Master Thesis Policy Economics:

The Elasticity of Taxable Income in Catalonia

Marc Casanova Roca

Abstract

The elasticity of taxable income (ETI) is a key parameter for welfare analysis in the framework of optimal taxation. The ETI allows to approximate the efficiency losses from income taxation. This study estimates the ETI in Catalonia around the years 2010-2013 using a large administrative panel including personal income tax information through an instrumental variables approach. I found that the overall elasticity of taxable income is approximately 0.85. The income effects are estimated to be very small and statistically insignificant, which implies that the compensated and uncompensated elasticities of taxable income are roughly equal.

Supervisor: Dinand Webbink

Student number: 538796

30th of June 2021

Table of Contents

1. Introduction

The elasticity of taxable income (ETI) is a parameter which is used in welfare analysis to approximate the efficiency losses produced by distortionary income taxation. It captures how the taxable income reported by taxpayers react in response to changes in the marginal tax rates (MTR) they face. Having information about the behavioural responses to taxation is of key importance from an optimal taxation point of view.

In this paper I estimate the ETI in Catalonia (Spain), using a panel data containing administrative information from a large and representative sample of taxpayers in Catalonia. I use the Personal Income Tax (PIT) reforms introduced in 2011 and 2012 as source of variation to compute the ETI using an Instrumental Variables (IV) approach widely used in the literature.

There are previous papers estimating the ETI for Spain as a whole, but the information about the ETI at regional level is very limited despite the highly decentralised nature of the Spanish administrations. Spain is a very heterogeneous country, and the regional governments have partial authority over the PIT, including the power to modify the MTR applied to the taxpayers in their respective regions.

Catalonia is one of the most populated and economically dynamic territories in Spain and the marginal tax rates applied in Catalonia are among the highest among Spanish regions. The top marginal tax rate reached a maximum of 56% in 2012. Obtaining an estimate of the elasticity of the taxable income in Catalonia is, therefore, a relevant policy question to answer.

This paper is structured as follows. It starts in section 2 with a discussion and literature review about the ETI as a parameter of interest for optimal taxation and continues reviewing the existing ETI estimates for Spain, in section 3. Section 4 presents the institutional context of Catalonia and Spain. Section 5 describes the data used in the paper, followed by an explanation of the methodology used, in section 6. The findings are presented and discussed in section 7 and section 8 concludes and discusses some policy implications of the results obtained by this study.

2. The Elasticity of Taxable Income

The elasticity of taxable income is a statistic that captures the behavioural change of taxpayers, following modifications in taxation. In particular, the ETI measures how the income tax bases vary in response to an increase or decrease of the income tax.

Taxes, including the income tax, can distort taxpayers' decisions (discouraging supply of labour, investment decisions both in education and financial assets, career choices, etc.). Due to these distortions, efficiency losses in the allocation of resources arise because the optimal choices that the economic agents would make in the absence of taxation are different from the ones they make after the introduction of taxation. As stated in the first fundamental theorem of welfare economics, under perfectly competitive markets (absence of market power and externalities, symmetric information, no transaction costs, complete markets) the allocation of resources generated by the market are Pareto efficient. In practice, this ideal situation of perfectly competitive markets is not usually the case, but it provides a useful theoretical framework to analyse the reality. The second fundamental theorem of welfare economics states that under the conditions defined by the first theorem, any desired allocation can be achieved without harming efficiency through the modification of the initial endowments of the agents, employing lump-sum (individualised) taxes. However, due to the existing information asymmetry between taxpayers and the government, these individualised lump-sum taxes are not feasible in practice (Mirrlees, 1971). Given the impossibility of using non-distortionary instruments to redistribute income, governments rely on distortionary taxes to carry out the desired redistribution. The use of distortionary taxes by governments aiming to redistribute income generates the well-known trade-off between efficiency and equity (Okun, 1975). In order to redistribute income, governments face a loss in efficiency (popularly known as the deadweight loss) due to the distortions generated by taxes, this is the "price to pay" to obtain redistribution.

In this context, policy makers need relevant parameters to approximate the efficiency cost produced by the distortionary income tax. Estimating the magnitude of this cost is of key importance because it provides information about the optimal level of taxation on income, considering both the social costs and the social benefits of taxing income. While the social costs consist of efficiency losses that can be approximated, the social benefits are determined by the redistributive preferences of society, which are ultimately a political question and therefore without a technical answer.

The ETI is not the only statistic that has often been used to measure the distortions generated by the income tax. Another parameter traditionally used for that purpose is the elasticity of labour supply. The difference between the ETI and the elasticity of labour supply is that the elasticity of labour supply takes only into account the changes that the income tax induces in the labour decisions of workers, while the ETI is a broader indicator which includes also other reactions of the taxpayers that may alter their taxable income beyond their labour supply, such as tax avoidance and evasion, career choices, the remuneration mix chosen, deductions choices, investments decisions, unobserved effort, housing tenure decisions, etc.

