

The Demand for Cigarettes in Ireland

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I. Introduction

Extensive research from numerous countries around the world has demonstrated the effectiveness of higher cigarette and other tobacco product taxes and prices in reducing cigarette smoking, other tobacco product use, and the death, disease, and economic costs caused by tobacco use. In its forthcoming Handbook on *Effectiveness of Tax and Price Policies for Tobacco Control*, the International Agency for Cancer on Research (IARC) reviews this extensive research and concludes that tax increases that raise price: reduce overall tobacco use; reduce the prevalence of adult tobacco use; induce current tobacco users to quit; reduce the prevalence of tobacco use among young people; reduce the initiation and uptake of tobacco use among young people, particularly the transition from experimentation to regular use; lower the consumption of tobacco products among those who continue to consume; improve population health; increase tobacco tax revenues; and produce additional public health benefits while not creating economic consequences (IARC, in press; Chaloupka, et al., 2011).

The evidence base for the effectiveness of higher tobacco taxes and prices in reducing tobacco use make tax and price increases a central component of the World Health Organization's (WHO) Framework Convention on Tobacco Control (FCTC), the first global public health treaty negotiated by WHO. Specifically, Article 6 of the WHO FCTC, on 'price and tax measures to reduce the demand for tobacco', states:

1. The Parties recognize that price and tax measures are an effective and important means of reducing tobacco consumption by various segments of the population, in particular young persons.
2. Without prejudice to the sovereign right of the Parties to determine and establish their taxation policies, each Party should take account of its national health objectives concerning tobacco control and adopt or maintain, as appropriate, measures which may include:
 - (a) implementing tax policies and, where appropriate, price policies on tobacco products so as to contribute to the health objectives aimed at reducing tobacco consumption; and
 - (b) prohibiting or restricting, as appropriate, sales to and/or importation by international travellers of tax- and duty-free tobacco products.
3. The Parties shall provide rates of taxation for tobacco products and trends in tobacco consumption in their periodic reports to the Conference of the Parties in accordance with Article 21. (WHO, 2003).

More recently, WHO has provided additional guidance to governments interested in implementing effective tax and price policies for the purpose of reducing tobacco use. In its *Technical Manual for Tobacco Tax Administration*, WHO provides a series of 'best practices' for tobacco taxation (WHO, 2010). These 'best practices' include a variety of recommendations regarding the objectives of tobacco taxation, tax structure and levels, and tax administration, including:

- Using tobacco tax increases to achieve public health goals, while recognizing that these taxes will also generate revenue in the short to medium term, but declining revenue in the long term as tobacco use is reduced by higher taxes and other effective tobacco control policies.
- Setting tobacco excise taxes so that they account for at least 70 percent of the retail prices of tobacco products and, once this target is met, increasing taxes further so as to maintain the real value of the tax and reduce the affordability of tobacco products.
- Adopting simple tax structures that rely more on specific excises and that are comparable across all tobacco products.
- Eliminating tax- and duty-free sales of tobacco products, as called for in the WHO FCTC.
- Including tobacco tax increases as part of a comprehensive approach to reducing tobacco use that includes other effective tobacco control policies, including: comprehensive smoke-free air policies; bans on all tobacco advertising, promotion and sponsorship; large, graphic health warning labels on tobacco product packaging and other efforts to inform about the health risks from tobacco use; and support for users interested in stopping their tobacco use.
- Dedicating a portion of the revenues generated by tobacco taxes for other tobacco control and/or health promotion activities.
- Strengthening tobacco tax administration in order to reduce tax avoidance and tax evasion by adopting new technologies, licensing all involved in tobacco product manufacturing and distribution, and insuring swift and severe penalties for those caught engaging in illegal trade in tobacco products (WHO, 2010).

Ireland has been among the leaders in implementing tax and price as part of a comprehensive approach to tobacco control with the aim of reducing tobacco use and its consequences. Cigarette excise taxes have been increased regularly over time and account for over 61 percent of the retail price of the most popular brands and over 71 percent of the price exclusive of the value added tax; when value added taxes are included, total taxes rise to nearly four-fifths of retail price. Ireland was the first country to implement a comprehensive smoke-free air policy, runs an effective mass-media campaign to inform the public about the harms from smoking, provides a variety of support for smoking cessation, and has among the most comprehensive limits on tobacco company marketing in the world. As a result, cigarette smoking prevalence

has fallen by more than 20 percent over the past decade, while cigarette sales have fallen even more sharply (Euromonitor International, 2011).

A recent report from the Office of the Revenue Commissioners (ORC), however, suggests that Ireland may have gone past the 'optimum point' with respect to cigarette taxation, concluding that while further tax increases will lead to additional reductions in smoking, they will lead to sharp increases in tax avoidance and tax evasion, resulting in a decline in cigarette excise tax revenues (Reidy & Walsh, 2011). In this report, we provide a reanalysis of the data used in the ORC report. While we also estimate relatively large reductions in tax paid cigarette sales in response to tax and price increases, our estimates are well below those obtained in the ORC report. Our estimates suggest that the revenue impact of additional cigarette excise tax increases would be minimal, in contrast to the ORC estimates that imply large reductions in cigarette tax revenues in response to additional tax increases.

In the next section, we provide some additional background on the existing evidence regarding the impact of taxes and prices on cigarette smoking, briefly reviewing the evidence from high-income countries, with a more thorough review of research from Ireland, including the recent ORC report. This is followed by a description of the data employed in our econometric analysis of Irish cigarette demand, including a discussion of the key differences between our approach and that used in the ORC estimation. We then present and discuss the results from our models. The final section contains a discussion of our findings, their implications for cigarette tax policy in Ireland, and suggestions on how to strengthen cigarette tax administration in order to maximize the public health and revenue impact of cigarette taxes in Ireland.

