *"In deciding on the 'best' set of explanatory variables for a regression model, researchers often follow the method of stepwise regression. In this method one proceeds either by introducing the X (explanatory) variables one at a time (stepwise forward regression) or by introducing all the possible X variables in one multiple regression and rejecting them one at a time (stepwise backward regression). The decision to add or drop a variable is usually made on the basis of that variable to the estimated sum of squares (ESS), as judged by the F-test".* Statistical packages usually allow the setting of significance levels at entry and exit points (levels). For example, in the above stepwise regression, a stepwise backward regression, beginning with a full model, variables may only enter the model if they are statistically significant at the 10 per cent level of significance or better. An issue with using stepwise regression techniques is that they take no account of whatever theory informs the model. As a statistical procedure, if a variable is significant at the entry level, it enters the model (or is not omitted depending on the form of stepwise). This aspect of the model is countered by giving the statistical package only variables that intuitively may affect consumption. The model chooses from these variables accordingly.

[14] The R squared indicates how much of the variation in cigarette consumption is explained by the explanatory variables. This model does a good job at explaining consumption over the course of the sample period. Going by the R Squared of both models, there is nothing to choose between them but looking at the R squared adjusted figures suggests that the stepwise regression model is a slightly better fitted model.

The first of these variables is the two-quarter lag of consumption. However, it does have a negative sign (like OLS), something unexpected given the nature of the good being consumed – it suggests that previous period consumption is linked to lower consumption in the current period. This may be linked to the downward trend seen in consumption overall in the period in question.

The second variable is the one-quarter lag of price. This is very similar to the reported coefficient from the OLS model, however its coefficient is slightly lower. This model's price elasticity of demand is –3.583 so a 1 per cent increase in price is found to reduce consumption by 3.6 per cent. It is important to remember that the variable modelled is consumption of taxed cigarettes. This issue is discussed further in the next section.

GDP is also quite similar to the coefficient estimated in the previous model. The stepwise regression reports an income elasticity of 2.109, slightly higher than in the OLS model.

The final three significant variables in the model are binary variables. The workplace ban on smoking is highly significant with a coefficient of –0.408 indicating a greater effect than that predicted by the OLS model.

The EU enlargement variable is statistically significant (at the 10 per cent level) with a coefficient of 0.162.

The further easing of restrictions on the personal consumption allowance for travellers from some EU member states is found to be significant in the stepwise model. The coefficient reported is –0.16. This indicates that consumption of cigarettes in Ireland is lower as a result of the easing of this restriction.

5 Discussion: Prices, Taxes and Smuggling

As previously noted, the coefficient returned on the price variable is quite high compared to the existing literature outlined in Section 2. Previous literature suggested a price elasticity of between -0.5 and -1 for Ireland, whereas the model produces an estimated elasticity of –3.6. That a 1 per cent change in lagged price is estimated to decrease consumption by 3.6 per cent is very large compared to any previous research.

This is clearly an important finding from the perspective of Revenue's role of administrating the tax system given that increased prices (often via taxation) are a key policy measure adopted to deter smoking.[15] At first glance, the high elasticity estimated might seem like a clear sign that higher taxation is effective at reducing cigarette consumption. However, a detailed reading of the analysis suggests this is not the case.

Consumption in this research is consumption of taxed cigarettes (excise duty payments are used as the data source). Therefore price increases are found to decrease consumption of taxed cigarettes, not all cigarette consumption.

It is quite likely that price increases cause consumption of taxed cigarettes to decrease and the consumption of untaxed cigarettes to increase. The fall in taxed consumption is not due only to lower levels of smoking but also from smokers substituting to a lower cost alternative (untaxed cigarettes).

There are two primary sources of untaxed cigarettes. The first is the purchase of cigarettes abroad by travellers that return to Ireland (these imported cigarettes may be taxed in purchasing country). As noted earlier, the restriction on the number of cigarettes that a traveller may bring into Ireland from certain EU countries freely for personal consumption has recently been further eased for newer member states. The second is the purchase of illegal untaxed cigarettes in Ireland (these are typically produced abroad and smuggled into Ireland for resale).

[15] Revenue Commissioners (2008) indicates that taxes, as a percentage of cigarette prices in Ireland, range from 76.9 per cent in 1998 to 80.1 per cent in 2008 (this is a combination of excise and VAT).

