THE ELASTICITY OF TAXABLE INCOME

DECEMBER 2018

An Roinn Airgeadais
Department of Finance

Contents

Tables and Figures

Executive Summary

Using Irish tax record data, this paper presents the first extensive evidence of taxpayer responses to changes in the marginal tax rate. The behavioural response of interest – the elasticity of taxable income (ETI) – measures how taxable income changes in response to net-of-tax rate changes (the net-of-tax rate is 1 minus the marginal tax rate).

We estimate an ETI of 0.168, on average, across the whole population of income taxpayers. This means that for each one percent increase in the marginal net of tax rate, table income increases by 0.168 percent on average. The ETI captures the full range of adjustments taxpayers make, from their labour supply to their tax planning response. This estimate lies within the bottom half of the range of international estimates, which may be due to Ireland-specific factors such as a lower level of deductions and reliefs compared to other countries, a high degree of income tax compliance, and labour market frictions for PAYE taxpayers in particular.

Since a single estimate of the ETI may be misleading, as different taxpayer categories can have very different behavioural responses, this paper examines responsiveness for different taxpayer categories. For PAYE taxpayers, the elasticity is 0.145, while it is more than double for the self-assessed at 0.363. There are also notable differences across incomes: high-income taxpayers are exceptionally responsive to their net-of-tax rate while low-income taxpayers are relatively unresponsive. Middle-aged taxpayers are relatively more responsive than the population as a whole, in part due to increasing incomes and opportunities to avail of tax reliefs over the life cycle.

The ETI is the central input into the calculation of the marginal excess burden of taxation, which captures the efficiency cost of a given euro of income tax revenue. Using our baseline ETI of 0.168, we estimate that the marginal excess burden for each additional euro of income tax revenue raised is €0.35 and the consequent shadow cost of public funds is €1.35. This is slightly above the current estimate for Ireland, which was derived theoretically (Public Spending Code, 2012). There is merit in considering the use of estimates derived in this paper in the next revision of the Code in order to have an up-to-date and data-driven assessment of the efficiency costs of taxation.

Overall, the results demonstrate that taxpayers in Ireland respond to their net-of-tax rate, and therefore their marginal tax rate. However, the relatively low responsiveness compared to other countries, coupled with the well-known progressivity of the Irish income tax system, suggest that the trade-off involved in pursuing both equity and efficiency objectives in the Irish system is reasonably limited. Nevertheless, the results indicate that broadening the tax base, for example by reducing deductions and reliefs, would further enhance efficiency.

The Elasticity of Taxable Income

December 2018[1]

Section 1 – Introduction

The elasticity of taxable income (ETI) – or how taxable income changes in response to a change in the net-of-tax rate – is of central importance in understanding how taxpayers react to changes in personal taxation. The net-of-tax rate rather than the marginal tax rate is studied as it defines the income retained after tax and so more appropriately governs behavioural responses to tax. The ETI is expected to be positive: as the net-of-tax rate increases (meaning the marginal tax rate decreases), taxable income increases.

In line with practice in the literature, the ETI is used in this paper to provide an estimate of the marginal excess burden of income taxation – in other words the efficiency cost arising out of tax-induced distortions to individuals' economic choices. This is important for policymakers as direct taxes can create considerable inefficiencies i.e. behavioural distortions such as reduced working hours or increased non-compliance in response to a tax rate change. This in turn diminishes the revenue-raising function of a tax. As pointed out in the seminal paper by Feldstein (1999), if taxpayers are extremely responsive, the efficiency cost of higher tax rates could in fact be very large relative to the tax revenues collected.

This paper follows in a similar methodological vein to the recent literature on the ETI and is notable for producing the first extensive estimates of the ETI in Ireland from tax record data. However, the results are distinct from the majority of the international literature in that they are estimated using taxpayers from across the income distribution and over a long time period (while typically the literature has focused on the highest-income individuals over a short time period). We also differentiate more completely by employment status, age, income and marital status than much of the literature. The contribution of this paper is therefore twofold: it provides the first extensive estimates of the ETI for Ireland and offers greater discussion on different taxpayer characteristics than is typically found in the international literature. The ETI estimates will also allow for more dynamic tax revenue forecasting in future, which should better reflect the true impact of a given tax policy change.

[1] This report was produced by Jean Acheson (Economic Division of the Department of Finance), Brian Stanley (Higher Education Authority, formerly Revenue Commissioners), Seán Kennedy (OECD, formerly Revenue Commissioners), and Edgar L.W. Morgenroth (Dublin City University, formerly ESRI). This research is part of the ESRI and the Department of Finance *Joint Research Programme on the Macro-Economy, Taxation and Banking*. The views expressed in this paper are those of the authors only and they should not be regarded as an official position of the Department of Finance, the Revenue Commissioners or the ESRI. The authors thank David Hegarty, Martina Lawless, Barra Roantree, Keith Walsh, and participants at the Department of Finance and IGEES annual policy conferences for comments.

Section 2 – The Irish personal tax system

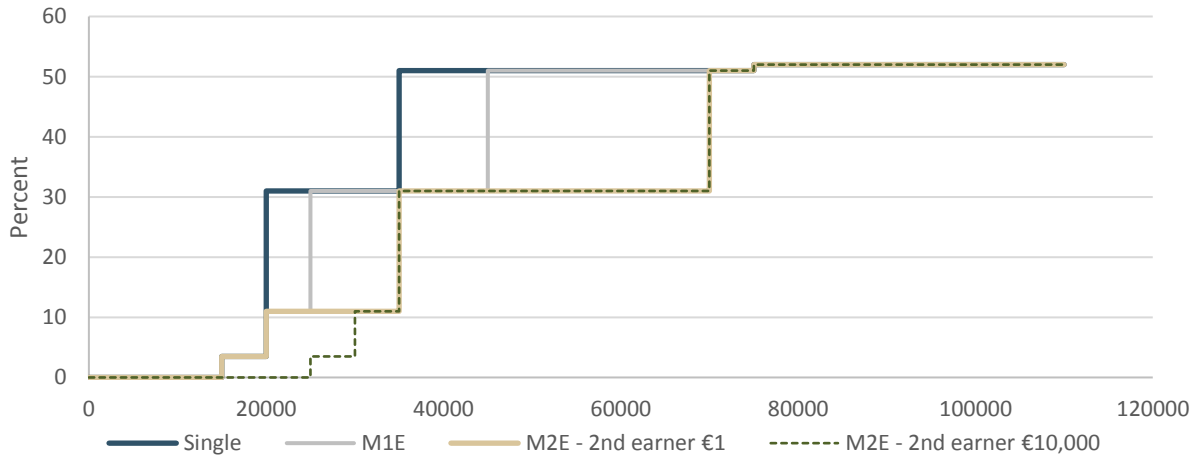
2.1: Context

Personal income taxes contributed €20 billion to the Irish Exchequer in 2017, accounting for almost 40 percent of total Exchequer tax receipts. Personal income tax is currently comprised of two taxes: income tax and the universal social charge (USC). There is an additional charge on income, pay-related social insurance (PRSI), which accrues directly to the Social Insurance Fund and is not included in Exchequer tax receipts. PRSI revenue in 2017 amounted to €8.9 billion. In common with most OECD personal tax systems, the charge on a Pay as You Earn (PAYE) worker in Ireland operates as a withholding tax while the charge on a self-assessed worker is voluntarily filed and paid once a year.[2]

2.2: Variation in marginal tax rates

Figure 1 demonstrates the headline marginal rates of tax at different income levels for a PAYE taxpayer in 2015, which is the latest year in our dataset.[3] The figure makes clear that there is substantial non-uniformity in the Irish tax system. That said, it is also clearly the case that income tax is responsible for the biggest changes in the headline marginal tax rate as incomes increase. In other words, it is the tax credits and the standard rate cut-off point (SRCO) of the income tax system that are responsible for the largest variation in a taxpayer's net-of-tax rate in the overall personal tax system in Ireland.[4] It is primarily for this reason that the ETI strategy in this paper focuses only on the income tax system.[5]

Figure 1: Headline marginal tax rates for PAYE taxpayers in Budget 2015



Note: Single refers to 'Single' in a tax classification sense, M1E refers to 'Married One Earner' and M2E refers to 'Married Two Earner'. For simplicity, the figure excludes the PRSI tax credit and assumes no income is derived from social welfare payments.

In the calculation of tax liability, tax credits directly reduce the amount of income tax that is due. However, tax credits can also be used to determine a range of income on which no income tax is due. Over this income range, taxpayers face a zero marginal tax rate. For the purposes of this paper, the point at which taxpayers move from this zero marginal rate to the standard rate is called the zero marginal rate cut-off point (ZRCO).[6] Table 1 shows the minimum ZRCO level and the SRCO level over time, for different employment and marital statuses. Unlike tax credits, the SRCO applies identically

[2] The self-assessed pay preliminary tax in October, which is usually based on an estimate of their liability for the full year.
[3] Although PRSI is not a tax, it is included in this calculation by convention.
[4] Large variations in effective marginal tax rates are also possible due to the withdrawal of particular social welfare benefits as incomes increase, but this is outside the scope of this paper.
[5] USC and PRSI are further discussed in the Appendix.
[6] The calculation of the ZRCO is detailed in the Appendix.

to both PAYE and self-assessed workers. In most years over 2004-2015, the SRCO increased, creating large increases in the marginal net-of-tax rate for certain income-earners around these income levels. Budget 2011 was a notable exception. In 2011, the SRCO fell by €1,600 for single taxpayers, by €3,600 for married one-earning couples and by €7,200 for married two earning. The ZRCO also fell in this year.