II. Existing Evidence on the Impact of Taxes and Prices on Cigarette Smoking

Global Evidence

Numerous studies have examined the impact of tobacco product taxes and prices on tobacco use. Prior to 2000,, nearly all studies came from high-income countries. These studies consistently found that increases in taxes and prices on tobacco products lead to reductions in tobacco use. The vast majority of studies from high-income countries have produced estimates of price elasticity - the percentage reduction in consumption resulting from a one percent increase in price - in the range from -0.2 to -0.6, with most clustered around -0.4 (IARC, in press). Several modeled the addictive nature of tobacco use, finding that tobacco demand is more price responsive in the long run than in the short run.

Over the past decade, many studies have examined the impact of taxes and prices on tobacco use in low- and middle-income countries. These studies produce a wide range of estimated price elasticities, with most, but not all, indicating that demand for tobacco products is at least as responsive, and often more responsive, to price in low and middle-income countries than it is in high income countries. For example, Hu and Mao (2002) estimated that the price elasticity of cigarette demand in China ranges from -0.50 to -0.64, while John (2008) estimated price elasticities in the range from -0.86 to -0.92 for bidis and -0.18 to -0.34 for cigarettes in India.

Findings from studies based on survey data of adult tobacco use show that taxes and prices influence both the prevalence of tobacco use and amount of tobacco consumed by users (IARC, in press). In general, estimates from high-income countries suggest that about half of the impact of price on tobacco use results from its effect on prevalence, largely reflecting cessation among adult users. This is confirmed by studies which find that increases in prices lead current users to try to quit, with some successful in doing so in the long run. Comparable studies from low and middle-income countries also find that cigarette prices affect both prevalence and intensity of cigarette smoking, although the relative impact on prevalence and consumption varies considerably across studies/countries (IARC, in press).

Several studies have examined the differential responses to price of population subgroups, including those based on age, gender, income, education, race/ethnicity, and location (urban vs. rural). Consistent patterns are evident with respect to differences by age and socioeconomic status (SES). Studies looking at tobacco use among adolescents and young adults find that young people are two to three times more responsive to tax and price than are older persons, with higher taxes and prices particularly effective in keeping young people from moving beyond experimentation with tobacco, and preventing them from becoming regular and, eventually, addicted users (IARC, in press). Research from high-income countries generally finds that lower SES populations are more responsive to price than are higher SES populations.

Comparable studies from low- and middle-income countries produce mixed findings, with some finding a socioeconomic gradient in price elasticities and others finding little difference among different SES groups (IARC, in press).

Finally, several studies examine substitution among tobacco products in response to changes in their relative prices. These studies generally find that part of the reduction in the use of one tobacco product in response to an increase in its price will be offset by increased use of other tobacco products if the prices of these products are not also increased (IARC, in press). This substitution highlights the importance of increasing taxes and prices for all tobacco products if the public health benefits of higher prices are one of the motives for tobacco tax increases.

To summarize, a large and growing literature clearly demonstrates that the overall demand for tobacco products is significantly affected by changes in tobacco product taxes and prices, with tobacco use among the young and lower SES populations most affected. These studies demonstrate that price affects all aspects of tobacco consumption, with higher prices preventing initiation among potential users, inducing cessation among current users, and reducing the frequency of consumption and amount consumed by continuing users, while changes in the relative prices of tobacco products will lead to some substitution among products.

Evidence from Ireland

A few studies have assessed cigarette demand in Ireland. Price elasticity estimates obtained in most of these studies are consistent with the evidence from other high-income countries. Koutsoyiannis (1963) estimated time-series models of cigarette demand for a number of countries, including Ireland. His estimated price elasticity of -0.15, not statistically significant at conventional levels, suggested that cigarette tax and price changes would have little, if any, impact on cigarette consumption. A few years later O'Riordan (1969) estimated a variety of time-series models using data from 1953 through 1967, producing estimates of price elasticities ranging from -0.69 to -0.92, suggesting that tax and price increases would lead to sizable reductions in cigarette consumption, while at the same time generating significant new tax revenues.

Several subsequent time-series studies produced estimates within the range produced in these earlier studies. Walsh (1980), for example, found that Irish cigarette demand was becoming increasingly inelastic over time, estimating price elasticities of -0.79 for the period from 1953 through 1960 and of -0.38 for the period from 1961 through 1976. Madden's (1993) estimates for the period from 1958 through 1988 were similar to these, with elasticities ranging from -0.33 to -0.68. Conniffe (1995) accounted for the addictive nature of tobacco demand in his

modeling, estimating short run price elasticities in the range from -0.29 to -0.40, with long run elasticities between -0.38 and -0.39.

Madden (2003) used retrospective data from a sample of Irish women - the 1998 Saffron Survey - to look at the impact of taxes on smoking initiation and cessation. He finds that higher cigarette taxes are generally associated with reduced smoking initiation and increased smoking cessation. In his models that assess differences in price responsiveness by education, he finds that higher taxes have the greatest impact on initiation of smoking among those with intermediate levels of education, while having their greatest impact on smoking cessation among those with the least education.

Most recently, Reidy and Walsh (2011) used quarterly time-series data for the period from 2002 through 2009 to produce an updated estimate of the price elasticity of demand for cigarettes in Ireland. Their model attempts to control for a variety of other factors that potentially influence cigarette demand, including general economic conditions, tobacco control policies, and the expansion of the European Union to include ten mostly central/eastern European countries. They estimate a price elasticity of -3.6, indicating that Irish cigarette demand in recent years is considerably more responsive to changes in taxes and prices than implied by the estimates from previous studies for Ireland, other high-income countries, and virtually any other country in the world. They attribute the substantially higher responses to price to significant tax avoidance and tax evasion. Specifically, given that their measure of cigarette consumption is tax-paid cigarette shipments at the wholesale level, they conclude that increases in taxes lead to significant reductions in these shipments that are the result of both real reductions in smoking and increased consumption of cigarettes on which taxes have not been paid. They speculate that the untaxed cigarettes result from both Irish smokers obtaining duty-free cigarettes from other EU countries (most notably the new members where taxes and prices are well below those in Ireland and other long standing member states) and increased smuggling of untaxed cigarettes into Ireland.