Revenue estimates that around 20 per cent of cigarettes currently consumed in Ireland are not Irish taxed and this figure has been rising in recent years. However, there is limited data on the consumption of untaxed cigarettes in Ireland so the scale of the issue is hard to assess. It is difficult to confirm the hypothesis above, that price increases lead to lower consumption of taxed cigarettes but increase the consumption of untaxed tobacco. However, there are several aspects of this research that support this theory.

First, Ireland's tax on cigarettes is one of the highest in Europe. Cigarettes prices are more than double the average for the EU overall. This in itself presents a powerful incentive for some smokers to substitute to untaxed illegal sources or to cigarettes legally sourced outside Ireland.

Table 3: Cigarette Price Index (EU Average =100)

Country	Price Index	Country	Price Index
EU27	100	Italy	104
Albania	33	Latvia	62
Austria	97	Lithuania	51
Belgium	108	Luxembourg	88
Bosnia	33	Malta	94
Bulgaria	46	Netherlands	111
Croatia	67	Norway	219
Cyprus	88	Poland	52
Czech Republic	75	Portugal	85
Denmark	117	Romania	47
Estonia	58	Serbia	30
Finland	110	Slovakia	73
France	133	Slovenia	65
Germany	119	Spain	73
Greece	72	Sweden	130
Hungary	51	Switzerland	104
Iceland	115	Turkey	52
Ireland	217	United Kingdom	166

Source: Eurostat data.

Second, as noted in the Section 4, the binary variable for the easing of traveller personal consumption allowances is found to be statistically significant and has a negative relationship with the consumption of taxed cigarettes. This measure has caused a decrease in taxed cigarette consumption in Ireland.

Third, for the reasons above, there may be a "Laffer" curve type effect in the cigarette market in Ireland. The tax rate and tax revenue are usually thought to have a positive relationship – a higher rate of taxation increases the tax revenue collected. Laffer (2004)

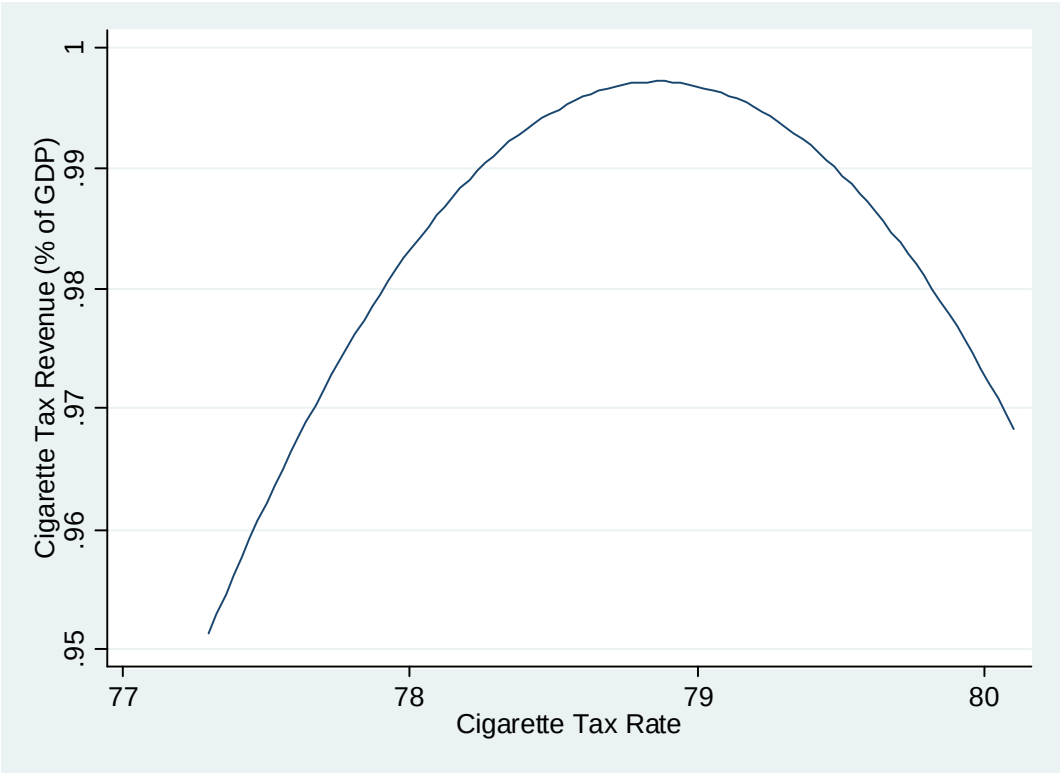
suggests that the relation between tax rates and revenue is often curved in nature. Initially, tax rate rises do increase tax revenue, however beyond a certain point tax rate rises may actually start to decrease revenue. The main causes for such decreases are that high levels of taxation either cause economic activity to reduce (the disincentive effect of higher taxation) or economic activity to switch to the shadow economy. Laffer suggests there is may be an optimum tax rate that maximises tax revenue (the peak of the Laffer curve), moving either direction (higher or lower taxes) from that peak will lower revenue.