Table 1: Marginal tax rate cut-off points

	Minimum Zero Marginal Rate Cut-Off (€)				Standard Rate Cut-Off Point (€)		
	Single		M1E and M2E		Single	M1E	M2E
	PAYE	SA	PAYE	SA	Both	Both	Both
2004	12,800	7,600	30,400	15,200	28,000	37,000	56,000
2005	14,250	7,900	31,600	15,800	29,400	38,400	58,800
2006	15,600	8,150	32,600	16,300	32,000	41,000	64,000
2007	17,600	8,800	35,200	17,600	34,000	43,000	68,000
2008	18,300	9,150	36,600	18,300	35,400	44,400	70,800
2009	18,300	9,150	36,600	18,300	36,400	45,400	72,800
2010	18,300	9,150	36,600	18,300	36,400	45,400	72,800
2011	16,500	8,250	33,000	16,500	32,800	41,800	65,600
2012	16,500	8,250	33,000	16,500	32,800	41,800	65,600
2013	16,500	8,250	33,000	16,500	32,800	41,800	65,600
2014	16,500	8,250	33,000	16,500	32,800	41,800	65,600
2015	16,500	8,250	33,000	16,500	32,800	41,800	65,600

Source: Authors' analysis based on Revenue data.
Note: Single refers to 'Single' in a tax classification sense, M1E refers to 'Married One Earner' and M2E refers to 'Married Two Earner'. SA refers to 'Self-Assessed'.

This paper relies on changes to tax credits and the SRCO to estimate the ETI, which were both a common feature of Irish budgetary policy during the 2000s. While the SRCO was often adjusted to advance the policy aim of ensuring a worker on the average industrial wage escaped the higher rate of income tax, the fact that the Irish income tax system involves a notable degree of joint assessment means that changes in the SRCO naturally created a lot of up-and-down movements in tax rates throughout the income distribution (typically from the 6th to 9th income deciles, while tax credit changes mainly affected the 2nd to 6th income deciles).[7]

[7] Nominal income thresholds are further discussed in Table 2.

Section 3 – Data

3.1: Context

The analysis in this paper is based on Revenue's Income Distribution Statistics (IDS), which follow the entire population of approximately 2 million taxpayers over the 12-year period from 2004 to 2015.[8] The data are compiled using income tax returns filed by self-assessed taxpayers (Form 11) and employers on behalf of PAYE employees (Form P35). IDS data are the most comprehensive source of information on incomes in Ireland. In addition, the dataset contains demographic information such as personal tax status (single male, single female, married one-earner and married two earner), schedule (PAYE or Self-Assessed), industry sector, region and age.

3.2: Data definitions

The unit of analysis in the data is a tax unit rather than a taxpayer. The difference arises in the case of married couples (or civil partners since 2011) who elect for joint assessment. These cases represent two taxpayers and either one or two incomes but only count as one tax unit.[9] For the sake of simplicity, the word taxpayer is used to refer to tax unit for the remainder of this paper.

The main variable of analysis in this paper is taxable income, which is defined as that part of income on which income tax is calculated. It is thus the total income of taxpayers less personal reliefs and other deductions but prior to the application of tax credits and reliefs at the standard rate (which are given by way of a reduction in tax chargeable).

In this dataset, taxpayers are assigned to either PAYE or Self-Assessed status, conditional on which category comprises a greater proportion of overall income.[10] In addition, sector relates to the sector of the employer (not the employee) and each taxpayer is associated with one sector in each year.[11] Taxpayers may also have multiple trades or businesses that are not accounted for in this analysis. Taxpayers with multiple traders are allocated to the primary trade as selected by the taxpayer. The region of employment relates to the region of the taxpayer's residence, not the region in which the employer is registered with Revenue.[12]

The data are confined to those who complete tax returns, or have employers who do so on their behalf, and do not cover those entirely reliant on untaxed benefits. Therefore, it can be seen as slightly under-representing lower-income groups. The data also do not contain any information on undeclared incomes. Nevertheless, it is a rich and detailed population data set and is complementary to household survey data, the other main source of micro data for assessing the impacts of direct taxation.

3.3: Estimation sample

The estimation sample is restricted to taxpayers with positive taxable income, an approach that is in line with the literature.

The literature review in Appendix 1 identifies two main estimation challenges - changing income shares and mean reversion in income – both of which are unrelated to how tax rate changes can influence income changes. To mitigate substantial mean reversion at the bottom of the income

---

[8] The same population data are also used to produce Revenue's income distributions statistics, available at: http://www.cso.ie/

[9] Married two-earning couples represent approximately 21 percent of tax units in 2015.

[10] Although PAYE and Self-Assessed status are mutually exclusive in our analysis, in practice a taxpayer can have both statuses at once. To overcome this limitation, we employ a switching variable in the regression analysis to account for when the majority of a taxpayer's income changes from one status to the other – see Section 5.3 for further detail.

[11] For self-assessed taxpayers, sector relates to the sector of the taxpayer's business.

[12] Region is drawn from Revenue's General Compliance Districts (GCDs). A relatively small number of high net worth individuals deal with Revenue's Large Cases Division (LCD) which is classified as a region in this analysis.

distribution, it is common to impose an income cut-off point on the sample. For example, Gruber and Saez (2002) exclude observations with real income less than US$10,000, Doerrenberg *et al.* (2017) use €10,000 as the cut-off and Kleven and Shultz (2014) exclude observations with income arising solely from social welfare benefits. Furthermore, those on the lowest incomes may face different marginal effective tax rates compared to standard taxpayers, for example due to the withdrawal of social welfare benefits. We choose a real taxable income cut-off level of €5,000 for our estimation sample, which effectively removes the first income decile from the analysis (see real income threshold table in Appendix A4).

Another sample decision relates to taxable income changes arising from taxpayers entering or exiting the labour force. While some papers address this using narrow age bands (for example, by using a sample aged 25-60), the most widely cited papers that estimate the ETI from the full income distribution of taxpayers adopt a broader age sample (Gruber and Saez, 2002; Kleven and Shultz (2014)).[13] Hansson (2007) tests how age restrictions affect the ETI for Sweden and finds that a wider age band increases the elasticity while a narrower band decreases it. We adopt a wide band of 15-64 years but also include a narrower band for robustness in the detailed results.[14]

It is common in the literature to drop observations that switch marital or regional status. However, as the estimation approach is applied to different taxpayer-specific samples, we prefer to include dummy variables to account for switchers, rather than drop them altogether from our regressions. Robustness checks found that this choice did not change our ETI estimates.

[13] Neisser (2017) documents which ETI papers have been most widely cited in the economics literature.

[14] The full dataset includes those in receipt of an occupational pension from their employer. Restricting the sample to those under the age of 64 removes a large part of taxpayers' retirement decisions.

Section 4 – Descriptive statistics

This section examines various descriptive statistics of the income distribution and provides graphical evidence of taxpayer responses to changes in marginal tax rates.

4.1: Developments in the Irish income distribution

Table 2 shows the thresholds of nominal taxable income by decile across the time period.[15] Incomes in the 6th to 9th deciles coincide with the SRCOs for single, married one earning and married two earning taxpayers. Tax credits typically run out for taxpayers in the 2nd to 6th decile, depending on marital and PAYE or self-assessment status. As the tax changes occur across almost all deciles except the top decile, we would expect more moderate elasticities than estimates from other countries, in particular the US, which often rely on tax policy changes for the very highest earners (in the tenth decile or 99th percentile).

Table 2: Nominal taxable income thresholds by decile

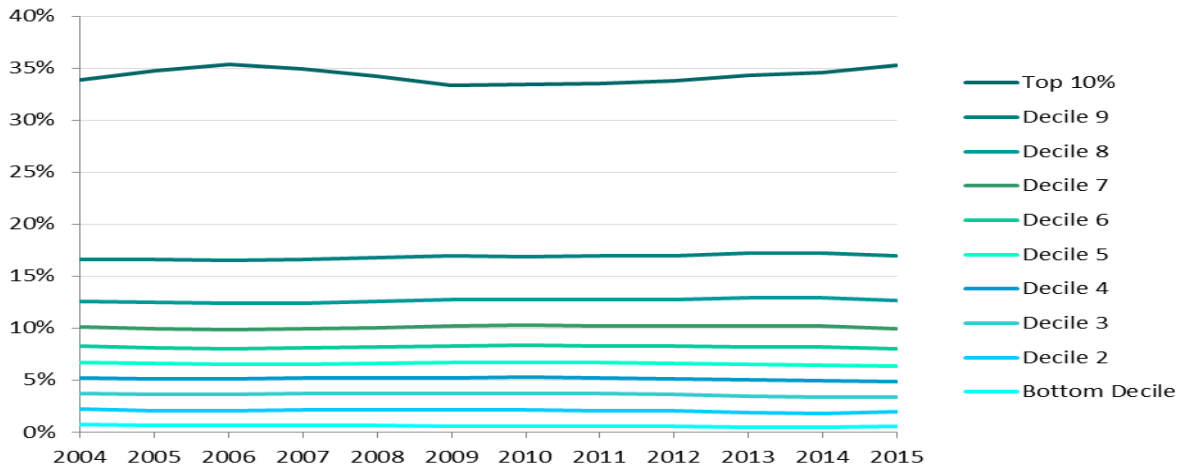
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bottom Decile	5,037	4,922	5,020	5,283	5,506	5,500	5,373	5,310	5,292	5,175	5,076	5,180
Decile 2	9,829	9,851	10,193	10,908	11,334	11,362	11,141	11,068	10,861	10,694	10,521	10,558
Decile 3	14,704	14,960	15,503	16,479	17,096	17,095	16,853	16,802	16,555	16,280	16,089	16,089
Decile 4	19,255	19,625	20,272	21,341	22,130	22,196	21,888	21,805	21,528	21,338	21,188	21,330
Decile 5	23,975	24,488	25,300	26,443	27,414	27,609	27,211	27,176	26,991	26,992	27,000	27,260
Decile 6	29,260	29,951	31,052	32,411	33,674	34,010	33,540	33,573	33,393	33,500	33,524	33,849
Decile 7	35,990	36,946	38,219	39,890	41,490	41,771	40,974	41,281	41,314	41,684	41,838	42,337
Decile 8	45,744	47,153	48,856	51,000	53,052	53,226	51,993	52,456	52,609	53,249	53,703	54,656
Decile 9	63,002	65,372	68,114	71,441	74,233	73,950	72,298	72,808	73,279	74,139	74,906	76,578
Top Decile	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: Authors' analysis based on Revenue data.
Note: Income thresholds show the maximum income for each decile of the All Taxpayer sample. Income thresholds for PAYE and self-assessed taxpayers are similar up to and including the 7th income decile. Real taxable income thresholds are shown in Appendix A4.