Feldstein (1995) was the first paper to point out the better accuracy of the ETI to estimate the deadweight loss. He estimated for the first time how taxable income responds to changes in the marginal tax rates, in this case for the United States (US). The author also discussed the characteristics of the ETI in Feldstein (1999), arguing why it is a better statistic than the elasticity of labour supply. He showed this formally, by introducing untaxed forms of compensation and deductible forms of consumption (such as mortgages) in the utility function developed by Harberger (1964), which had been the framework traditionally used until then.

Many other authors attempted to estimate the ETI in the US after Feldstein (Auten and Carroll, 1999; Gruber and Saez, 2002; Weber, 2014; among others) showing a wide variety of estimates. There are also numerous estimates for European countries such as Kleven and Schultz (2014) for Denmark, Jongen and Stoel (2013) for the Netherlands, Doerrenberg, *et al.* (2017) for Germany, or few other studies for Spain that will be specifically discussed in the next section.

Yet, despite the interest generated by the ETI in the last two decades, there has been discussion among scholars about the sufficiency of the ETI as a measure to compute the deadweight loss. For instance, Chetty (2009) contradicted Feldstein about the relevance of tax evasion and tax avoidance in explaining deadweight losses, arguing that only the costs of sheltering income should be considered as a loss of efficiency and not the total amount of taxes not paid to the government, given that this is only a distributional issue between agents, not an overall loss of resources for society. On the other hand, Saez *et al*.

(2012) argue that the ETI is only a sufficient statistic for welfare analysis under certain conditions. Namely, the absence of fiscal externalities (shifting of income between different tax bases or over time within the same tax base). Also, according to these authors, conventional externalities should be considered in order to adjust the ETI, as some deductions that may lead to higher elasticities (thus higher efficiency losses) might imply positive externalities (housing, education, etc.) which should be accounted for in a welfare analysis.

Beyond the exact definition of deadweight loss and the discussion about the sufficiency of the ETI to approximate it, the elasticity of taxable income is still the central parameter in the literature about income tax and welfare analysis. More research is still required to improve the methodology for its estimation as well as theoretical discussions about relevant factors other than the ETI to be considered for a complete analysis of the efficiency of income taxation. Finally, regardless of possible limitations of the ETI in estimating the distortions of income taxation, it is still useful for policy makers from the revenue maximization point of view.

3. Existing estimates for Spain

There are few estimations of the ETI for Spain published in scientific journals, (Almunia and Lopez-Rodriguez, 2019; Diaz-Caro and Onrubia, 2018; Sanz-Sant et al, 2015; Sola, 2007). Out of these four papers, only Sanz-Sanz *et al* (2015) contains also estimates of the ETI at the regional level (for all the regions), as a supplementary sensitivity analysis of their main estimation for Spain as a whole. The focus of the available evidence only at the national level contrasts with the reality of the income tax system in Spain, which is highly decentralised, as explained in Section 4.2.

The most recent of these studies, Almunia and Lopez-Rodriguez (2019), is the most complete paper estimating the ETI in Spain, to date. They use administrative panel data containing a large sample of taxpayers with tax information and some background characteristics[1]. They exploit the variation for the whole period 1999-2014, mainly coming from the three major income tax reforms of 2003, 2007 and 2012. Through

[1] All papers listed in this section use the same panel provided by a Spanish public institution. This is the same dataset used for my analysis, which is described in section 5.

different specifications following the approaches proposed by Gruber and Saez (2002), Kleven and Schultz (2014) and Weber (2014). All these papers fall within the standard approach in the literature using instrumental variables. Almunia and Lopez-Rodriguez (2019) find a complete set of estimations for the elasticity of taxable income with respect to the net-of-tax-rate in Spain, ranging from 0.32 to 0.85. However, they consider the most reliable estimates to be between 0.45 and 0.64. In some of their specifications they account for income effects by including virtual income (following Kleven and Schultz, 2014) which they estimate to be positive but small, close to zero.

Diaz-Caro and Onrubia (2018) and Sanz-Sanz *et al* (2015) use only the tax reform of 2007 as source of variation, comparing the pair of years 2006 and 2007. Both use panel data as well, and the standard instrumental variables methodology, with few variations. Diaz-Caro and Onrubia (2018) follow Gruber and Saez (2002), with an extension following Bakos *et al.* (2008) to account for income effects. They provide an interesting breakdown of elasticities by groups of people with different characteristics, and their average ETI estimations lay around 0.41-0.43, while the income effects are negative and around -0.18. Interestingly, they find that removing retired people from the sample lowers the elasticity, which seems counterintuitive. In addition, these authors find that the marginal cost of public funds increased after the tax reform of 2007 and argue that the top marginal tax rate is above the optimum. Sanz-Sanz *et al* (2015) don't use Taxable Income to compute the elasticity with respect to the net-of-tax-rate, but instead a broader definition of Gross Income. They use a specification in line with Auten and Carrol (1999), including controls for base year income, but they also incorporate specifications following Gruber and Saez (2002), separating substitution and income effects. Their preferred specification yields an elasticity of gross income with respect to the net-of-tax-rate of 0.676 for Spain as a whole, while the income effects are estimated to be negative but not significant.