It seems likely that a Laffer type effect exists in the cigarette market in Ireland and the current level of taxation may be beyond the optimum. Therefore higher tax rates (higher prices) will lead to lower tax revenue. This may explain, at least partially, the price elasticity found in this research.

Given the findings in the previous section, the relationship between tax rate and revenue is modelled by regressing the tax rate and the rate squared (the explanatory variables) on cigarette taxation revenue as a percentage of GDP (the variable to be explained). The estimated coefficients for the explanatory variables have the signs expected (there is a curved shape to the relationship between rate and revenue) but are not found to be statistically significant.

Because of the lack of statistical significance, robust conclusions from findings cannot be drawn. However, for illustrative purposes the curve predicted by the estimated coefficients is plotted in Figure 6 (this figure requires careful interpretation given the units of the axes).

Figure 6: Cigarette Taxes and Revenues in Ireland



Source: authors model.

The curve indicates the level of tax revenue that is expected to be collected at each tax rate. Its shape supports the idea that beyond a certain level of taxation, the tax revenue will start to fall. It appears that the current level of cigarette taxation in Ireland is just beyond (but very close) to the optimum rate (the peak of the curve).[16] Any further increase in taxation will move the rate further down the curve, implying lower revenue from cigarettes.

This is consistent with the high price elasticity estimated above. Again, it must be stressed that the above regression is not found to be statistically significant so the robustness of this finding is not certain. However, it supports the theory that higher taxes, causing higher prices, will reduce the consumption of taxed cigarettes in Ireland as taxes move further into the downward part of the curve. This will arise through a

[16] The horizontal axis represents the rate of cigarette taxation in Ireland as a percentage of the average price per pack. This price is calculated as a yearly average by the Revenue Commissioners (2009). The vertical axis measures cigarette tax revenue generated at each tax rate as a percentage of GDP. Therefore with the optimal rate estimated, the revenue will vary for each year as it depends on price and GDP level in that year. For illustrative purposes, the revenue maximising tax rate is 78.8 per cent, at the 2008 level of GDP, cigarette tax revenue would be maximised at about €1.16bn if the rate was set to the optimum level, compared the actual cigarette tax revenue of €1.13bn. The difference is small given the tax rate in 2008 (and currently) is very close to the optimum rate.

combination of less consumption of cigarettes (as people quit smoking) and less consumption of taxed cigarettes (as people substitute to untaxed cigarettes).

An additional point, that reinforces this theory, is that regression analysis using the same models as those in Section 4 but only focusing on the more recent years in the sample (i.e., not the whole period from 2002 onwards) suggests that the price elasticity is higher when earlier years are excluded. From the econometric perspective, the robustness of such findings is limited by the small number of observations. Nevertheless, it does provide some more evidence to support the theory that Ireland has in recent years moved to a position that further prices rises will encourage increases in untaxed consumption.

These findings are also consistent with some of the literature reviewed in second Section 2.4. The existing research on substitution towards untaxed cigarettes is limited at present but, as discussed in Section 2.4, there is some evidence from countries such as Australia, Canada and the UK that supports similar results.

6 Conclusion

There is an array of factors that affect the demand for cigarettes in Ireland. What is clear from this report and the results of the research is that consumption of taxed cigarettes in Ireland has decreased since 2002. While prices (taxes) are important variables, they must be added to recent legislation to explain how consumption has developed and changed in Ireland since 2002.