Figure 2 shows that the shares of taxable income have been remarkably stable for the first nine deciles over the last decade.[16] The share of taxable income held by the top decile peaked at 35.1% in 2006 before falling to 33.1% in 2010. Since then, the share of taxable income owing to the top decile has been increasing slowly and is approaching the 2006 peak. Stable shares over time indicate that non-tax changes in income are less problematic for the ETI estimation procedure (see literature review in Appendix A1 for details). Most tax changes under examination in this paper do not change the marginal tax rate of taxpayers in the tenth income decile (for example, the SRCO for married two-earner taxpayers is well below the threshold level for the tenth income decile in all years but one in the sample period (2010)).

[15] Elasticities are estimated using real taxable income, which is calculated by re-basing nominal taxable income in terms of 2015 consumer prices (using the headline CPI). Thresholds for real taxable income are shown in Appendix A4.
[16] Figure 2 will not be fully comparable with Gini co-efficient income inequality analysis, which typically relies on equivalised household gross income or equivalised household disposable income. The income referred to in Figure 1 is nominal taxable income of tax units.

Figure 2: Share of taxable income by decile

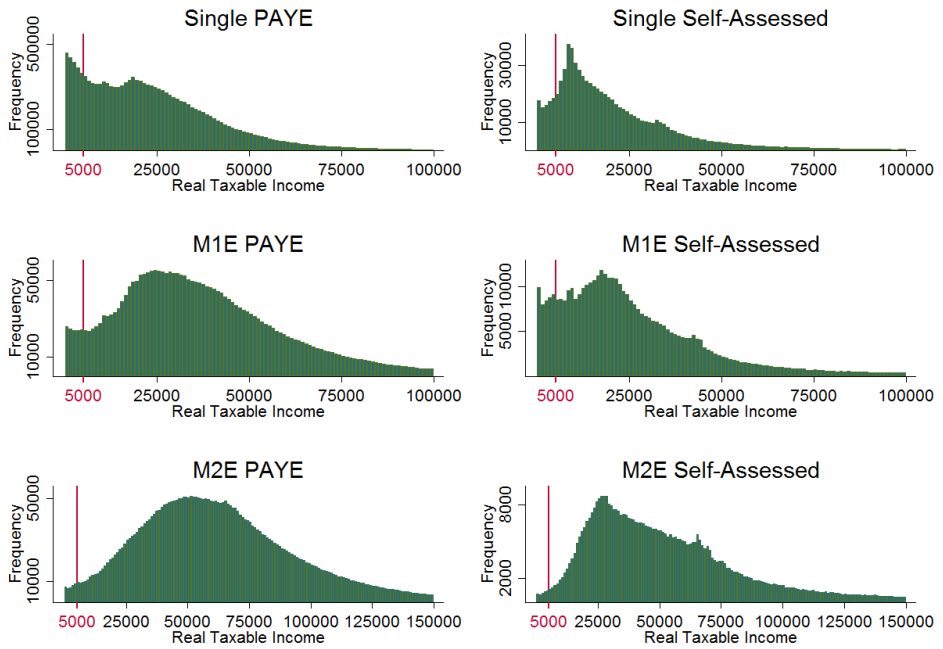


Source: Authors' analysis based on Revenue data.

4.2: Income distributions by taxpayer category

Figure 3 shows the real taxable income distribution over the period (2004-2015) for the six types of taxpayer category. It shows that differences between PAYE and self-assessed taxpayers tend to arise across rather than within taxpayer categories (such as single or married two earner). This provides suggestive evidence that the ETI should be estimated separately by taxpayer category in the Irish context. Differences across categories may reflect sample composition – for example single taxpayers are typically younger than married taxpayers and earn less on average – and it may also be due to tax system design, as the income tax system treats marital status differently and this may affect the final taxable income response of the individual or couple.

Figure 3: Real taxable income distributions by taxpayer category



Source: Authors' analysis based on Revenue data.

4.3: Distribution of taxable income around the SRCO

This section examines the distribution of taxable income specifically around the SRCO, where the marginal tax rate typically doubles in value. Income distributions are disaggregated over specific income ranges for single taxpayers, married one earning and married two earning taxpayers for an example year pair (2006 and 2009). Intervals of €100 are employed for single and married one-earner taxpayers and €200 intervals for married two-earners.

In Figure 4, the axis labels and lines in red indicate the SRCO in that year. The axis label and dashed grey line indicates the standard rate cut-off in the previous and following periods. In 2006, for example, there appears to be a concentration of single taxpayers earning taxable income around that year's SRCO (€32,000) (Panel A). In 2009, such bunching occurs around the subsequent SRCO (€36,400), though the number of taxpayers bunching declines. The same observations hold true for self-assessed taxpayers but the relative size of the bunching is far more pronounced.

Some bunching occurs for married one earning PAYE taxpayers in 2006 (Panel B). However, this bunching does not follow into 2009. In contrast, the distributions of married one earning taxpayers who are self-assessed is similar to their single self-assessed counterparts. Bunching appears to be significant around the thresholds in both 2006 and 2009 for married two earning taxpayers (Panel C). Again, the effect is more pronounced for self-assessed taxpayers.

Overall, this graphical evidence suggests that the behavioural response we are trying to quantify is positive and that we can expect a higher ETI for the self-assessed relative to PAYE taxpayers.

Figure 4: Distribution of taxable income, 2006 and 2009

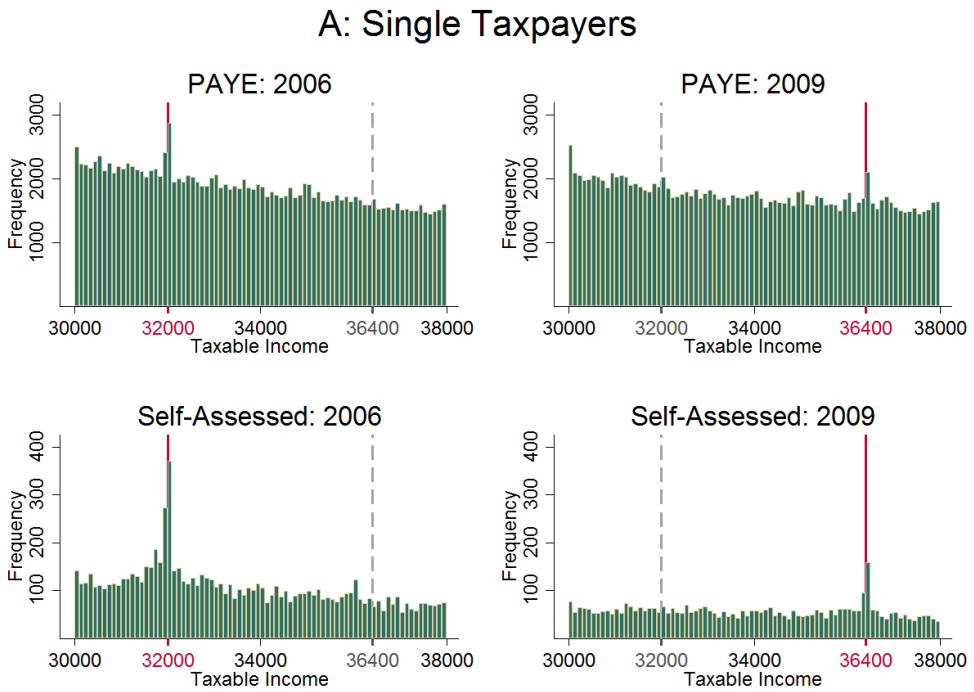
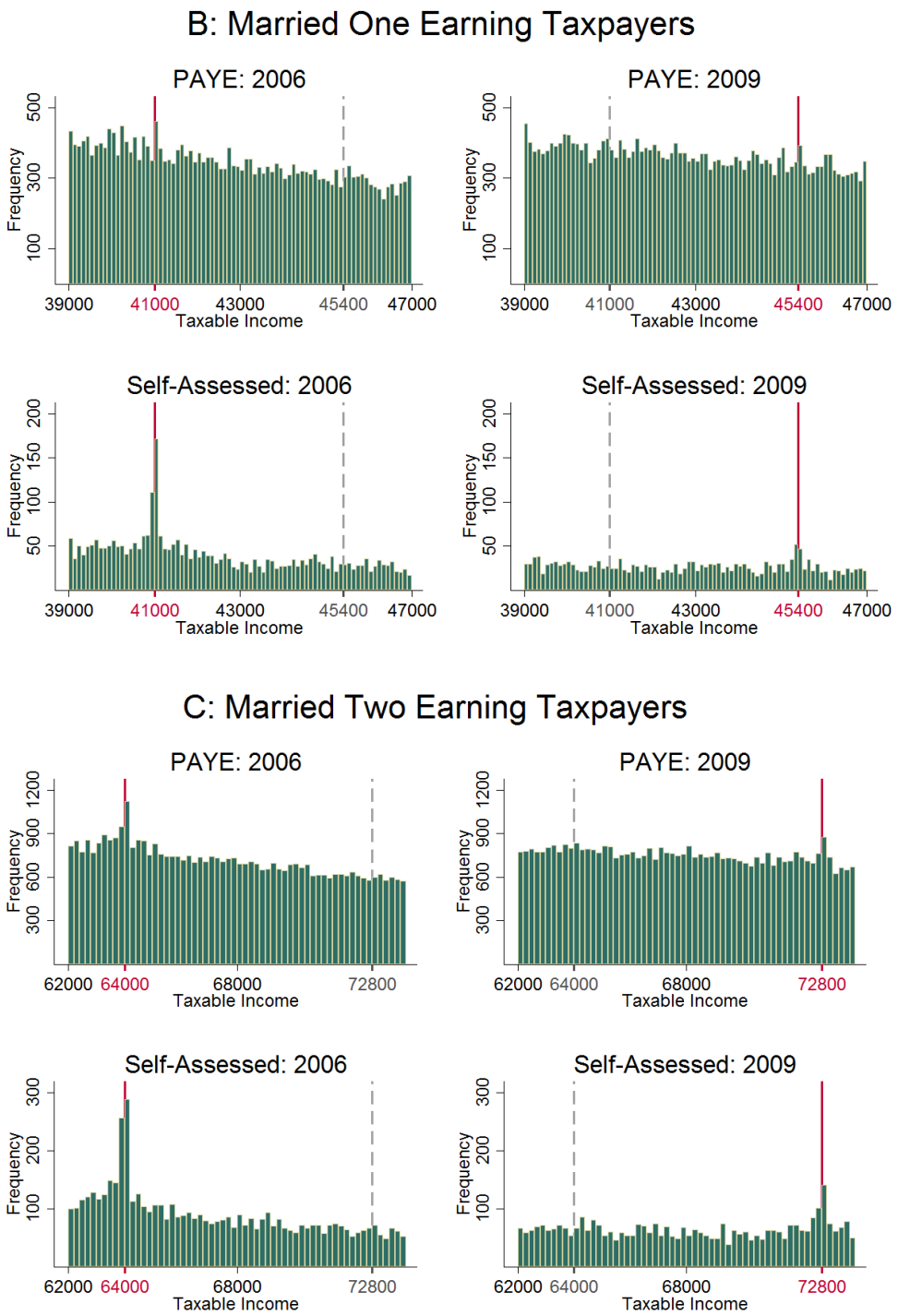


Figure 4 continued



Source: Authors' analysis based on Revenue data.