Sanz-Sanz *et al* (2015) is the only existing study, to the best of my knowledge, which also estimates the elasticities for all the regions of Spain individually, as part of their sensitivity analysis. Therefore, their estimation is the only reference I have to compare my coefficient for the ETI in Catalonia with. They estimate that the elasticity of gross income in Catalonia is 0.879, which is higher than the Spanish average. Similarly, Valencia, the Balearic Islands and Murcia (the Mediterranean regions), all present similar elasticities, above the average of Spain as a whole and sensibly above the other regions.

These substantial territorial differences, and the partially decentralised nature of the PIT in Spain underpin the relevance of obtaining an estimation of the ETI at the Catalan level.

Finally, Sola (2007) is the oldest paper computing the ETI in Spain. He uses the tax reforms from the years 1988 and 1989 to perform his analysis. As the others, he uses panel microdata and an IV approach, following the specification proposed by Auten and Carrol (1999) and he finds elasticities of between 0.1 and 0.2. The low elasticities found by this paper seem to suggest the ETI has grown over time.

Table 3.1. summarises the available literature about the ETI in Spain, presenting the approaches followed by these four papers as well as their main estimates.

Table 3.1. Summary literature about the ETI in Spain.

Paper	Tax reforms used	Approach	Estimates
Almunia and López-Rodríguez (2019)	2003, 2007, 2012	Standard IV approach following Gruber and Saez (2002), Kleven and Schulz (2014) and Weber (2014). They use panel microdata for the period 1999-2014.	0.45-0.64[2]
Díaz-Caro and Onrubia (2018)	2007	Standard IV approach following Gruber and Saez (2002) and Bakos *et al.* (2008). They use panel microdata for the years 2006 and 2007.	0.415
Sanz-Sanz et al (2015)	2007	Standard IV approach following Auten and Carrol (1999) and Gruber and Saez (2002). They use panel microdata for the years 2006 and 2007.	0.676
Sola (2007)	1988, 1989	IV approach following Auten and Carrol (1999) using panel microdata for the period 1987 to 1990.	0.1-0.2

[2] This is the range of values the authors consider reliable, although they find a wider range of estimates from 0.32 to 0.85.

4. Institutional context

4.1. The Spanish Dual Personal Income Tax

The Personal Income Tax system in place in Spain since 2007 is a particular case of the so-called Dual Income Tax (DIT) systems. The DIT designs are very common in northern European countries (Norway, Denmark, Sweden and Finland) where they were introduced between the late 80s and early 90s. The main feature of these systems is the division of taxpayers' income in two different tax bases, corresponding to capital income and labour income, which are taxed at different tax rates. The system combines a progressive tax schedule for labour income, with a lower and flat tax rate for capital (and corporate) income. Dual Income Taxation was conceived in order to achieve more tax neutrality. This means minimizing distortions from taxation and not favouring some economic activities over others through taxation, affecting taxpayers' behaviour.

A pure DIT system would tax capital income at a flat rate equal to the lowest tax rate applied to labour income. The rationale behind this includes several arguments. Some concerns about taxing capital at high rates are the potential taxation of the inflation premium[3] if capital income is taxed at a high rate; the double taxation of savings implied by taxing returns on savings which have already been taxed in the past, and most importantly, the reduction of distortions. This last argument refers to the fact that capital mobility is much higher than labour and capital gains realisations are more discretional. Hence, capital income taxation implies higher efficiency costs due to this higher responsiveness of capital to taxation, and this implies that marginal tax rates for capital income should be lower from an optimal taxation point of view. For these reasons separating taxation from labour income and capital income, and taxing capital income at lower, flat rates is supposed to mitigate efficiency costs of income taxation. For a complete discussion about Dual Income Tax systems see Sørensen (2005).

In the case of Spain, the reform of the PIT introduced in 2007 was designed following this idea, although with some deviations with respect from the "pure" theoretical DIT.

[3] The inflation premium refers to the part of the returns on capital which compensate for the erosion of the value of assets imposed by inflation. Since this part of the capital returns are not real returns, they should not be taxed.