Taxation of cigarettes is an important source of revenue for the Irish Exchequer. From the analysis in this report, increasing cigarette prices will lead to lower taxed consumption as some smokers consume fewer cigarettes and others substitute to untaxed cigarettes. A price elasticity of demand is estimated that is extremely high given the previous literature and the current situation of the tobacco market in Ireland. Although the estimate is statistically robust, a price elasticity of demand of –3.6 cannot be explained entirely by reduced levels of smoking,

Higher prices (taxes) will contribute to lower smoking rates but, given current levels of taxation, they will also contribute towards more untaxed consumption. Further analysis suggests that Ireland has moved beyond the optimum point regarding the effectiveness of taxation to reduce cigarette consumption. This implies that further increases in taxes may not lead to further increases in tax revenue.

This research suggests that higher cigarette taxes in Ireland will no longer produce a win-win situation of public health benefits (lower rates of smoking) and benefits to the public finances (higher levels of tax revenue). More likely, it appears that in the Irish market for cigarettes as it current stands, a tax increase will reduce revenue but only have a lesser impact on tobacco consumption by encouraging further substitution away from taxed cigarettes.

Given the importance of the public health benefits, it is only right that policy-makers should aim to reduce smoking and tobacco taxation has been a key tool in addressing this objective. However, policy-makers should be cognisant of the full impacts of higher tobacco taxes and consider the costs of as well as the benefits of higher taxation.

Appendix: Model Specification

The Model

The model is outlined briefly in Sections 3 and 4. This Appendix provides a detailed analysis that may be of interest to the more technical reader.

Consistent with the aims of the analysis, the model attempts capture effects that have occurred in past years. In this respect, in various specifications, lagged variables for consumption, price and GDP are included, all of which are in logged form to allow for an elasticity analysis. The basic equations of the model discussed below are taken from Chaloupka, Tauras and Grossman (2000) on the economics of addiction.[17]

"Most empirical applications of myopic models of addiction are based on the pioneering work by Houthakker and Taylor (1966, 1970). They formally introduced the dependence of current consumption of an addictive good on its past consumption by modelling demand as a function of a 'stock of habits':

$$C(t)=a+bS(t)+X(t)G, \qquad \text{EQN (1.1)}$$

where C (t) is consumption of the addictive good at time t, X (t) is a vector of factors influencing demand, and S (t) is the stock of habits at time t, defined as:

$$S(t)=C(t-1)+(1-d)S(t-1), \qquad \text{EQN (1.2)}$$

Where d is the rate of depreciation. This stock of habits, or 'addictive stock,' represents the depreciated sum of all past consumption of the addictive goods and explicitly captures the dependence of current consumption on past consumption. Making appropriate substitutions, Houthakker and Taylor derived the following demand equation:

$$C(t)=p+tC(t-1)+[\mathbf{X}(t)-\mathbf{X}(t-1)]j+\mathbf{X}(t)q. \qquad \text{EQN (1.3)}$$

[17] This paper is aimed at researchers undertaking tobacco analyses in developing countries thus their discussion is framed accordingly. However, the basic mathematical equations outlined in the paper are applicable to our own analysis.

Thus, after simplification, making current consumption dependent on past consumption captures the addictive nature of demand. Houthakker and Taylor predicted that t will be positive for addictive or habit forming goods like tobacco products. Houthakker and Taylor estimated alternative versions of equation 1.3 for a number of goods, including cigarettes, using annual aggregates for the US and several Western European countries. Their estimates provided considerable support for their hypothesis of habit formation in demand, with positive estimates of the structural stock coefficient (b) for almost all of the non-durable consumer goods, including cigarettes, they examined".

Variable Specification

Throughout the estimation process the variables are transformed subject to various specification tests, some of which are unique to time series econometrics. The first such transformation is the introduction of logged versions of all continuous variables. By doing so an elasticity analysis is provided for. This is especially important for interpreting the results with regard to consumption, price and GDP in a way that is consistent with previous literature on the topic.

The second stage of specification deals with stationarity in the variables. The aim in time series is a stationary stochastic process. Stochastic refers to a random process where collections of random variables are ordered in time (Gujarati 2003). Then if this stochastic process is stationary, *"its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed"* (Gujarati 2003).