Section 5 – Methodology

5.1: Conceptual framework

The traditional labour supply model assumes individuals maximise a utility function *u(c, l)* where *c* is consumption and *l* is hours of work. The budget constraint is *c=w*l*(1-t)* where *w* is the hourly wage and *t* is the tax rate. The ETI literature generalises this model by observing that hours of work is only one of several behavioural responses to personal taxation.[17]

In the ETI version of the model, therefore, individuals maximise the utility function *u(c, z)* where *z* is reported real taxable income, which is a function of the net-of-marginal tax rate i.e. *z(1-t)*. In simple terms, the elasticity is defined as:

$$\varepsilon = \frac{(1-t)}{z} \frac{\delta z}{\delta(1-t)} \qquad (1)$$

In a regression structure for panel data, this can be written as:

$$\log (z_{it1}/z_{it0}) = \varepsilon.\log((1-t_{it1})/(1-t_{it0})) + u_{it} \qquad (2)$$

We take three-year differences which is typical in the literature, starting with Feldstein (1995). This provides enough time for taxpayers to respond to the marginal tax rate and is not so long that other non-tax factors, such as work experience, would change substantially for most taxpayers. ε is directly interpretable as the elasticity since the outcome measure (real taxable income) and the net-of-tax rate enter the regression in logs. We characterise ε as a medium-term elasticity.[18]

As marginal net-of-tax rates are not directly observed in the data, these are simulated using an almost complete model of the Irish tax system.[19] Taxpayers are assigned to one of three marginal rate categories: the zero, standard or higher marginal tax rate on the basis of their taxable income, their personal tax status, their tax credits and the SRCO in each year.

However, income and marginal tax rates are endogenous in a multi-rate tax system: an individual's income level affects their marginal tax rate but their marginal tax rate also affects their income level. More formally, a shock to the tax rate - captured in the term $\log((1-t_{it1})/(1-t_{it0}))$ – is correlated with the error term because, if there is a positive shock to income, ($u_{it} > 0$), the tax rate automatically rises in a multi-rate system. In other words, income can respond to changes in the marginal tax rate but an increase in income also automatically changes the net-of-tax rate, because in progressive tax systems higher incomes are taxed at higher marginal tax rates. Therefore, an OLS regression of Equation (2) would lead to a biased estimate of the elasticity.

5.2: Instrumental variables

The estimation strategy therefore relies on introducing instrument variables (IV) to overcome this bias. Since Gruber and Saez (2002), the economic literature has typically created these using t*, which is the marginal tax rate the individual would face in year 1 if their real taxable income did not change

[17] There is one important respect in which the ETI literature simplifies the standard model; it usually assumes no income effects and ignores intertemporal issues (Saez et *al.,* 2012). This latter omission implies that the estimates generated are assumed to be permanent. There is little empirical evidence of the magnitude of income effects on tax changes. Gruber and Saez (2002), for example, estimate small and insignificant income effects. Kleven and Shultz (2014) find the inclusion of income effects in their model does not change their baseline results.

[18] Saez *et al.* (2012) point out that the relative magnitudes of the ETI in the short-term and the long-term are theoretically ambiguous. They also note that the literature has yet to successfully identify very long-term responses.

[19] The simulation of the Irish tax system is only almost complete because we assume that each taxpayer receives their basic tax credits as outlined in Table 2. If a taxpayer receives any credits in addition to this, their unique ZRCO is calculated. However, in a minority of cases, a taxpayer's credits may be reduced to collect underpayments of tax due in previous years.

between years 0 and 1. This instrument is known in the literature as a "mechanical" tax rate change, the idea being that it is free of any behavioural response. In equation 2, therefore, $\log((1-t_{it1})/(1-t_{it0}))$ is instrumented by $\log(1-t_{it1}(z_{it0}))/(1-t_{it0}(z_{it0}))$.

5.3: Income dynamics

Running an IV regression of Equation (2) may still lead to a biased ETI if u_{it} is correlated with z_{it0}. The first reason for this is mean reversion: for example, high incomes in year t_0 tend to be lower in subsequent years, creating a negative correlation between u_{it} and the dependent variable (which would bias the ETI downward). The second reason relates to non-tax related income dynamics over time. For example, if the income distribution were to widen, there would be a positive correlation between u_{it} and the dependent variable (which would bias the ETI upward). If this occurs, the instrument (which is also a function of z_{it0}) will be correlated with the error term, producing biased estimates. For these reasons, a base-year income control is included.[20] In practice, we use a ten-piece spline based on the natural log of base-year income for each regression sample.[21] If high base-year income signals a likely decline in income, then, intuitively, adding base-year income as an explanatory variable can absorb the bias.

While there is a concern with using one explanatory variable to control for two biases, Figure 2, which demonstrated a steady share of income by decile over time, provides reassurance that widening income inequality does not represent a risk to identification in the Irish context. The risk of mean reversion is also mitigated by employing a sample cut-off strategy. As mean reversion can be expected to be most pronounced at the bottom of the income distribution and at the beginning and end of a working life, we apply an age cut-off (16-64 years old) and an income cut-off (real taxable incomes greater than €5,000).

5.4: Other control variables

To account for individual heterogeneity, demographic information is incorporated into all regression specifications by controlling for taxpayer age, location (region) and industry. Gender is also included in the case of single taxpayers. Given the changing composition of Irish employment and self-employment over the 2000s, we also include a dummy variable for industry switching (for example, from farming to construction). Dummy variables for marital, regional and tax status switching are also included. Using data from the Live Register and interpolated Censuses, a proxy unemployment rate is also created for each region and year to account for changes in region-specific labour market slack over time. This control is expected to mitigate against the notable changes in macroeconomic conditions in Ireland over the period, which could otherwise affect taxable income and be erroneously attributed to tax rate changes.

5.5: Standard errors

Our sample is a panel covering 2004 to 2015. Given our choice of "first difference" as a three year change, this results in a dataset of stacked observations for nine pairs of years (2007/2004, 2008/2005, … , 2015/2012). In many cases, we have multiple observations for the same taxpayer. To account for any taxpayer-specific correlation in income changes over time, we present estimates that correct the standard errors for intra-taxpayer correlation (in other words we cluster the standard errors on the taxpayer's identification number in the tax record).

[20] A base-year income control has become very common in the literature – see Auten and Carroll (1999), Gruber and Saez (2002), Saez *et al.* (2012), and Kleven and Shultz (2014) for examples.

[21] The spline of logarithm of base-year income is a richer control than simply the log of base-year income as it allows income growth to vary along the income distribution and it may account for unobservable factors that have a heterogeneous impact on income growth along the distribution.

Section 6 – Results

6.1: Introduction

This section outlines the results from the panel regressions. The results are based on 2SLS estimations of Equation (2) using mechanical tax changes (t*) as instruments. The sample is based on population taxpayer data adjusted for an age threshold (15 – 64) and removes the very lowest income levels (less than €5,000). All regressions are weighted using sample-specific taxable income weights e.g. all observation weights in a regression for PAYE Single taxpayers sum to one.[22] All results tables show the estimated elasticities and standard errors in parentheses. First-stage regressions of $\log((1-t_{it1})/(1-t_{it0}))$ on $\log(1-t_{it1}(z_{it0}))/(1-t_{it0}(z_{it0}))$ are not presented, but are very strong with F statistics well above 100.[23]

6.2: Baseline results

In Table 3, the first panel shows the baseline ETI estimates from the model. In the first column, the ETI for all taxpayers is 0.168. This coefficient is interpreted as follows: for a one percent increase in the marginal net-of-tax rate, taxable income increases by 0.168 percent on average. When applying this to the marginal tax rate itself, the result implies, for example, that taxable income (i.e. the tax base) increases by 0.3 percent when the higher rate of income tax decreases by one percentage point (i.e. goes from 40 percent to 39 percent). The result is symmetric for an increase in the higher rate.

When looking at PAYE and the self-assessed separately, the latter group are more than twice as responsive as the former. This is unsurprising given the greater scope for the self-assessed to adjust taxable income through labour supply decisions, tax-deductible expenses and capital allowances.

The time period in question in Ireland was one of substantial macroeconomic change, including a boom, bust and recovery. The second panel drops our macroeconomic control (region-specific changes in unemployment). The ETI decreases in this version of the model, which suggests that income losses in the recession may be a non-tax system change that could bias the results if we did not include a macroeconomic control in the baseline model.

Table 3: Baseline ETI results

	All taxpayers	PAYE	Self-Assessed
Elasticity of taxable income:	0.168***	0.145***	0.363***
Baseline	(0.019)	(0.02)	(0.054)
Elasticity of taxable income:	0.147***	0.124***	0.348***
No macroeconomic control	(0.019)	(0.02)	(0.054)
Observations	*10,612,887*	*9,825,540*	*787,347*

Note: standard errors in parentheses; *, ** and *** denotes significance at the 5%, 1% and 0.1% level respectively. All regressions employ an age cut-off range (15-64 years inclusive) and an income cut-off (€5,000) unless otherwise specified.

[22] In line with the literature, weights are used to give proportionally more weight to high-income taxpayers, as their response contributes proportionally more to the aggregate elasticity that will be used to calculate the excess burden of taxation in Section 7.

[23] This strength is unsurprising given that we are using population data and regressions are estimated using a minimum of 100,000 observations and often over one million observations.