The Spanish PIT splits taxpayers' income in two tax bases, the general tax base and the savings tax base. However, these two tax bases do not strictly correspond to labour and capital income. Instead, the general tax base includes labour income, but also income components which should, in theory, be considered returns from capital, such as income from business and some types of capital gains. The savings tax base is composed only by the other types of capital income, mainly the returns from financial investments and other types of capital gains.

Another difference between the Spanish PIT and a pure DIT is that the income included in the savings tax base is not taxed at a flat rate, but instead there is a minor element of progressivity, with two brackets in its tax schedule (three after the reform of 2012, see Section 6.3) and it is not taxed at the same rate as the lowest bracket for labour income, but even lower. Finally, the corporate income tax is not linked to the personal income tax as it should be the case in a pure DIT to avoid income transformation in closely held corporation, but this issue won't be discussed in this paper.

4.2. Decentralisation in Spain

Spain is one of the most decentralised countries in the world. According to the latest score in the Regional Authority Index (RAI)[4], developed by Hooghe, Marks and Schakel, in their popular book *The rise of regional authority: A comparative study of 42 democracies* (2010), Spain is the second most decentralised country in Europe and the fourth in the world, only behind Germany, Bosnia and Herzegovina and India. The RAI has become one of the most used measures of decentralisation in the literature and includes several dimensions of decentralisation, including fiscal autonomy.

The Spanish territorial institutional organisation includes several subnational layers of government: regional, provinces, municipalities, special insular governments in the Balearic and Canary Islands, a special regime in the two autonomous cities of Ceuta and Melilla, and the counties (supra-municipal but sub-provincial) in few regions such as Catalonia, Basque Country, Navarra, and Aragon.

[4] The updated and complete information about the Regional Authority Index (latest information included is from 2018) can be found here https://garymarks.web.unc.edu/data/regional-authority

Despite not being formally a federal country, the autonomous communities (the official names for the regions and nations within Spain) have extensive powers and competences. They have political autonomy, with their own governments and legislative chambers, and a wide range of areas regulated by regional laws. The regional governments have almost full control of education (at all levels), healthcare and social policies, as well as partial control over cultural and sports policies, environment, territorial organisation within the region.

In terms of Economic Policy, the powers of regions are, nonetheless, more limited. Despite managing a big portion of Spanish public spending -mainly funds transferred by the central government- control over taxation is very limited. Taxes are centrally collected, and the main taxes (Value Added Tax, Corporate Income Tax, PIT, and payroll taxes) are largely determined by the central government[5]. Also, labour legislation is an exclusive competence of the central government. The personal income tax, however, is an exception because the regions have partial control over this tax in their respective territories. In Catalonia and the Basque Country they control security policies through their own police forces and administration of prisons as well.

The PIT in Spain is formally a competence of the central government, but it is 50% shared with the regional governments. The autonomous communities are transferred the 50% of the revenues generated by the income tax in their territory, although the tax is centrally collected by the Spanish Tax Authority. In addition, more relevant for this study, the regional governments have wide regulatory powers. They can partially modify the definition of the tax bases, introducing deductions and tax credits. Also, they can set their own tax schedule, defining the income brackets to consider, and setting their own marginal tax rates, on top of the general marginal tax rates set by the central government. Consequently, they can substantially alter the overall MTR in their region. In the case of Catalonia, the fiscal burden imposed by the Catalan government is more than half of the overall fiscal burden generated by the income tax.

Considering the decentralised nature of the income tax in Spain, it is relevant to know the ETI for each autonomous community, as it can vary substantially across regions due to

[5] The only exception are the Basque Country and Navarra, which have full control over their taxes and can collect them themselves due to historical reasons (ancient privileges and constitutions still in place).

the heterogeneity of the country. Having this information would be useful for regional policy makers when setting their statutory tax rates and making other fiscal decisions.

4.3. Catalan relevance

Catalonia is one of the most populated territories in Spain, with a population of 7.780.479 inhabitants. It is located in the north-east of the Iberian Peninsula, bordering France and Andorra, and the Mediterranean Sea. Barcelona is the capital of Catalonia, the second largest city in Spain and the main economic and social centre in the region.

Catalonia has traditionally been considered one of the main economic engines of Spain. It was one of the first regions to be industrialised in the 19th century, remaining one of the main industrial and economic centres of Spain ever since. With a GDP per capita of 31.119 euros in 2019, Catalonia represents a 16,4% of the Spanish population, a 19% of the GDP (or 236,8 billion euros), a 22,6% of the industry and a 23% of the Spanish exports (INE and IDESCAT, 2021). Catalonia is also the first touristic destination in Spain, with 19.4 million visitors in 2019, a 23% of the Spanish total[6].