While it is true that cigarette tax increases create incentives for increased tax avoidance and tax evasion that would lead to less inelastic estimates of price elasticity (Chaloupka, et al., 2000a), the Reidy and Walsh (2011) estimated price elasticity of -3.6 appears implausibly high and the differences between their estimate and estimates from the existing literature seem likely to be driven by more than just increased tax avoidance/evasion. From 2002 through 2009, taxes and prices were regularly increased, with inflation adjusted prices rising by more than 40 percent from 2002 through 2009. The Reidy and Walsh estimated price elasticity suggests that the market for tax-paid cigarettes in Ireland should have virtually disappeared over the past decade while being replaced by a somewhat smaller, but sizable illegal market. Tax avoidance and evasion did increase in Ireland during this period, but not to the extent suggested by the Reidy

and Walsh estimates. Euromonitor International (2011), for example, estimates that untaxed cigarettes accounted for about 5.6 percent of Irish cigarette consumption in 2002, rising to about 27.4 percent in 2009.

Instead, several other factors are likely to contribute to the unusually elastic estimate obtained by Reidy and Walsh (2011). First, they claim to be estimating a model of cigarette demand based on an economic model of addiction, but the specification they propose is unlike any other model of addiction in the extant economic literature. Myopic models of addiction typically include a lagged measure of consumption, in addition to current price, to account for the dependence of current consumption decisions on past consumption (addiction) (Chaloupka, et al., 2000b). Rational addiction models extend this approach by treating smokers as farsighted, implying that future prices and other determinants of demand will affect current consumption decisions; most empirical applications of the rational addiction model include both future and past consumption as determinants of current consumption, with less restricted versions of the model include lagged and led price in addition to current price (Chaloupka, et al., 2000b). In contrast, Reidy and Walsh's initial specification includes two lags of consumption, current price, and one lag of price, in addition to other factors, as determinants of current consumption - a completely atheoretical specification that seems likely to result in considerable difficulty in obtaining a precise estimate of the impact of price on cigarette consumption given the substantial correlations between the two lags of consumption and the lagged and current cigarette price variables.

The problems with this specification are apparent in the estimates they present in Table 2 of their report. Rather than past consumption having a positive impact on current cigarette consumption, as implied by addiction, Reidy and Walsh's estimates for the two lags of consumption are both negative, albeit statistically insignificant. Similarly, their estimated coefficient on current cigarette price is essentially zero, implying that current cigarette prices have no impact on current cigarette consumption (in contrast to the large and growing evidence base demonstrating that changes in cigarette prices have immediate effects on cigarette consumption), while lagged price is found to have a negative and statistically significant effect.

The specification problems inherent in their model are exacerbated by the use of stepwise regression methods - an atheoretic approach that drops variables from the model based on their lack of statistical significance. As suggested above, there is likely to be considerable correlation between the multiple measures of the same variables in consecutive periods, creating multicollinearity problems that can result in imprecise, statistically insignificant estimates for these variables. The stepwise regression approach arbitrarily eliminates some of these variables; in the Reidy and Walsh modeling, this results in a final specification that

includes the second lag of consumption and not current price, but rather one lag of price. In this specification, the second lag of consumption is found to have a negative and statistically significant effect on current cigarette consumption - the opposite of addiction, implying that higher past smoking leads to lower current smoking. This specification, based on the lag of cigarette price, produces the unusually high estimate for the price elasticity of cigarette demand.

Their approach suffers from several other shortcomings. In contrast to virtually every previous time series study of cigarette demand, Reidy and Walsh do not adjust their measure of price for inflation, arguing that the inflation adjusted measure of price is non-stationary while the nominal measure is stationary. This seems inconsistent with the data they present. Non-stationarity implies that there is some underlying trend, either up or down, in the variable of interest. Based on the data presented by Reidy and Walsh, there is a clear upward trend in nominal cigarette prices over time making it likely that the nominal price variable is non-stationary. This upward trend is less pronounced in the inflation adjusted price measure, given that nominal cigarette prices are rising in part because of general increases in raw material, labor, and other production and distribution costs. Indeed, the inflation adjusted measure of price, while generally rising over time, often falls in consecutive quarters when there are no tax increases or industry price increases. If they are concerned that the inflation adjusted cigarette price variable is non-stationary, then the appropriate approach would be to use cointegration techniques that directly address the stationarity problem, not to use the nominal price variable instead. Given that there are underlying trends in the data, an alternative approach would be to directly model these trends. However, Reidy and Walsh do not account for trends in their data. Given that price and cigarette consumption are trending in opposite directions, omitting a trend variable from their analysis is likely to result in an overestimate of the impact of price changes on cigarette smoking, with this problem exacerbated by the use of the nominal price variable.