Overall, the baseline results (first panel of Table 3) are in the lower half of the range of estimates internationally.[24] This has several interpretations. Firstly, these low estimates for Ireland may be a function of the parameters of the Irish tax system. As argued by Slemrod and Kopczuk (2002), the ETI will be lower where tax deductions are fewer. When expressed as a percentage of GDP or income tax revenues, Ireland has relatively fewer deductions and reliefs for income taxpayers than other OECD countries, in particular the English-speaking ones (OECD, 2010; Department of Finance, 2017).[25] Secondly, the Irish income tax system may offer relatively small opportunities for noncompliance and evasion, which could in part be due to Revenue's effective tax enforcement measures and the generally high levels of compliance in Ireland. Thirdly, many employees may not have the opportunity to adjust taxable income, even if they would like to (for example, if they are contracted to work a fixed number of hours per week). In this case, the distortions realised by tax at an aggregate level are not that high, although individual welfare suffers as individual's preferences cannot be accommodated due to labour market frictions.

It is also worth noting that the paper uses information from almost the entire income distribution, so the results will inevitably be lower than those from studies which focus solely on top earners or use a higher income floor for sampling. Finally, the reasonably stable income distribution for Irish income taxpayers likely plays a role (see Figure 2); as was the case for ETI results for Denmark and Japan (Kleven and Schultz, 2014; Miyazaki and Ishida, 2016), a stable income distribution reduces the likelihood of mean reversion upwardly biasing the results.

6.3: Income levels

When we decompose the "all taxpayer" sample into different income bands in Table 4, we observe that responsiveness increases with income, which is an effect commonly seen in the literature (Sillamaa and Weall (2001) for Canada; Gruber and Saez (2002) for the US; Kleven and Schultz (2014) for Denmark). For the lowest band (5k-50k), which contains the majority of taxpayers, the response to changes in the net-of-tax rate is very low. This is in line with the estimate of the ETI produced from a recent paper examining USC and levy notches (Hargaden, 2015). The response increases for the middle band (50k-100k) and is extremely large for the highest band (>100k) with an ETI of 3.527. This last result is unsurprising as more of the income of higher income taxpayers typically comes in forms that are more readily manipulated for tax purposes, for example benefits-in-kind. While the baseline results may be most applicable to a general assessment of taxpayer responsiveness and the efficiency of the income tax system, such estimates are obscured by significant variation in taxpayer responses. If a proposed marginal tax rate change was centred on very high-income earners, for example, then the ETI for that income group would be a more meaningful estimate than the central ETI of 0.168.

Table 4: ETI results by income level

	5k – 50k	50k-100k	>100k
Elasticity of taxable income:	0.071***	0.329***	3.527***
Baseline model	(0.02)	(0.059)	(0.966)
Observations	*7,563,465*	*2,459,743*	*589,679*
Share of All Taxpayer sample	*71%*	*23%*	*6%*

Note: standard errors in parentheses; *, ** and *** denotes significance at the 5%, 1% and 0.1% level respectively. All regressions employ an age cut-off range (15-64 years inclusive) and an income cut-off (€5,000) unless otherwise specified.

[24] Table A1 in the Appendix documents the range of ETI estimates in the recent literature, with values roughly spanning from 0.05 to 0.5.

[25] However, US employees are obliged to file tax returns annually so the salience of paying tax is likely higher compared to other English-speaking countries, which may also be a factor in the higher ETI values observed in US studies.

6.4: Age

The age profile of taxpayers will likely matter for the ETI. On the one hand, the ETI may increase if we constrain the sample to those of peak working age (25-55 years), as these taxpayers' circumstances change as they get older and they have more opportunities to use tax reliefs (for example, their income rises and they make tax-deductible pension contributions to save for retirement). On the other hand, we may also expect the estimates to reduce for the 25-55 year cohort, as their income growth will be less affected by labour market entry and exit dynamics.

In our results in Table 5, where we look at a narrowed age sample by taxpayer status, we find that the ETI increases for all taxpayers. This supports the first explanation that opportunities to use the available deductions of the tax system increase over time and most particularly in mid-life.

Table 5: ETI results by age (25-55 years)

	All Taxpayers	PAYE	Schedule D
Elasticity of taxable income:	0.231***	0.213***	0.406***
Baseline model	(0.022)	(0.024)	(0.061)
Observations	*7,418,265*	*6,874,097*	*544,168*

Source: Authors' analysis based on Revenue data.Note: Standard errors in parentheses; *, ** and *** denotes significance at the 5%, 1% and 0.1% level respectively. All regressions employ an age cut-off range (25-55 years inclusive) and an income cut-off (€5,000).

To better understand these findings, Table 6 shows median real income over the period for different age cohorts of the taxpayer population. The figures suggest that the cohort aged 15 to 24 may play a role in the low average response observed in the baseline results in Table 3. Such taxpayers are unlikely to have sufficient discretionary income available to either reduce taxable income in response to a tax rate increase or to avail of tax reliefs. Younger taxpayer are also less likely to purchase a property or save for retirement, for example, both of which are subsidised via tax expenditures in the Irish income tax system.

Table 6: Median real taxable income by age, 2004-2015

	All taxpayers (€)
15-24 years	14,467
25-34 years	28,774
35-44 years	39,362
45-54 years	42,070
55 -64 years	38,144

Source: Authors' analysis based on Revenue data.

6.5: Marital status

This section considers how marital status, as defined in the tax system, impacts on taxpayer responsiveness. On average, married taxpayers, whether single or dual-earning, have higher incomes than single taxpayers (see Table 7). Several studies, such as Kleven and Schultz (2014), have found that lower income taxpayers are less responsive to tax rate changes. In addition, married taxpayers who elect to file with Revenue as either a married one-earner or married two-earners have more margins to adjust along in response to a tax rate change i.e. two labour supply decisions and potentially two sets of income tax reliefs.

We would expect this to cause single taxpayers to have lower responsiveness than married taxpayers.

Table 7: Median real taxable income by marital status, 2004-2015

Single		Married One Earning (M1E)		Married Two Earning (M2E)		Total
PAYE	Self-Assessed	PAYE	Self-Assessed	PAYE	Self-Assessed	
24,123	18,764	36,667	25,460	61,017	49,905	30,310

Source: Authors' analysis based on Revenue data.

The results in Table 8 show that single taxpayers have lower responsiveness than married taxpayers, but only when comparing Singles and M1Es. For M2Es, there is little evidence of responsiveness to the marginal tax rate, contrary to expectation. Although the standard errors for the M2E sample are notably higher than for the other samples, the first stage results for M2E indicate that weak identification is not a concern for this sample. However, M2E is a category for tax assessment purposes, and, as such, it may not fit well the framework for estimation of the ETI. Any given income level observed for an M2E observation represents two incomes and it may be the case, for example, that the income response to the net-of-tax rate is not made jointly by the couple.

A comparison of Single and M1E is more straightforward as there is one income per observation but different margins of adjustment across observations. Here we observe that a married individual earner is more responsive than an unmarried (for tax purposes) individual earner. However, it is unclear to what extent this is due to a sample selection issue (M1E have higher incomes on average than Single taxpayers) or due to joint assessment. If, for example, the SRCOs and tax credits for all individual earners were equalised, it would be interesting to observe whether the M1E would still be as sensitive or perhaps they would respond more like Single taxpayers. Although we cannot conclude on this issue in the present paper, exploring issues of sample selection and tax system features would be a useful avenue for future research.

Finally, the previously observed pattern of more responsive self-assessed taxpayers, compared to PAYE taxpayers, is also true by marital status.

Table 8: ETI by marital status

	Single		Married One Earning		Married Two Earning	
	PAYE	Self-Assessed	PAYE	Self-Assessed	PAYE	Self-Assessed
	0.130***	0.370***	0.193***	0.460***	0.131*	0.331
	(0.025)	(0.074)	(0.055)	(0.108)	(0.062)	(0.182)
Observations	*5,663,464*	*292,566*	*1,579,723*	*192,800*	*2,451,519*	*288,605*

Note: standard errors in parentheses; *, ** and *** denotes significance at the 5%, 1% and 0.1% level respectively. All regressions employ an age cut-off range (15-64 years inclusive) and an income cut-off (€5,000) unless otherwise specified.

Section 7 – Discussion

7.1: Implications for policy and revenue forecasting

The central estimate of the ETI is non-negligible, although for certain sub-groups it is very low and for others it is extremely high. The results reinforce the position held by most economists and international organisations that low tax rates should be applied to a broad base. That said, Irish estimates are in the lower half of the range of international estimates, which could reflect a relatively low availability of reliefs compared to other jurisdictions, low opportunities for non-compliance, and labour market frictions. Our estimates take into consideration a wide distribution of taxpayers, from very low income to very high incomes – which may also explain why we observe a more muted response than other studies, particularly in the US, which have often relied on the response of high earners to estimate the elasticity. Lastly, the stability of the Irish income distribution over the period likely reduces the risk of over-estimating the ETI.

The ETI estimates will allow for more dynamic tax revenue forecasting in future by the Department of Finance and the Revenue Commissioners. Taking taxpayer behavioural effects into account should better reflect the true revenue impact of a given tax policy change.

The size and scope of tax reform has been shown in the literature to be an important factor in the size of the ETI. This paper relied on small but frequent changes to tax credits and the SRCO in its estimation strategy. While taxpayers may respond more to larger "big bang" reforms, it is not clear why estimates from a large reform would be more appropriate for revenue forecasting than the estimates derived here. The tax changes we relied on are the most typical form of tax policy change in Ireland and, as such, the resulting ETI values are appropriate to use for forecasting outcomes from any similar future change to the Irish tax system.

A common result in the literature is that much of the behavioural response to higher tax rates takes the form of increased use of deductions rather than reduced labour supply (see Saez *et al.* (2012) for a recent exposition). The consistent differential we found between PAYE and self-assessed taxpayers supports this view. However, we acknowledge that the response channel (deductions versus labour supply) cannot fully be investigated using the current data, and other explanations exist to explain some of the differential (for example, as a withholding tax, PAYE is less salient than self-assessed income tax).