Graphing a variable over time gives a good sense of whether it is stationary or not, however, most statistical packages provide tests of stationary, the most common of which are the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) Unit Root test. The computed statistics are then compared to critical values (produced by the test). If a tested variable is non-stationary, the appropriate transformation to convert it to stationary form. Such transformations include first differencing ($\Delta x_t = \psi_o + \psi_1 x_{t-1}$) and the application of filters and smoothers, the latter depending on whether a variable exhibits a seasonal trend. Examples of non-stationary series include variables that exhibit patterns such as random walk with drift, random walk without drift, trend stationarity, difference stationarity, pure random walk, deterministic trend or possibly random walk

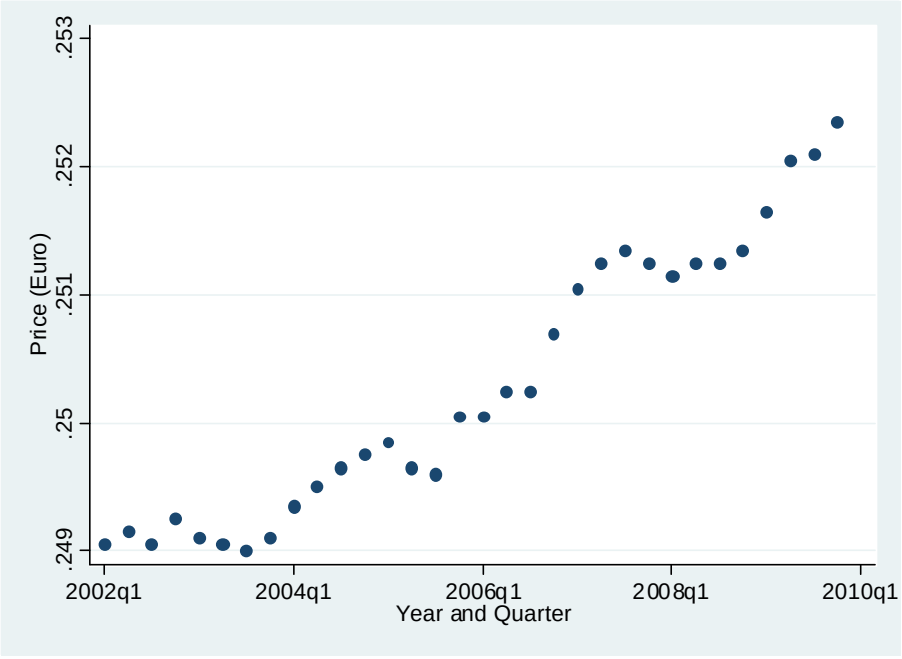
with drift and deterministic trend together. After the transformations, most of the variables are specified in a differenced stationary form.

The above procedures are used frequently in the modelling phase of this analysis in attempting to find the correct specification for the variables and ultimately the model itself. Upon completion of this, problems were still evident in the price variable.

Issues with Price

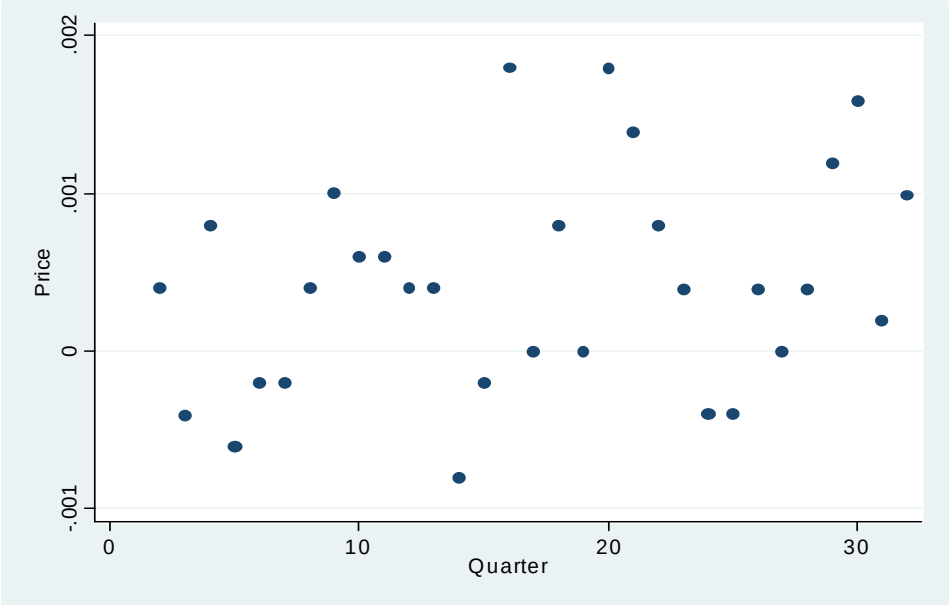
Figure A1 shows real price per cigarette. From including the logged and first differenced price variable, Figure A2, into the model, it became apparent that it was not correctly specified even though it now exhibits stationarity as a result of these transformations. In many of the different specifications, its reported standard error is too large and thus the coefficient on the variable is reported as being insignificant. From consulting with the literature available on such issues, Gujarati (2003) identifies the problem. To gain greater precision in the predicted coefficients, a large variation in the X values is needed. This type of variation does not exist in the observations of price as graphed in Figure A2 above. Essentially, the observations of price are too closely centred around zero.