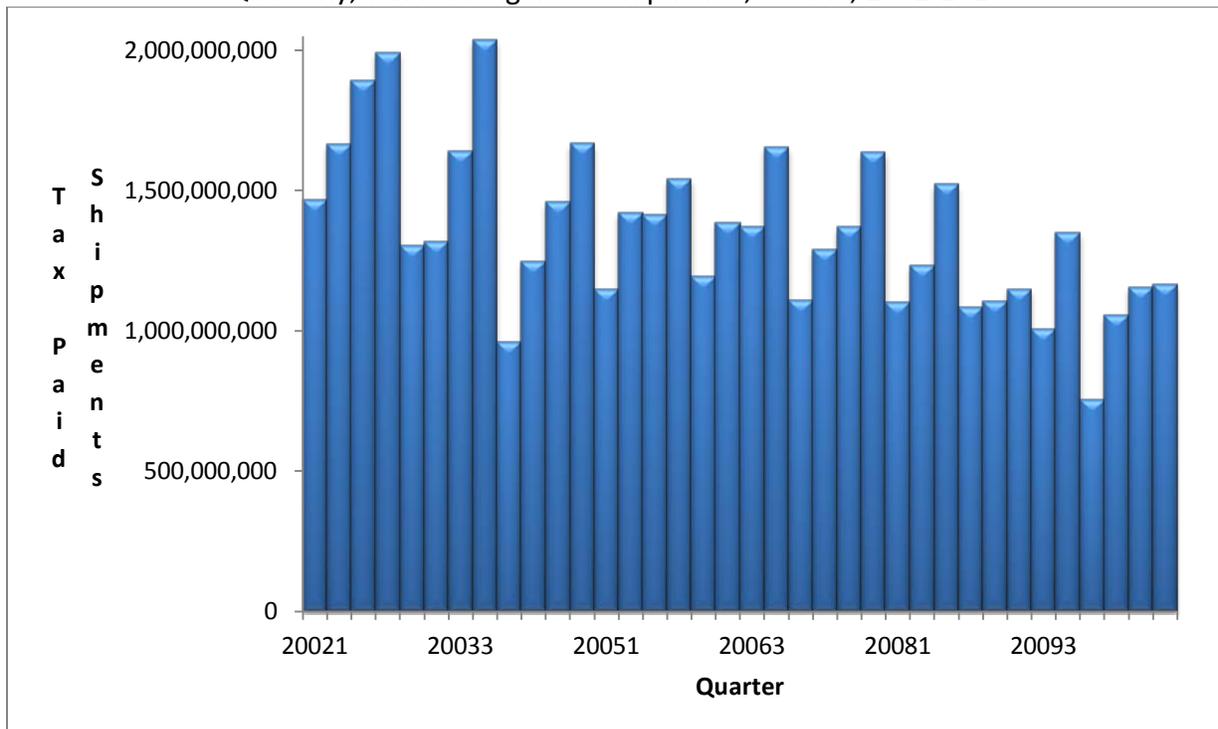
There are additional omitted variables that are likely to bias the estimates for the included variables. Reidy and Walsh make no effort to control for the likely seasonality and other factors that will influence the tax paid wholesale shipments measure that is their proxy for cigarette consumption. As they note, there are large increases in shipments in anticipation of tax increases that do not reflect changes in consumption, but rather efforts by wholesalers to avoid the tax increase by distributing more cigarettes before an increase takes effect. Given that tax changes are somewhat predictable and tied to the budgeting process in Ireland, this will lead to larger than normal sales in the month or two leading up to an anticipated tax increase, followed by lower than normal sales in the month of the increase. Failing to account for this type of tax avoidance results in a biased estimate of price elasticity that suggests greater changes in consumption in response to tax increases than is actually the case.

To summarize, findings from existing research estimating the price elasticity of cigarette demand in Ireland are consistent with the large and growing global evidence base. Specifically, higher cigarette prices are found to lead to reductions in cigarette consumption, with most estimates of price elasticity centered around -0.4, implying that a ten percent increase in the price of cigarettes would reduce overall cigarette consumption by about four percent. Given that tax is only a fraction of price and that the reductions in cigarette consumption are proportionately smaller than the increase in price, these estimates imply that increased cigarette taxes would lead to significant increases in cigarette tax revenues, despite the reductions in cigarette smoking that result. The recent report by Reidy and Walsh (2011) based on data for the period from 2002 through 2009 concludes that the price elasticity of cigarette demand in Ireland is much greater than found in any of the prior studies not just for Ireland but for any other country. This study, however, contains a number of methodological problems that likely result in a biased estimate of price elasticity. Our analysis, described below, addresses these problems.

III. Data and Methods

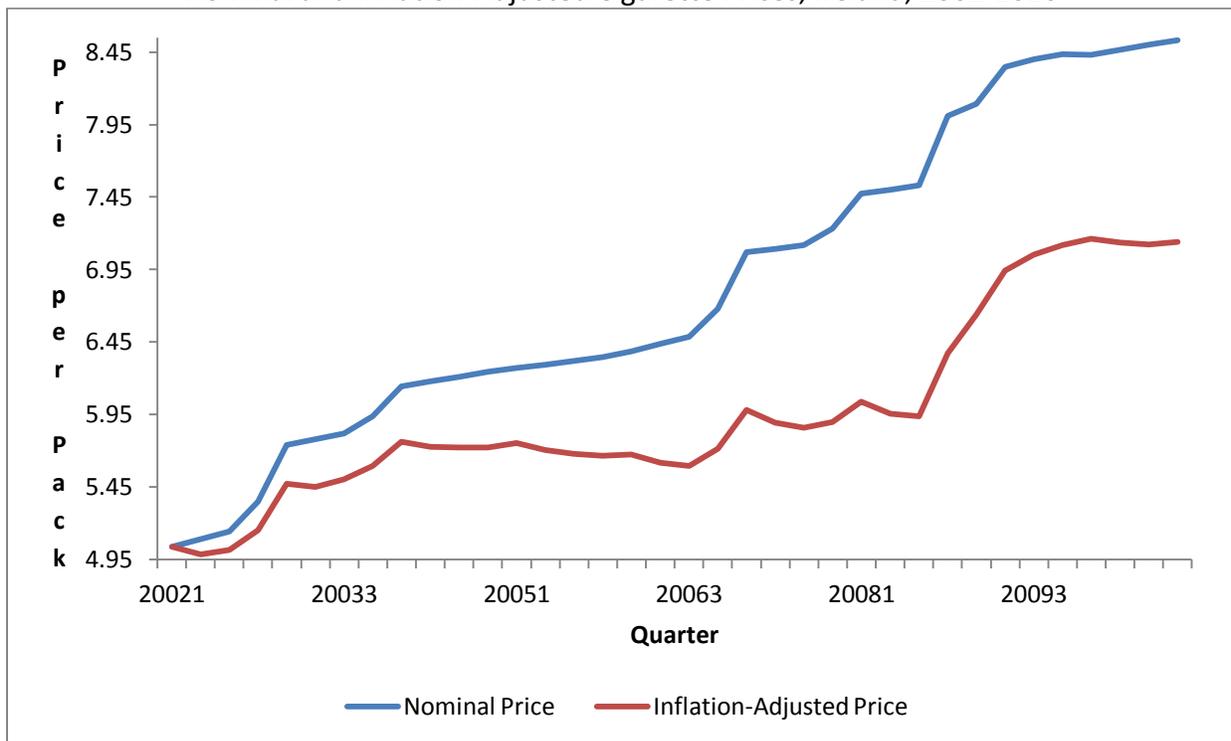
We use quarterly data from 2002 through 2010 to estimate the demand for cigarettes in Ireland. While actual cigarette consumption would be the ideal dependent variable in this type of aggregate demand analysis, data on actual cigarette consumption do not exist. Instead, we use a measure of tax paid cigarette sales, based on cigarette clearance data from the Office of Revenue Commissioners. These data reflect the payments of cigarette excise taxes at the wholesale level. As a result, they will differ from consumption in two key respects. First, they do not include consumption of cigarettes for which Irish cigarette taxes have not been paid - those obtained by Irish smokers through various forms of tax avoidance (most likely duty free cigarette purchases in other countries and cigarettes purchased in other countries on which local taxes have been paid). Second, while generally highly correlated with consumption of tax paid cigarettes, there will be some disconnect between shipments and actual consumption. As described above, shipments will likely be more variable than actual consumption as shipments can be increased in periods leading up to anticipated tax increases and can fall sharply when taxes are increased, while consumption will be smoother over time. This greater variability is reflected in the underlying data, as shown in Figure One below. Finally, in the estimated models, we use per capita cigarette consumption, based on the population ages 15 years and older.