7.2: Efficiency considerations

Using our baseline estimate of the ETI (0.168), we calculate the marginal excess burden of taxation in this section. We use our ETI estimate to assess the efficiency of the tax system in the context of marginal, typical changes to the Irish income tax system – for example, they can be used when assessing the efficiency implications of changing the standard rate cut-off point (SRCO) or changes to tax credits or small changes to marginal tax rates. They are less applicable for larger tax reforms, which may involve very different behavioural responses. Individuals' responses may also change over time, often due to changing parameters of the tax system itself, meaning the ETI itself could change over time for taxpayers with the same characteristics (Slemrod and Kopczuk, 2002).

For the ETI to be a sufficient statistic for welfare analysis, the behavioural response should not include externalities, for example charitable donations in order to reduce taxable income. However, as the Irish income tax system does not offer relief for actions which could involve externalities, we believe this assumption is met. As noted in our methodology, there is no compelling evidence of income effects in the case of reported taxable income, so our ETI estimation procedure – along with the majority of others in the literature – does not consider them. This decision also simplifies the estimation of efficiency effects.

We rely on the methodology outlined in Saez *et al.* (2012) to assess efficiency. In our calculation, we assume that additional tax revenue raised is done so through a marginal increase in the top marginal

rate i.e. the current rate of 40% is raised to 41%.[26] An increase in the top marginal rate will result, firstly, in a mechanical increase in tax revenue (which is currently captured in the Department of Finance and Revenue forecasting models) and, secondly, a behavioural response which will reduce taxable income. The ETI captures the second response.

The mechanical effect is:

$$dM \approx N\,[z^m - \check{z}]\,dt > 0 \qquad (3)$$

The behavioural effect is:

$$dB \approx -\,N\,.\,e\,.\,z^m\,.\,(t/(1-t))\,.\,dt < 0 \qquad (4)$$

And the total revenue effect is:

$$dR = dM + dB = N\,.\,(z^m - \check{z})\,.\,[1 - e\,.\,(z^m/(z^m - \check{z}))\,.\,(t/(1-t))\,]\,.\,dt \qquad (5)$$

Table 9 explains each parameter.

Table 9: Efficiency analysis parameters

Parameter	Description
ž	Mean SRCO level during the period 2004-2015
N	Number of individuals in the top income bracket (above ž)
z^m	Mean taxable income during the period 2004-2015, for all those with incomes above ž
t	The top marginal tax rate (assume a one percentage point increase from current top rate of 40%)
e	The elasticity of taxable income
a	The thinness of the income distribution above the SRCO i.e. the Pareto parameter. Measured by: $z^m/(z^m - \check{z})$

$z^m/(z^m - \check{z})$ can be denoted by *a*, and is known as the Pareto parameter. It measures the thinness of the top tail of the income distribution: the thicker the tail of the distribution, the larger z^m is relative to *ž* and hence the smaller is *a*. The parameter increases as income concentration decreases. Using the Pareto parameter *a*, we can simplify the effect of a small tax rate increase as:

$$dR = dM\,.\,[1 - (t/(1-t))\,.\,e\,.\,a] \qquad (6)$$

The second term in the square brackets shows the fraction of tax revenue lost through behavioural responses. Intuitively, it increases with the tax rate, *t*, the elasticity, *e*, and the Pareto parameter a. Importantly, the term *(t/(1-t)).e.a* is exactly equal to the marginal deadweight burden created by the increase in the tax rate. The *marginal excess burden per euro of extra tax collected* can then by defined using (5) and (6) as:

$$-\frac{dB}{dR} = \frac{e.a.t}{1-t-e.a.t} \qquad (7)$$

For each euro of additional tax raised, the government imposes an extra cost equal to (7). In other words, for each euro raised in taxation to fund public expenditure, there is a deadweight loss or "excess burden" to society arising from the distortion of private decisions that taxation typically

[26] As equations (4) to (7) make clear, the efficiency results would alter if the assumption was a larger increase in the higher rate, or an increase in the standard rate instead (which is currently 20%). In general, inefficiency increases with *t*.

causes. From (7), we can also define the *shadow price of public funds* as $1 - dB/dR$. It is this latter parameter which is used in the evaluation of new public expenditure projects. It is applied by inflating the nominal costs of a project in order to account for the distortions created by taxation.

Table 10 outlines the results for different values of *e*, the elasticity of taxable income. Our estimate of the shadow price of public funds for all taxpayers (€1.35) is above the estimate currently used in the Public Spending Code (€1.30). There is merit in considering the use of the estimates derived in this paper in the next revision of the Code in order to have an up-to-date and data-driven assessment of the efficiency costs of taxation.

Our estimate for the shadow price for self-assessed taxpayers is higher at €1.61. This does not mean that lower rates should *specifically* apply to the self-assessed as the efficiency costs of taxation for this group are large; rather, it means that for *any taxpayer* who faces multiple margins of adjustment, the efficiency costs of taxation will likely be higher and the rule of thumb of a low rate and a broad base (i.e. limited tax reliefs and deductions) is particularly important.

Table 10: Efficiency results

	Elasticity of taxable income	Marginal excess burden (€)	Shadow price of public funds (€)
All taxpayers	0.168	0.35	1.35
PAYE taxpayers	0.145	0.32	1.32
Self-assessed taxpayers	0.363	0.61	1.61

Source: Authors' analysis based on Revenue data.

Section 8 – Conclusion

This paper presents the first extensive evidence of taxpayer responses to changes in the marginal tax rate using the Irish tax record data. The behavioural response of interest – the elasticity of taxable income (ETI) – measures how taxable income changes in response to net-of-tax rate changes. The ETI captures the full range of adjustments taxpayers make, from their labour supply response to their tax planning response. As such, our results have implications for economic efficiency as any distortions created by income taxation - such as working fewer hours or purchasing non-productive capital to lower tax liabilities – create a deadweight loss and lower the productive capacity of the economy. However, the results indicate that the inefficiency cost of Ireland's notably progressive income tax system is reasonably contained.

Our results are in keeping with the range of estimates from other countries. Our central estimate lies in the bottom half of the international range, which may be due to Ireland-specific factors such as a relatively smaller level of tax deductions and reliefs in Ireland compared to other jurisdictions, a high degree of income tax compliance, and labour market frictions for PAYE taxpayers in particular.

Due to the richness of the tax record data, the research can distinguish how taxpayer characteristics affect the ETI. There is a notable difference between PAYE workers and the self-assessed, as the latter have more deductions, tax reliefs and capital allowances to adjust their taxable income. There are also notable differences across incomes; high-income taxpayers are extremely responsive while low-income taxpayers have a very limited response. In addition, middle-aged taxpayers are relatively more responsive than the population as a whole, in part due to relatively higher incomes and opportunities to avail of tax reliefs over the life cycle.

Overall, the results demonstrate that taxpayers are responsive to the marginal tax rate, which has clear implications for economic efficiency. Using our central ETI estimate of 0.168, we estimate that the marginal excess burden for each additional euro of tax revenue raised is €0.35 and the consequent shadow cost of public funds is €1.35. This is above the current estimate for Ireland, detailed in the Public Spending Code (2012), which was derived theoretically. There is merit in considering the use of the estimates derived in this paper in the next revision of the Code in order to have an up-to-date and data-driven assessment of the efficiency costs of taxation.

Given the well-known progressivity of the Irish income tax system, the result derived here for the marginal excess burden of taxation suggests that the trade-off involved in pursuing both equity and efficiency objectives in the Irish income tax system is reasonably limited. Nevertheless, the ETI results found in this paper indicate that broadening the tax base, for example by reducing deductions and reliefs, would further enhance efficiency.

References

Aarbu, K. and T. Thoreson. (2001). “Income Responses to Tax Changes – Evidence from the Norwegian Tax Reform”, *National Tax Journal*, Vol. 54(2), pp.319-334.

Adam, S., Browne, J., Phillips, D. & B. Roantree. (2017). “Frictions and taxpayer responses: evidence from bunching at personal tax thresholds”, Institute for Fiscal Studies Working Paper W17/14

Atkinson, A. and A. Leigh. (2008). “Top Incomes in New Zealand 1921-2005: Understanding the Effects of Marginal Tax Rates, Migration Threat, and the Macroeconomy", *Review of Income and Wealth*, Vol. 54(2).

Auten, G. and R. Carroll. (1999). “The effect of income tax on household income”, *Review of Economics and Statistics*, Vol. 81(4), pp.681-693.

Brewer, M., Saez, E. and A. Shephard. (2010). “Means Testing and Tax Rates on Earnings" In *Dimensions of Tax Design: the Mirrlees Review*. Oxford: Oxford University Press.

Chetty, R. (2009). “Bounds on Elasticities with Optimization Frictions: A Synthesis of Micro and Macro Evidence on Labor Supply", *Econometrica*, Vol. 80(3), pp. 969-1018.

Creedy, J., Gemmell, N. and J. Teng. (2016). “The Elasticity of Taxable Income: Allowing for Endogeneity and Income Effects”, Victoria Business School Working Papers 03/2016.

Department of Finance. (2017). “Tax Expenditures Review 2017”. Tax Strategy Group Paper No. 17/13. Dublin: Department of Finance.

Department of Public Expenditure and Reform. (2012). “Public Spending Code”. Available at: https://publicspendingcode.per.gov.ie/

Doerrenberg, P., A. Peichl, and S. Siegloch. (2017). “The elasticity of taxable income in the presence of deduction possibilities”, *Journal of Public Economics,* Vol.151, pp. 41-55.

Feldstein, M. (1999). “Tax Avoidance And The Deadweight Loss Of The Income Tax”, *The Review of Economics and Statistics* Vol. 81(4), pp.674–680.

Feldstein, M. (1995). “The Effect of Marginal Tax Rates on Taxable Income: A Panel Study of the 1986 Tax Reform Act", *Journal of Political Economy*, Vol. 103(3), pp. 551-572.

Gruber, J. & E. Saez. (2002). “The Elasticity of Taxable Income: Evidence and Implications”, *Journal of Public Economics*, Vol.84 (1), pp.1-32.

Hansson, Å. (2007). “Taxpayers’ Responsiveness to Tax Rate Changes and Implications for the Cost of Taxation in Sweden”, *International Tax and Public Finance*, Vol. 14(5), pp.563–582.

Hargaden, E. (2015). “Taxpayer Responses over the Cycle: Evidence from Irish Notches”. PhD working paper.