Beyond its economic dynamism and demographic importance, Catalonia is one of the territories in Spain with a strongest own identity. Catalan, the ancient language of Catalonia, is still spoken by 10 million people[7] and it has an official status in Spain and Andorra. The Catalan self-government institutions have a long history and tradition, and the Spanish Constitution recognises the existence of regions and *nationalities*[8], making an explicit distinction between the regular administrative regions and the territories with their own national identity, such as Catalonia, the Basque Country or Galicia. This is relevant since it is in the origin of a deeply rooted will of self-rule among Catalan population, proven by the existence of its own political system and political parties, media and differentiated institutions.

[6] El Periódico de Catalunya (2020). *España cierra 2019 con 83,7 millones de turistas, un 1,1% más.* (https://www.elperiodico.com/es/economia/20200203/espana-cierra-2019-record-turistas-837-millones-7833418).

[7] Catalan is also spoken in Valencia, the Balearic Islands, the South of France and Andorra, where it is the only official language of the State.

[8] Article 2 of the Spanish Constitution from 1978.

Considering the relative economic and demographic importance of Catalonia, and the extensive power of the Catalan government over the income tax in the context of its own political dynamics, it is relevant to know the ETI at the Catalan level. As this parameter has not been specifically estimated for Catalonia before, beyond the supplementary estimation by Sanz-Sanz et al (2015). Obtaining a sound estimation of the ETI in Catalonia will be my contribution to the literature.

5. Data

The data used for my analysis is a publicly available dataset provided by the Institute of Fiscal Studies (IEF, from *Instituto de Estudios Fiscales* in Spanish), a public institution attached to the Ministry of Finance. The IEF, particularly López *et al* (2018), has produced an extensive and comprehensive panel dataset for a long period of time (1999-2015) collecting a large representative random sample of income tax returns during that period. This sample represents about 3% of the total income tax returns in Spain, around half a million per year.

The sample from each year accounts for the change in the total number of taxpayers, adding new observations every year corresponding to new taxpayers representing the increases of taxpayers in the population over time, while keeping (when possible) the same individuals who filled their income tax in previous periods. When some individuals disappear from the population (due to decease or because they stop filing their taxes), those observations are replaced by taxpayers with similar characteristics to avoid panel attrition. However, individuals have a unique identifier which allows to follow them over time and in case of being replaced, the new individuals have completely new identifiers.

This administrative dataset contains information about the main source of income (labour income as a main source or not), and about the income components, deductions, tax credits, and other tax-related details. In addition, the gender, age, or city (and province) of residence are observed.

However, the marginal tax rates are not directly observable in the data. As this is a key variable for my analysis, this imposes the need to calculate the MTRs based on the available information, using the tax simulator I developed, as explained in the methodology section.

The region of residence of the taxpayer is known, and furthermore, the samples are stratified by autonomous community. This ensures the representativeness of the samples within each region. This allows me to generate a representative sample of Catalan observations.

The dataset is complemented by a supplementary panel composed by some of the spouses from the sampled taxpayers included in the main dataset. In Spain, due to the characteristics of the PIT, it is generally advantageous to jointly file the PIT returns as a household. But in some cases (in general when the secondary earner has a very low income) it is fiscally preferrable to fill in two separate declarations. As a result, the individuals included in this additional dataset have much lower incomes and they are not directly sampled but included only as the spouses of sampled taxpayers who fill the tax return individually. This additional dataset is only used to complement the analysis in the sensitivity analysis section, but the baseline estimations of this paper are based on the representative sample from the main dataset.

The available information in the data is sufficient to generate the necessary explanatory (and control) variables required to perform the analysis to obtain the estimation of the ETI in Catalonia. It is reassuring to note that this dataset is the same panel used by all the previous studies computing the ETI for Spain, listed in the section 3.

6. Methodology

The general purpose of this paper is to estimate the effect changes in income taxation have in the income reported by taxpayers. In order to perform this analysis, I use the approach proposed by Gruber and Saez (2002) as a basic framework, as it has become standard in the literature regarding the Elasticity of Taxable Income. Their methodology is the one followed by most papers empirically estimating the ETI with panel data, in different countries, even if with some variations. Some of the existing papers for Spain, already mentioned and summarised in section 3 (Almunia and López-Rodríguez, 2019; Diaz-Caro, 2018) follow their approach as well.

The identification strategy consists in using fiscal reforms as a source of variation to relate the changes in taxpayers' taxable income with the change in marginal tax rates. This change in MTR is translated to a change in the net-of-tax-rate, which is the inverse of the MTR, or in other words: the percentage from the last euro earned by the taxpayer kept after taxes. The literature uses the net-of-tax-rate instead of the marginal tax rate when estimating the ETI.

To do so, an instrumental variables approach is used in combination with a model taking differences. This model explains the log-difference between the taxable income before and after the reform using the log-difference between the predicted net-of-tax-rate after the tax reform (the counterfactual) and the net-of-tax-rate pre-reform. This predicted net-of-tax-rate is the instrument for the actual change, and it is constructed keeping income constant between the two periods.