Figure One
Quarterly, Tax-Paid Cigarette Shipments, Ireland, 2002-2010



Our measure of cigarette price also comes from the Office of Revenue Commissioners and reflects the inflation adjusted price for a pack of 20 of the most popular category, filter tipped cigarettes, inclusive of all cigarette excise and value added taxes. As shown in Figure Two, nominal and inflation adjusted (2002, first quarter base) cigarette prices have risen steadily in Ireland over the past decade, with nominal prices increasing monotonically, while real (inflation adjusted) prices have fallen for some quarters or remained relatively flat over several quarters/years, in part due to the stability of cigarette taxes. Interestingly, even in years when the cigarette industry successfully lobbied against cigarette tax increases, it increased its own prices.

Figure Two
Nominal and Inflation-Adjusted Cigarette Prices, Ireland, 2002-2010



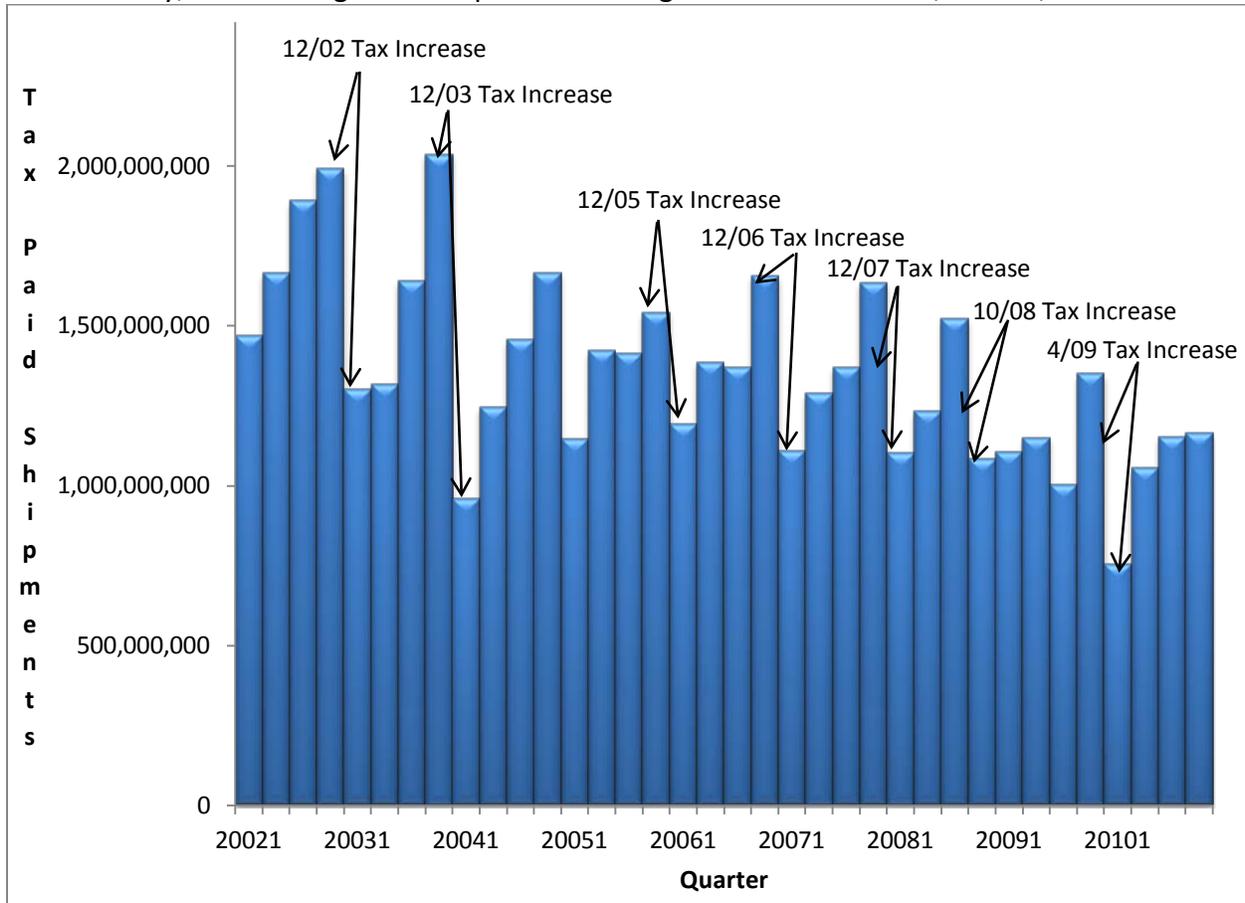
Two variables are included to control for underlying economic conditions in Ireland - per capita, inflation adjusted gross domestic product, as a proxy for income, and the quarterly unemployment rate. Over the past few decades, the relationship between income and cigarette smoking has changed in most high-income countries. In the past, increases in income would result in increases in cigarette smoking; more recently, however, as knowledge about the health consequences of smoking has increased, this relationship has either disappeared or reversed (Jha and Chaloupka, 1999). At the same time, stressful situations like unemployment can lead to increases in cigarette smoking as a means for coping with stress.