Hausman, J. (1981). “Labor Supply”, in *How Taxes Affect Economic Behavior*, ed. H. Aaron and J.Pechman, The Brookings Institution: Washington D.C., pp. 27-72.

Honohan, P. & I. Irvine. (1987). “The Marginal Social Cost of Taxation in Ireland”, *Economic and Social Review*, Vol.19(1), pp.15-41.

Kennedy, S., D. Haugh and B. Stanley. (2018) “Income Dynamics and Mobility in Ireland: Evidence from Tax Record Microdata”, Revenue Commissioners Research Paper.

Kiss, A. and P. Mosberger. (2015). “The elasticity of taxable income of high earners: evidence from Hungary”, *Empirical Economics*, Vol. 48(2), pp. 883-908.

Kleven, H. and E. Schultz. (2014). “Estimating Taxable Income Responses Using Danish Tax Reforms”, *American Economic Journal: Economic Policy,* Vol.6(4), pp.217–301.

Miyazaki, T. and R. Ishida. (2016). “Estimating the Elasticity of Taxable Income: Evidence from Top Japanese Taxpayers”. MPRA Paper No. 74623.

Mattika, T. (2016) “The Elasticity of Taxable Income: Evidence from Changes in Municipal Income Tax Rates in Finland”, *Journal of Scandinavian Economics*, forthcoming

Neisser, C. (2017). “The Elasticity of Taxable Income: A Meta-Regression Analysis”, ZEW Discussion Paper No. 17-032. ZEW - Zentrum für Europäische Wirtschaftsforschung / Center for European Economic Research.

OECD. (2010). “Tax Expenditures in OECD Countries”. Paris: OECD.

Rogerson, R. (2006). “Understanding Differences in Hours Worked”, *Review of Economic Dynamics*, Vol. 9, pp. 365-409.

Sillamaa, M. and Veall, M. (2001). “The Effect of Marginal Tax Rates on Taxable Income: A Panel of the 1988 Tax Flattening in Canada,” *Journal of Public Economics*, 80(3), pp.341-356.

Weber, C. (2014). “Toward obtaining a consistent estimate of the elasticity of taxable income using difference-in-differences”, *Journal of Public Economics*, 117: 90–103.

Appendices

Appendix A1: Literature review

Developments in estimating behavioural responses to taxation

The starting point for the present research, in an Irish context, is Honohan and Irvine's 1987 paper concerning the excess burden of taxation in Ireland. This paper, along with others from that time, focused on the elasticity of labour supply in determining the distortive effect of labour taxation. However, beyond consideration of the marginal tax rate, the methodology does not consider in depth the income tax system itself or how taxable income is generated.[27] Generally, older research that modelled labour supply found that it was very sensitive with respect to its price (the after-tax wage).[28] Nevertheless, subsequent work in this area, which relied on microeconomic data, typically found smaller estimates for the labour supply elasticity than those which relied on macroeconomic data. This could be reconciled by the explanation that micro-studies focused on the intensive margin whereas macroeconomic studies captured both the extensive and the intensive margins of labour supply (Rogerson, 2006). Labour market frictions, such as adjustment costs, which are easier to model in micro-studies, are also an increasingly studied explanation for the discrepancy (Chetty, 2012).

In the 1990s and 2000s, a new literature emerged which rested on the insight that changes in hours worked is only one component of the behavioural response to taxation. Feldstein (1995), in particular, argued that the overall elasticity of taxable income - rather than the elasticity of labour supply - is more important for evaluating the economic effects of taxation. A taxpayer can respond to a change in the net-of-tax rate along a range of margins in addition to adjusting hours worked. For example, a taxpayer may reduce effort or switch to compensation in non-income form or adjust spending on tax-deductible activities, such as pension contributions or capital expenditure for the self-assessed. The income tax system, therefore, creates incentives for taxpayers to change their behaviour along more than just the traditional labour supply margin. In principle, all of these potential responses can be captured in this single elasticity, as the variable of interest is taxable income (which captures the full set of responses in terms of labour supply, asset management, tax planning decisions etc.).

Feldstein (1995) also pioneered the use of microeconomic tax record panel data in estimation as opposed to macroeconomic time series data. Relying on a major episode of US tax reform in 1986, which mainly benefited high-earners, the paper used a simple differences-in-differences approach to estimate an ETI range of between 1 and 3. This implies that for every one percent increase in the net-of-tax rate, taxable income increased by up to 3 percent. Feldstein (1995) prompted a large amount of subsequent empirical research on the ETI, which up to the mid-2000s primarily focused on the US tax system. Most of the subsequent research also relied on panel data and employed increasingly sophisticated techniques (which are considered in a later section of this review).

A growing strand of the research, particularly in the United States and more recently in Europe, has produced ETI estimates using individual tax records (recently surveyed by Saez *et al*., 2012; Kleven and Schultz, 2014). As tax administrative data do not include many socioeconomic characteristics, most of these studies can only include control variables for age and marital status but cannot control for occupation or education levels.[29]

[27] We note that in 1986 Ireland had three marginal tax rates: 35%, 48% and 58%. If distortions rise with the square of the tax (as indicated by optimal tax theory), then there was a particularly strong motivation for the authors to investigate high distortions from income taxation in Ireland at that time.

[28] See for example the influential contribution of Hausman (1981).

[29] A recent paper on Japan is an exception in that occupation is available on the tax record there (Miyazaki and Ishida, 2016).

Estimates of the ETI in the literature

Over the last twenty years, estimates for the ETI have fallen in value as, firstly, identification methods changed for isolating the impact of net-of-tax changes on incomes and, secondly, as the estimation samples increasingly covered taxpayers at all income ranges. Nevertheless, there is a very wide range of estimates in the available literature, which can range from close to 0 to greater than 1. There can often be a high degree of uncertainty around the central estimate.

The older, mainly American studies typically estimated the ETI to be above 1 (Feldstein, 1995). More recent estimates from the US, which take greater account of all the potential identification issues, typically range from 0.12 to 0.4 (Saez *et al*. 2012). The estimates are generally higher when 1980s US tax reform episodes are used and lower when 1990s US episodes are used (ibid).

There is no reason to expect the ETI to be the same either across time or across countries, as preferences and tax systems can differ across countries, and the tax code within a country can differ across time. A recent meta-analysis of publications estimating the ETI found that roughly two-thirds of all papers rely on US data and that while publications have increased in the late 2000s, the sample period estimated is, on average, the early 1990s (Neisser, 2017). The ETI is not considered by economists to be a structural parameter, meaning that the specific context (time and place) will matter when interpreting results. Slemrod and Kopczuk (2002) argue that the strength of the behavioural response is dependent on environment and may be manipulated by government instruments (for example the comprehensiveness of tax enforcement or the breadth of the tax base). Therefore, if a large ETI is estimated the policy conclusion is not simply that the efficiency costs of taxation are large but, rather, that it is important to adopt policies to broaden the tax base and reduce opportunities in the tax code for income shifting or tax evasion.

Recent estimates for a variety of other countries are outlined in Table A1. It must be underscored that the papers do not use identical methodologies. Some sampling differences are also detailed. Two papers report ETI estimates far below those cited in the majority of papers we reviewed, namely Japan with a range of 0.055-0.074 for substantial tax reform that occurred in the late-1980s (Miyazaki and Ishida, 2016), and Denmark with a central estimate of 0.049 for a series of reforms that span the 1980-2000s (Kleven and Schultz, 2014). In both cases, the estimates increase slightly when the samples are restricted to the highest earning taxpayers, but still remain well below the estimates for other countries. The latter paper, in particular, is able to successfully deal with many of the most common estimation issues, such as mean reversion and income inequality, due to the richness of Danish tax records and the variety of historical tax reforms which impacted right across the income distribution. Interestingly, both papers note that the income distribution of the respective country was stable throughout the sample period, which is consistent with the argument that income inequality results in upwardly biased estimates of the ETI.

Table A1: ETI estimates from the recent literature

Authors (publication year)	Country	Central estimate of ETI	Sample: year and income ranges
Kleven and Schultz (2014)	Denmark	**0.05-0.1**	1984-2005; positive real income, excluding those relying solely on benefits
Miyazaki and Ishida (2016)	Japan	**0.06-0.07**	1986-89; real income > US$ 280,000
Sillamaa and Weall (2001)	Canada	**0.14**	1986-89; real income > CA$ 9,000
Aarbu and Thoresen (2001)	Norway	**0-0.21**	1991-94; real income > NOK 50,000
Mattika (2016)	Finland	**0.21**	1995-2007; real income > EUR 20,000
Kiss and Mosberger (2015)	Hungary	**0.24**	2005-2008; real income > EUR 20,000
Gruber and Saez (2002)	US	**0.4**	1979-90; real income > US$ 10,000
Hansson (2007)	Sweden	**0.4 – 0.5**	1989-1992; positive real income
Atkinson and Leigh (2008)	New Zealand	**0.41**	1921-2005; top 1% incomes
Brewer *et al.* (2010)	UK	**0.5**	1962-2003; top 1% incomes
Auten and Carroll (1999)	US	**0.5**	1985-89; real income > US$ 15,000
Doerrenberg *et al*. (2017)	Germany	**0.54-0.68**	2001-2008; real income > EUR 10,000
Neisser (2017)	n/a	**0.4**	Meta-analysis of 51 studies

Source: Authors' analysis based on literature review

Estimation challenges: instrumental variable approach

A causality problem arises when estimating the ETI for a country with a multi-rate tax system, such as Ireland, because the level of taxable income and the tax rate are jointly determined. Economic theory indicates that on the margin the tax rate will influence the level of taxable income, but in a multi-rate system the level of taxable income also determines the marginal tax rate. Therefore, the literature exploits changes in the tax rate structure created by tax reforms to generate instruments to overcome this potential endogeneity problem (Creedy *et al*., 2016).

Gruber and Saez's (2002) choice of instrument to solve the issue of joint determination has subsequently become a standard one used in estimation of the ETI. They argue that while the observed net-of-tax rate is endogenous in a multi-rate tax system, the net-of-tax rate *that would apply post-reform under unchanged income levels* can be instrumented in its place.[30] Their preferred estimate of the ETI was 0.4 (this covered income responses at different income levels as opposed to only high income taxpayers).

[30] A large number of studies have used this instrument including: Giertz (2004, 2007, 2010), Hansson (2007), Auten *et al.* (2008) and Kleven and Shultz (2014).