I use the tax reform introduced around 2012, when marginal tax rates in Spain were increased substantially for all income groups. I use this reform because it is the most recent tax reform (the other major PIT reforms are from 2003 and 2007) for which there is data available. I compare the pair of years 2010 and 2013, since the first tax changes started in 2011 and the main reform came into force in 2012, being 2013 the second fiscal year after the changes started. This is also in line with the usual three-year period comparison used in the literature about ETI, intended to leave some room to observe effects in taxpayers' behaviour, which may take some time to react to tax changes.

Using more than one reform is considered a more solid approach by Saez *et al* (2012) since it provides richer sources of variation to exploit. However, I chose to focus only on the most recent tax reform for two reasons. On the one hand, the ETI is likely to change over time, since the characteristics of taxpayers and the economy vary, globalisation and digitalisation provide opportunities to more easily reallocate income and economic activities, tax sheltering activities are easier not only for companies but also for some individuals, etc. For this reason, I wanted to use the most recent information possible since an average ETI obtained using reforms from almost 20 years ago might be misleading. On the other hand, the Spanish PIT suffered a fundamental reform in 2007, transiting towards a Dual Personal Income Tax type of system, as explained in section 4.1, which makes comparisons before and after 2007 unclear and technically complicated.

6.1. Theoretical model

The theoretical framework of the ETI literature is an extension of the traditional microeconomic model of labour supply with two goods, where taxpayers maximize a utility function $u = (c, z)$ of two goods, consumption c and (reported) taxable income z. Taxable income z is determined by several choices: labour supply, unobserved effort, tax sheltering decisions, etc. While consumption yields positive marginal utility, taxable income affects utility negatively because generating income is assumed to be costly. As pointed out by Kleven and Schultz (2014), the implicit assumption behind this model is that the underlying decisions determining taxable income are weakly separable from consumption in the utility function.

Taxpayers, therefore, maximize utility subject to a budget constraint given by $c = z - T(z)$, where $T(z)$ represents the tax liability[9] faced by the individual (or household). In simple words, consumption is the income minus the taxes paid. It is possible to decompose further this budget constraint, rewriting it in the following way:

$$c = z - T(z) = (1 - \tau) + y$$

[9] Tax liability is the absolute amount (in monetary units) paid in taxes, resulting from applying the tax schedule, which in most cases is a non-linear function of taxable income.

where τ is the marginal tax rate $\tau \equiv T'(\cdot)$ and y represents the virtual income. Virtual income is defined as the difference between the product of the marginal tax rate and taxable income and the tax liability: $y = \tau \cdot z - T(z)$. This can be thought as a measure of progressivity of the tax schedule. The first term is the amount that would result from a linear or flat tax applying the same tax rate to all the income, while $T(z)$ is the tax liability resulting from a tax function $T(\cdot)$, potentially nonlinear. Most income taxes are nonlinear, and particularly progressive. This means that the tax function increases with income, and the average tax rate paid by the taxpayer is lower than the marginal tax rate. In a linear tax, the average and the marginal tax rate are equal. Therefore, in a progressive tax scheme, virtual income is positive by definition.

Hence, under these assumptions, the optimal choice of taxable income can be written as follows:

$$z = z(1 - \tau, y)$$

Following Kleven and Schultz (2014), as it is done in Almunia and López-Rodríguez (2019) for Spain, I can write the following specification, taking logarithms:

$$\ln\left(z_{i,t}\right) = \alpha + \varepsilon \ln(1 - \tau_{i,t}) + \delta \ln(y_{i,t}) + \gamma_t x_i + \theta_t x_{i,t} + \mu_i + v_{i,t} \qquad (1)$$

where ε is my main parameter of interest since it captures the elasticity of taxable income with respect to the net-of-tax-rate. On the other hand, δ is the elasticity of taxable income with respect to virtual income. There are two types of individual characteristics: x_i ,which represents variables whose effects are assumed to remain constant over time (such as age) and $x_{i,t}$ whose effects are possibly time-varying (such as gender). Finally, the μ_i term captures the individual fixed effects, which don't vary over time, and $v_{i,t}$ is the error term.

Next, I take differences in equation (1), since I am comparing the difference between two periods t and $t + s$ (before and after the tax reform):

$$\Delta\ln\left(z_{i,t}\right) = \alpha + \varepsilon \Delta\ln(1 - \tau_{i,t}) + \delta \Delta\ln(y_{i,t}) + \gamma_t \Delta x_i + \theta_t \Delta x_{i,t} + v_{i,t} \qquad (2)$$

where $\Delta\ln(z_{i,t}) = \ln(z_{i,t+s}) - \ln(z_{i,t})$; $\Delta\ln(y_{i,t}) = \ln(y_{i,t+s}) - \ln(y_{i,t})$ and $\Delta\ln(1-\tau_{i,t}) = \ln(1-\tau_{i,t+s}) - \ln(1-\tau_{i,t})$. The fixed effects μ_i disappear from equation (2) when taking differences.