Multiple variables are included to control for tobacco control policies in Ireland. In some model specifications, these policies are controlled for by multiple policy indicator variables. These include: an indicator variable capturing the implementation of the Public Health (Tobacco) Act amendment of 2004 that implemented the first national-level comprehensive smoke-free policy in the world in late March 2004; an indicator reflecting the implementation of the ban on smaller cigarette packs (those with 10 or 15 sticks) that went into effect in the second quarter of 2007; and an indicator reflecting the comprehensive ban on point-of-sale marketing that went into effect in 2009. Given the potential for collinearity between these policy variables and other variables included in the model, a second set of models replaces these individual indicators with a 'tobacco control policy scale' variable that combines these into one measure reflecting the breadth and strength of Ireland's tobacco control policies. This has the added advantage of capturing the existing policy environment from the beginning and is based on a modified version of the tobacco control scale (TCS) developed by Joossens and Raw (2006). Their TCS captures multiple tobacco control policy domains, including tax and price, smoke-free air policies, warning labels and other information interventions, bans on tobacco marketing practices, and access to cessation treatments and services. Given the focus of our analyses on price, the TCS is modified by excluding price and rescaling the other measures that are included in the index (Currie, 2011).

Similarly, multiple measures are included in an effort to control for opportunities for tax avoidance. These include the two indicator Reidy and Walsh (2011) employed. The first of these is an indicator for the expansion of the European Union in 2004, reducing travel barriers between Ireland and the accession countries where cigarette prices are well below prices in Ireland. The second indicator captures the late 2008 easing of limits on the number of cigarettes that individuals can transport from these accession countries. In addition, we add three new measures. Two of these capture travel inflows and outflows, reflecting the opportunities for cigarette purchases in other countries from duty free shops and/or at prices that include local taxes but are well below prices in Ireland. The third is an indicator for the period immediately preceding an excise tax increase and captures the likely stockpiling of cigarettes in an effort by distributors and retailers to avoid the tax increase. During the period covered by our analysis, most of the tax increases went into effect in early December; thus, this variable captures the likely extranormal shipments of cigarettes in October and November, and below average shipments in December and in subsequent months. This tax avoidance is apparent in Figure Three, which repeats the data shown in Figure One highlighting the quarters containing the months immediately preceding excise tax increases. Excise tax increases were adopted in December 2002, December 2004, December 2006, December 2007, October 2008, and April 2009. As seen in Figure 3, the quarters containing the months immediately before the tax increases have much higher shipments than earlier quarters, while shipments in the quarters containing the months following the tax increase are well below those in other

quarters. This suggests that there is considerable stockpiling in an effort to avoid tax increases and that failing to account for this stockpiling would lead to a biased estimate of the price elasticity of cigarette demand. Indeed, the only spike in shipments that does not precede a tax increase is in the fourth quarter of 2004 when a tax increase seems to have been anticipated given increases in previous Decembers, but did not occur.

Figure Three
 Quarterly, Tax-Paid Cigarette Shipments and Cigarette Tax Increases, Ireland, 2002-2010



Finally, we include a set of variables to capture trends and seasonality in cigarette smoking. The underlying trend is captured by a linear year variable, while seasonality is controlled for by three indicator variables - one for each of the first, second and third quarters, with the omitted fourth quarter serving as the comparison quarter.

All models are estimated using ordinary least squares regression methods in Stata v9.

IV. Results

Table One contains the estimates from eight alternative models of cigarette demand in Ireland over the period from 2002 through 2010. The models differ based on the use of separate tobacco control policy indicators (Models 1, 2, 5 and 6) versus the inclusion of the tobacco control policy scale (Models 3, 4, 7 and 8). Models 5 through 8 differ based on the inclusion of the variables that attempt to control for additional forms of tax avoidance - those reflecting opportunities for stockpiling and travel flows into/out of Ireland.

As expected, price has a negative and statistically significant impact in nearly all of the estimated models, with the magnitude of the estimated effect varying across models. This variability likely reflects the relatively short time period being examined and the correlations between price and other variables in the model. As expected, the magnitude of the estimated price effect is reduced when the indicator reflecting opportunities for stockpiling is included in the model. Estimated price elasticities vary from -1.0 to -2.3, well below the estimated -3.6 produced by Reidy and Walsh (2011), but considerably higher than past estimates for Ireland, as well as for other high-income countries.

Economic conditions appear to have little impact on cigarette demand in Ireland over the past decade. Coefficients on per capita GDP and the unemployment rate are generally positive, but never statistically significant. This is consistent with findings from recent studies of cigarette demand in high-income countries (IARC, in press).