Figure A1: Real Price Per Cigarette in Non-Stationary Form



Source: CSO data.

Figure A2: Real Price Per Cigarette in Stationary Form (logged and differenced)

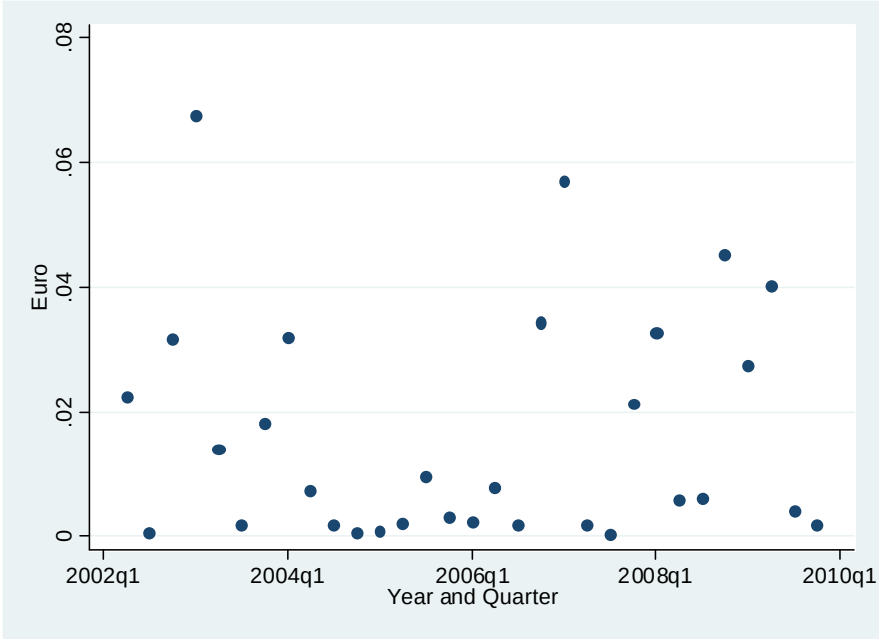


Source: CSO data and authors' calculations.

This left a couple of issues. First, from the previous literature on this topic, it is evident that price, is in most if not all cases, a very significant determinant of changes in the consumption of cigarettes. Accordingly, it is not a variable to include in the model in a specification that is not ideal.

Second, including the log of price into the model minus the first difference transformation would be incorrect, given that it would no longer be a stationary variable. Given these difficulties it was decided to re-specify price from real to nominal terms, log it and apply a first difference transformation. While the advantage of having the variable in deflated form is lost, the price now exhibits more variation while being stationary.

Figure A3: Nominal Price Per Cigarette (logged and differenced)



Source: CSO data and authors' calculations.

Models used in Analysis

In consulting the time series literature, a researcher will quickly become aware of the divergence in modelling technique used. Specific time series models include distributed lag models, autoregressive models, the adaptive expectations approach, partial adjustment models, simultaneous equation models, Error Correction Modelling, ARIMA models, VAR models, ARCH models and GARCH models. The type of model chosen depends to a large extent on the data. For example, with data whose volatility increases over time, such as stock market activity or possibly some types of consumption, an ARCH model would account for increasing variation in a series over time.

Each of the above models satisfies the varying concerns that may arise during an analysis of a given dataset but what is also true is that Ordinary Least Squares (OLS) estimation should be the preferred option if possible. Accordingly, where possible, this analysis is completed using OLS. Extensions of OLS such as an Error Correction Model and stepwise regression are also incorporated in the correct model.

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