Estimation challenges: non-tax related income trends and mean reversion

Much of the literature has focused on the top end of the income distribution, which is more likely to result in upwardly biased ETI estimates due to non-tax changes in income (such as, for example, skill changes and globalisation effects) and greater opportunities for income shifting for high earners. This issue can be exacerbated by increases in top incomes shares over time i.e. income inequality.

A further issue identified in the literature is known as the mean-reversion problem, where an income shock in the year prior to the change may be less likely to recur in the following year. This can, to a certain extent, be corrected for by adding a control for initial income in the base year. Most studies since 2000 have employed such a control (Neisser, 2017). However, Gruber and Saez (2012) and Weber (2014) find that elasticity estimates are extremely sensitive to the specification of pre-reform income controls.

The ETI is increasingly estimated using panel data. However, one weakness of panel analysis is that the identification assumptions lack transparency as they combine the two key estimation challenges of changes in income shares and mean reversion. Saez *et al.* (2012) find "large sensitivity of panel regressions even in the case where many years are pooled and many base-year income controls are included". Panel data are most useful if taxpayer income in a base year is a good predictor of income after the marginal rate change. In other words, the presence of either income mobility or mean reversion weakens the case for using panel data. Substantial income mobility among a small group of taxpayers can have a significant and non-trivial influence on panel estimates. Recent research using the Irish income tax record shows that, over three year periods, more than 55 per cent of taxpayers moved upwards from the bottom decile while 22 per cent moved downwards from the top decile (Kennedy *et al*., 2018). These findings highlight the need to carefully consider the sample restrictions employed to estimate the ETI.

Comparisons of income bases

Many papers find that elasticities calculated using broader definitions of income are much smaller than elasticities calculated using taxable income. The response of broad income (i.e. income prior to any deductions, reliefs or capital allowances) is thought to better reflect how economic activity (i.e. labour supply) responds to the tax rate. The response of taxable income, on the other hand, incorporates this response alongside activity which could reflect tax-planning (i.e. reducing taxable income through legal or illegal means). Notably smaller elasticities for broad income imply, therefore, that the majority of an ETI value is due to tax-planning.[31]

Gruber and Saez's (2002) elasticity for a broader measure of income than taxable income is much smaller than their ETI, 0.12 as opposed to 0.4, suggesting that much of the taxable income response comes through deductions, exemptions, and exclusions, rather than changes in labour supply in the American context. Kleven and Schultz (2014) also create elasticities for both broad and taxable income in Denmark; the difference between the two estimates is far smaller in this case, suggesting that the additional avoidance or evasion opportunities associated with the deduction component of taxable income are smaller in Denmark than the US.

It is not currently possible in the Irish case to create the elasticities using a broader definition of income than taxable income. It will be left to future research to determine whether the behavioural response

[31] We note there is also a mechanical reason for an elasticity using broad income to be lower: as the base is wider, a given income response will result in a smaller elasticity. Gruber and Saez (2002) estimate that roughly two-fifths of the difference between elasticities based on the two income definitions arises from the mechanical effect with the remaining three-fifths relating to a behavioural effect.

here is primarily one involving tax planning or labour supply, or a balance of both.[32]

Efficiency costs of taxation

One of the primary reasons for taxation is to raise revenue for Government spending. Such spending can be extremely worthwhile from both a social and individual perspective, but for every euro raised in taxation to fund it, there is a deadweight loss or "excess burden" to society arising from the distortion of private decisions that taxation typically causes. In order to be considered worthwhile, therefore, an expenditure proposal should have a social benefit large enough to cover not only the direct costs but the excess burden of taxation (Honohan and Irvine, 1987). In practice, a "shadow price of public funds" is applied to the evaluation of new expenditure projects. Currently this parameter is 1.3 in the Irish Public Spending Code (DPER, 2012). This means that the nominal costs of a project are multiplied by 1.3 to account for the distortion created by tax revenues (which typically finance the project).

Older work on this topic relied on the research of Honohan and Irvine (1987) who found a deadweight loss range of £1.21 to £1.73 for each punt of extra tax raised (the lower bound assumed redistribution of the revenue raised while the upper bound did not). Later work for Forfás recognised that marginal tax rates had fallen since the 1980s and therefore treated the marginal cost of €1 of public funds as €1.25 (Murphy et al., 2003). It is important to note that both studies cited here relied primarily on theory to parameterise their models rather than investigation of taxpayer behaviour using micro-data.

Since Feldstein (1999), the ETI has been recognised as a sufficient statistic for welfare analysis under certain conditions (such as, for example, the behavioural change not generating externalities). Chetty (2009) shows that the channel along which taxable income responses occur will make a difference to the interpretation. For example, if one adjustment is for a taxpayer to transfer income to another individual (say by gifting money to a child), then the loss in overall welfare is lower than the ETI would indicate. At the other extreme, if resource costs associated with income adjustment are particularly high then the ETI is an under-estimate of the welfare loss.

Gruber and Saez (2002) discuss optimal taxation and different revenue-maximising rates in detail (differences arise when different social weights are placed on different types of taxpayer). In the present paper, we will restrict ourselves to calculating the marginal excess burden per euro of extra income tax collected, using the approach detailed in Saez *et al.* (2012), which is discussed further in Section 7.2 of the paper.

[32] A comparison of PAYE and self-assessed taxpayers will not be sufficient in the Irish context as although there are far fewer tax deductions available to PAYE taxpayers, there are some notable exceptions such as income tax relief for pension contributions, mortgage interest and health expenditure.

Appendix A2: USC and PRSI

Although the present research only relates to income tax, it is important to consider the different bases for the various charges on income in Ireland. Some key differences in the three bases are outlined in Table A2. Firstly, income from social welfare payments is included in the charge to income tax and PRSI, but excluded from USC. Secondly, the existence of various tax expenditures in the income tax system narrows its base relative to that of USC. For PRSI, the effect is dependent on employment status.

Using tax record population data typically allows an estimation procedure to be as precise as possible, but the existence of three different personal income bases complicates matters as not all components of income are observable on the tax record. It was deemed prudent to defer estimation of an elasticity that included the two other charges until such time as the three income bases are readily observable.

The ETI estimation strategy in this paper therefore focuses solely on the income tax system for two key reasons: it produces large variation in tax rates which assists identification and the income tax base as captured in the tax record micro-data presents a minimum risk of measurement error.

Table A2: Tax base differences across the three charges on income

	Tax expenditures e.g. for pension contribution	Social Welfare payments	Minimum (annual) taxable income at which the first positive tax rate applies in 2018
Income Tax	Exclude	Include	PAYE: €16,500 - €33,000 Self-assessed: €14,000 - €22,250 (Range depends on marital status)
USC	Include	Exclude	PAYE: €1 if gross income exceeds €13,000 Self-assessed: €1 if gross income exceeds €13,000
PRSI	Include for PAYE Exclude for Self-assessed taxpayers who pay income tax under the PAYE system	Include	PAYE: €18,304 Self-assessed: €1

Source: Authors' analysis.

Appendix A3: Calculation of the zero marginal rate cut-off point (ZRCO)

The ZRCO calculated in two steps. First, all taxpayers are assumed to be in receipt of the personal tax credit while only PAYE taxpayers are assumed to receive the employee tax credit. The ZRCO is calculated by dividing these tax credits by the standard tax rate (20 percent over the period under review here).[33] This is considered the minimum ZRCO that each taxpayer faces. The second step exploits the tax credit information on the tax records. Where a taxpayer is in receipt of additional tax credits (such as the single person child carer or home carer tax credit) such that their total tax credits exceeds the minimum calculated in the first step, then their ZRCO is calculated using the higher amount of tax credits.

Appendix A4: Real taxable income thresholds by decile

The main paper documents nominal income thresholds by decile in Table 2. Table A3 below documents the thresholds in real (i.e. price-adjusted) terms.

Table A3: Real taxable income thresholds by decile

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bottom Decile	4,374	4,377	4,640	5,125	5,555	5,303	5,132	5,204	5,271	5,181	5,092	5,180
Decile 2	8,535	8,761	9,421	10,582	11,436	10,954	10,641	10,847	10,818	10,705	10,553	10,558
Decile 3	12,769	13,304	14,328	15,986	17,249	16,482	16,097	16,467	16,489	16,297	16,137	16,089
Decile 4	16,721	17,453	18,736	20,703	22,329	21,399	20,906	21,370	21,442	21,359	21,251	21,330
Decile 5	20,820	21,778	23,383	25,652	27,660	26,618	25,990	26,634	26,883	27,019	27,081	27,260
Decile 6	25,409	26,636	28,699	31,442	33,976	32,789	32,035	32,904	33,260	33,533	33,624	33,849
Decile 7	31,254	32,857	35,323	38,697	41,862	40,272	39,136	40,458	41,149	41,726	41,963	42,337
Decile 8	39,724	41,935	45,154	49,475	53,528	51,316	49,660	51,410	52,399	53,302	53,863	54,656
Decile 9	54,711	58,137	62,953	69,304	74,899	71,296	69,054	71,356	72,987	74,213	75,130	76,578
Top Decile	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: Authors' analysis based on Revenue data.
Note: 2015 prices for the All Taxpayer category. Real taxable income is calculated by re-basing nominal taxable income in terms of 2015 consumer prices (using the headline CPI). Income thresholds show the maximum income for each decile. Income thresholds for PAYE and Self-Assessed taxpayers are similar up to and including the 7th income decile.

[33] For example, in 2015 the personal tax credit is €1,650 while the employee tax credit is €1,650. Therefore, the minimum zero marginal rate cut-off for single PAYE taxpayers is (€1,650 + €1,650) / 0.2 = €16,500; Single self-assessed taxpayers is €1,650 / 0.2 = €8,250; Married one and two earning PAYE couples is [2*(€1,650) + 2*(€1,650)] / 0.2 = €33,000; Married one and two earning self-assessed couples is [2*(€1,650)] / 0.2 = €16,500.

Tithe an Rialtais
Sráid Mhuirfean Uacht
Baile Átha Cliath 2
Éire

Government Buildings
Upper Merrion Street
Dublin 2
Ireland

T: +353 1 676 7571
www.finance.gov.ie
@IRLDeptFinance