Estimates for the tobacco control policy indicators are mixed, likely reflecting the colinearity between these policies and other variables in the model. One manifestation of a colinearity problem is statistically significant coefficients that are of the 'wrong' sign on at least one of the correlated variables. In these models, the point-of-sale marketing ban indicator that turns 'on' in the first quarter of 2009 is almost perfectly colinear with the transport indicator that turns 'on' in the fourth quarter of 2008. When both are included in the model, each is statistically significant but the sign on the marketing ban indicator is the opposite of what would be expected given the existing evidence that comprehensive marketing bans reduce demand (Blecher, 2008; Saffer and Chaloupka, 2000). The ban on sales of small pack sizes has no impact on cigarette demand, while that indicator capturing the implementation of Ireland's comprehensive smoke-free policy in 2004 is consistently found to reduce cigarette demand. When the separate indicators are replaced by the tobacco control policy index, the index is found to have a consistently negative, albeit statistically insignificant impact on cigarette demand. This may reflect the fact that the changes in Ireland's tobacco control policies after the implementation of the smoke free policy in 2004 were relatively modest resulting in this variable being relatively stable for most of the period covered by the data.

Table One

Estimated Cigarette Demand, Ireland, 2002-2010

Name	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Price	-92.984** (-2.26)	-60.964 (-1.64)	-135.507** (-2.70)	-88.195* (-1.95)	-100.049** (-2.36)	-73.093* (-1.77)	-140.136** (-2.75)	-100.509** (-2.07)
Travelers In					-.00018* (-1.83)	-.000094 (-0.95)	-.00020* (-1.73)	-.000012 (-1.07)
Travelers Out					.00018 (1.54)	.000068 (0.55)	.00017 (1.43)	.000069 (0.59)
Tax Avoidance Indicator		48.744*** (2.94)		64.191*** (3.21)		40.907** (2.10)		55.904*** (2.52)
Per Capita GDP	0.019 (0.93)	0.018 (1.02)	0.026 (1.28)	0.022 (1.23)	-0.003 (-0.13)	0.009 (0.39)	0.017 (0.84)	0.017 (0.92)
Unemployment	5.342 (0.42)	11.640 (1.04)	6.684 (0.46)	13.347 (1.06)	-7.607 (-0.44)	1.972 (0.12)	-3.732 (-0.17)	3.095 (0.15)
Year	-16.028 (-1.21)	-26.845** (-2.22)	-5.304 (-0.51)	-19.711* (-1.99)	-13.327 (-0.62)	-19.719 (-0.98)	-10.414 (-0.37)	-14.107 (-0.56)
Quarter 1	-133.674*** (-6.55)	-106.785*** (-5.36)	-137.936*** (-6.48)	-108.178*** (-5.30)	-180.403*** (-5.09)	-137.553*** (-3.56)	-178.858*** (-4.34)	-140.263*** (-3.49)
Quarter 2	-92.297*** (-5.52)	-63.457*** (-3.62)	-84.135*** (-4.16)	-50.103** (-2.47)	-93.374** (-2.37)	-60.058 (-1.51)	-70.617 (-1.49)	-37.088 (-0.83)
Quarter 3	-58.027*** (-3.32)	-38.373** (-2.32)	-46.134** (-2.19)	-24.898 (-1.30)	-42.712 (-0.51)	-14.83 (-0.19)	-2.776 (-0.03)	18.804 (0.20)
Small Pack Ban	31.982 (1.05)	27.479 (1.04)			-3.499 (-0.10)	14.652 (0.42)		
Public Health Act 2004	-94.305** (-2.60)	-97.689*** (-3.10)			-83.247** (-2.36)	-91.326** (-2.77)		
EU Enlargement	56.361 (1.39)	85.142** (2.33)	53.910 (0.60)	110.185 (1.40)	30.139 (0.72)	66.134 (1.56)	35.410 (0.41)	92.837 (1.13)
POS Marketing Ban	344.657*** (3.16)	257.323** (2.60)			369.232*** (3.50)	281.934** (2.65)		
Easing of Cig	-295.223**	-262.014**	99.654	27.313	-265.816*	-244.660*	144.762	71.454

Transport	(-2.28)	(-2.32)	(1.13)	(0.35)	(-2.04)	(-2.02)	(1.45)	(0.75)
Tobacco Control Policy Index			-1.993 (-0.98)	-2.477 (-1.43)			-1.608 (-0.81)	-2.301 (-1.27)
Constant	33046.21 (1.25)	54470.31** (2.27)	11808.06 (0.58)	40375.61* (2.06)	28006.37 (0.66)	40467.47 (1.01)	22292.19 (0.40)	29405.23 (0.58)
Adj R-squared	0.900	0.925	0.836	0.881	0.908	0.921	0.848	0.877
F Statistic	27.29	34.20	18.88	24.50	25.76	28.23	17.24	20.12
Price Elasticity	-1.506** (-2.26)	-0.987 (-1.64)	-2.194*** (-2.53)	-1.428* (-1.94)	-1.620** (-2.36)	-1.183* (-1.77)	-2.269*** (-2.75)	-1.627** (-2.07)

T-ratios are in parentheses. ***, **, and * reflect statistical significance at the 1%, 5%, and 10% levels, respectively, based on a two-tailed test.

The variables reflecting opportunities for tax avoidance are similarly mixed, with the exception of the indicator capturing the opportunities for stockpiling in the months leading up to a tax increase. The stockpiling indicator is positive and statistically significant in all models that include it, demonstrating that cigarette shipments are higher than normal in the months prior to a tax increase as wholesalers ship more cigarettes to retailers to avoid the tax. The variable capturing the enlargement of the EU in 2004 is positive in all models, but generally statistically insignificant. This likely reflects two factors that would have opposite effects on cigarette demand in Ireland - an increase in the number of people from the accession countries where smoking rates are generally higher living and working in Ireland and raising demand and an increase in purchases of cigarettes from these countries which would reduce cigarette demand in Ireland. The two variables reflecting travel flows into and out of Ireland were included in an effort to control for this, but neither of these variables is statistically significant at conventional levels in any of the models that include them. The last indicator - that for the loosening of restrictions on the number of cigarettes individuals could bring with them from the accession countries - has a negative and statistically significant impact on cigarette demand in Ireland in the models that include the individual policy indicators. However, when the individual indicators are replaced by the tobacco control policy index, greatly reducing the near perfect colinearity between this indicator and that for the point-of-sale marketing ban, this variable has no impact on cigarette demand.