However, if I would estimate equation (2) by simply using ordinary least squares (OLS) I would not obtain a consistent estimation of the ETIs due to endogeneity problems. These endogeneity issues and the strategy to overcome them are explained in the section below.

6.2. Empirical strategy

It is not possible to estimate the coefficients of equation (2) with an OLS regression due to an endogeneity problem which arises from the progressivity of the income tax system.

If there is a positive (negative) shock in income, then because of the progressive nature of the tax schedule there will be a mechanical increase (decrease) in the marginal tax rate. This implies that without accounting for this, an OLS regression of the specification (2) would result in biased estimates as the error term would be correlated with the tax rate.

I am interested in the behavioural response of taxpayers after a tax reform, indicating a change in their optimal choice of taxable income, due to the fact that the tax reform alters the amount of consumption a taxpayer can afford with the same taxable income supply (since the proportion of her income she will keep after the reform, will change). But if the net-of-tax rate changes also mechanically due to the progressivity of the tax schedule, I cannot disentangle the behavioural effect I am interested in from other factors.

In order to overcome this endogeneity issue, the literature has generally used an instrumental variables approach, as proposed in Gruber and Saez (2002). Their method to isolate the change in taxable income due to the re-optimisation of the taxpayer's optimal choice consists in generating a counterfactual instrumenting the observed change in the net-of-tax-rate using a predicted net-of-tax-rate $(1-\tau_t^p)$. This predicted net-of-tax-rate is generated computing the marginal tax rate (τ) a taxpayer would have faced after the reform, in period $t + s$[10], if her income would have remained "constant" with respect to period t. This is a good instrument since it is considered that income in period t is a good predictor of income in period $t + s$.

By constant it is meant that the taxable income from period t is used to predict taxable income in period $t + s$ adjusting it using some parameter. The idea is to reproduce the expected taxable income ($z^p_{i,t+s}$) of each taxpayer after the tax reform, absent from behavioural responses to the reform, but considering some other factors affecting taxable income, other than the change in taxes itself or the behavioural change. This expected variation is captured through the parameter chosen, which can be the GDP growth rate, the evolution of the primary income of households, the inflation, etc. In this paper I use the GDP growth rate to generate the adjusted taxable income. By doing this it is possible to bring pre-reform taxable income to $t + s$ simulating the evolution that each individual's taxable income would have had in absence of behaviour effects.

Then, using this adjusted taxable income from period t , I can obtain the marginal tax rate (τ^p_t) that the taxpayer would have faced, if his income would have followed the expected trend in $t + s$, with the new tax schedule after-reform in place.

In order to obtain τ^p_t it is crucial to build a tax calculator reproducing the real personal income tax. With this constructed tax calculator it is possible to simulate the tax liability for every taxpayer using this adjusted (hypothetical) taxable income. The predicted marginal income tax is obtained by first generating the tax liability (using the tax simulator) of both the adjusted taxable income and of the same amount plus ten[11], and dividing the difference of both tax liabilities by ten:

$$\tau^p_{i,t+1} = \frac{T_{t+s}\left(z_{i,t} + 10\right) - T_{t+s}(z_{i,t})}{10}$$

[10] In the literature it is conventional to use s=3, as it is done in this paper comparing the pair of years 2010-2013.
[11] Any marginal amount (in this case 10 euros) added to the taxable income would suffice to observe the marginal tax rate faced by the taxpayer: the tax rate applied to this marginal 10 euros.

Once I obtain the predicted marginal tax rate for $t + s$ (τ^{p}_{t+s}) I automatically know the predicted net-of-tax-rate $(1 - \tau^{p}_{t+s})$, which will replace the observed net-of-tax-rate $(1 - \tau_{t+s})$. And, therefore, the instrument for $\Delta\ln(1 - \tau_{i,t})$ then becomes:

$$\Delta\ln(1 - \tau^{IV}_{i,t}) = \ln\left(\frac{1 - \tau^{p}_{i,t+s}}{1 - \tau_{i,t}}\right)$$

The instrument for virtual income is constructed in the same way. Instead of the difference between $\Delta\ln(y_{i,t}) = \ln(y_{i,t+s}) - \ln(y_{i,t})$ I substitute the observed virtual income after the reform ($y_{i,t+s}$) by the predicted virtual income ($y^{p}_{i,t+s}$), which is calculated using the predicted marginal tax rate τ^{p}_{t+s} and the predicted taxable income I generated ($z^{p}_{i,t+s}$) as explained above.