The year variable is generally negative but statistically insignificant in most models, suggesting a weak underlying downward trend in cigarette smoking in Ireland over the past decade. Considerable seasonality is implied by the quarterly indicators, with shipments significantly lower in the first quarter than in other quarters, and with shipments lower in the second quarter than in the third or fourth quarter. Some of the first quarter effect in the models that do not include the tax avoidance indicator reflects the tax avoidance resulting from stockpiling in response to end of the year tax increases. After controlling for the stockpiling opportunities, the first quarter indicator is still negative and statistically significant, but has a smaller impact on demand. This is likely to reflect reductions in consumption following New Year resolutions to quit smoking.

V. Discussion and Recommendations

Our estimates of the price elasticity of Irish cigarette demand, ranging from -1.0 to -2.3 and averaging -1.6 are well above estimated price elasticities obtained in earlier studies for Ireland and other high-income countries, most of which fall into the range from -0.2 to -0.6, centering on -0.4. However, they are well below the -3.6 price elasticity estimated by Reidy and Walsh (2011) in their recent study for the Office of Revenue Commissioners. As described above, there are a number of methodological flaws in the Reidy and Walsh study that are likely to bias their estimated elasticity, resulting in an overestimate of the price responsiveness of cigarette smoking in Ireland.

Nevertheless, our estimates for the period from 2002 through 2010 are much higher than expected. Much of the difference between our estimates and the -0.4 obtained in previous studies on Ireland and other high-income countries is likely to be explained by increased tax avoidance and tax evasion in response to increased cigarette taxes and prices in Ireland. Euromonitor International (2011), for example, estimates that consumption of untaxed cigarettes in Ireland rose roughly five-fold between 2002 and 2010, from just under 400 million sticks to nearly 2 billion sticks, while the overall cigarette market, including both taxed and untaxed cigarettes, fell by nearly 14 percent overall, from 6.9 billion sticks to 5.9 billion sticks, and by over 31 percent on a per capita (15 and older) basis. Moreover, data on smoking prevalence from Euromonitor International (2011) show a steady decline from 2002 through 2010, with an overall drop in prevalence of more than 20 percent over this period.

Our estimates and these data suggest that increases in cigarette taxes and the strengthening of tobacco control policies and programs in Ireland are having the desired public health effect in that they are effective in reducing smoking prevalence and cigarette consumption. The growth in tax avoidance and tax evasion, however, suggests that Ireland is not realizing the full public health benefit of the higher taxes and prices and that the government is underachieving when it comes to the revenues that could be generated by cigarette taxes. Our least elastic estimate of price elasticity suggests that further tax increases would lead to small increases in revenues, while most of our estimates indicate that further tax increases would lead to reductions in tax revenues as consumption of taxed cigarettes would fall sharply with much of the drop resulting from some smokers switching to untaxed cigarettes.

The Revenue Commissioners recognize that tax avoidance and tax evasion are costing the Irish Exchequer hundreds of millions in lost revenues and have developed strategies for curbing these activities (Office of Revenue Commissioners, 2010). Their approach includes five key components: reducing the demand for untaxed cigarettes through a public education campaign highlighting the negative impact of tax avoidance and evasion and through increased coverage of enforcement efforts; maintaining tax compliance among those engaged in licit trade;

increased enforcement actions to detect illicit trade in tobacco products; increased partnerships among domestic and international organizations combating illicit trade in tobacco products; and increased prosecutions of those engaged in tax evasion.

Most of these strategies have been demonstrated to be effective in reducing tax evasion in countries that have adopted and implemented them. In addition to these actions, there are a few other strategies that would likely lead to further reductions in tax avoidance and tax evasion. A relatively simple strategy to implement is the adoption of a 'floor tax' or 'inventory tax' when cigarette excise taxes are increased. This tax would be applied to all existing stocks of cigarettes on which the previous, lower tax rate had been applied and would significantly reduce the incentives for stockpiling cigarettes in anticipation of a tax increase. Such a tax would likely generate tens of millions of Euros in new revenue following tax increases, revenues that have been lost in recent years as a result of stockpiling.

Additionally, Ireland could join the small but growing number of governments that have adopted sophisticated new technologies targeting tax evasion that include the use of a new generation of harder to counterfeit tax stamps and tracking-and-tracing systems that follow cigarettes as they move through the distribution process (WHO 2010). When coupled with licensing of all involved in cigarette distribution, such technologies facilitate enforcement efforts and increase the likelihood that untaxed cigarettes will be identified and make it easier to identify those engaged in tax evasion.

Finally, in addition to increasing enforcement and prosecutions, Irish authorities could increase the swiftness and severity of the penalties imposed on those engaging in tax evasion. Allowing sizable administrative penalties to be imposed immediately on those engaging in tax evasion would significantly increase the certainty of punishment and the costs of engaging in tax evasion (WHO, 2010).

Ireland has been among the world's tobacco control leaders over the past decade, adopting strong national policies and implementing effective tobacco control programs. Increases in cigarette taxes and prices that have reduced the affordability of cigarettes have been a key component of this comprehensive approach and have contributed to the real reductions in cigarette smoking and the death, disease, and economic costs caused by smoking. Strengthened cigarette tax administration will enhance the effectiveness of past and future cigarette tax increases in further reducing smoking and its consequences, while at the same time recouping the revenues currently being lost to tax avoidance and tax evasion.

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