$$y^{p}_{i,t+s} = \tau^{p}_{t+s} \cdot z^{p}_{i,t+s} - T(z^{p}_{i,t+s})$$

My instrument for the change in virtual income is then:

$$\Delta\ln(y^{IV}_{i,t}) = \ln\left(\frac{y^{p}_{i,t+s}}{y_{i,t}}\right)$$

With the two instruments I generated it is possible to perform an IV regression for which the two first stage regressions are:

$$\ln\left(\frac{1 - \tau_{i,t+s}}{1 - \tau_{i,t}}\right) = \emptyset\ln\left(\frac{1 - \tau^{p}_{i,t+s}}{1 - \tau_{i,t}}\right) + \delta\ln\left(\frac{y^{p}_{i,t+s}}{y_{i,t}}\right) + \gamma_t\Delta x_i + \theta_t\Delta x_{i,t} + v_{i,t} \quad (3)$$

$$\ln\left(\frac{y_{i,t+s}^{p}}{y_{i,t}}\right) = \emptyset\ln\left(\frac{y_{i,t+s}^{p}}{y_{i,t}}\right) + \delta\ln\left(\frac{1-\tau_{i,t+s}^{p}}{1-\tau_{i,t}}\right) + \gamma_t\Delta x_i + \theta_t\Delta x_{i,t} + v_{i,t} \quad (4)$$

Finally, it is important to note that the definition of taxable income used in this paper does not match the legal definition of taxable income. The definition of taxable income I use does not include capital gains as it is standard to do in the ETI literature. Capital gains are excluded because they are a component of income which can be very volatile and usually imply relatively big amounts of money in some specific years for some taxpayers, not related to the main recurrent income which is what I am most interested to study. Therefore, including them can generate noise and bias the estimators.

6.3.1. Heterogeneous income trends and mean reversion

With the empirical strategy explained above it is possible to tackle the principal endogeneity problem arising from using a simple before-after comparison. However, this is not the only concern regarding identification. There are two main threats to my identification strategy which are commonly discussed in the literature about the ETI[12]. These threats are the potential presence of heterogeneous income trends and/or mean reversion.

On one hand, heterogeneous income trends might be a confounding factor threatening the identification of the behavioural response of taxpayers. If the income of taxpayers from different income groups follows persistent diverging trends over time, for instance, due to the secular trend towards more concentration of incomes at the top that it is observed in some countries (Piketty, 2014), then disentangling the reaction of taxpayers to tax reforms from these secular trends might be problematic. However, this concern is more relevant for papers estimating the ETI using share analysis methods with aggregated data, as proposed by Feenberg and Poterba (1993) and Slemrod (1996). When microdata at taxpayer level was not available and the tax reforms used for identification affected only a segment of the taxpayers (this was common for the first studies on ETI focusing on the US), many authors used the segment of taxpayers affected by the reform as a treatment

[12] See Saez *et al* (2012) for an extensive discussion and review about ETI's estimation methodologies.

group, and the others as control, and compared their aggregated income shares before and after the reform linking it with the change in marginal tax rates. Since these analyses need the shares of different income groups to follow the same trend for identification, heterogeneous income trends are a serious threat. This is less important in our case, although it could still be problematic. However, as it is remarked in Almunia and López-Rodríguez (2019), in the case of Spain it seems heterogeneous income trends (and more specifically increasing and persistent concentration of incomes at the top) are not observed, with income from different levels evolving following a similar pattern over the last years, including the period of interest. Moreover, considering the period of analysis in this paper comprises only 3 years, even if there would be some long-term heterogeneous income trends, the effect in such a short period would probably be negligible.

On the other hand, mean reversion happens when there are short-term income shocks followed by a return to the average (or permanent) income. These short-term fluctuations in income are a threat for the identification of behavioural effects. In Almunia and López-Rodríguez (2019) they identify the presence of mean reversion in Spanish taxpayers, which is greatly concentrated at the bottom of the distribution. To mitigate this threat, I exclude observation with yearly incomes below 12,000 euros from my regression. This is a common practice in the literature to mitigate mean reversion although it does not solve the problem completely. Excluding the individuals with low income would only solve the problem if all the remaining taxpayers in the sample would experience the same transitory income shocks (Weber, 2014). To further prevent mean reversion, I additionally include base year income controls following the approach firstly proposed by Auten and Carrol (1999) and followed (with variations) by other papers such as Gruber and Saez (2002), which use also splines for controlling for base year income.

6.3. Tax Reform of 2012

Between the years 2011 and 2012, the Spanish government carried out major tax reforms. In the context of the second dip of the double-dip recession following the economic crisis of 2008, the government implemented an ambitious fiscal adjustment program aiming to reduce the deficit. Those fiscal adjustments included important public expenditure cuts and a significant increase in several taxes.

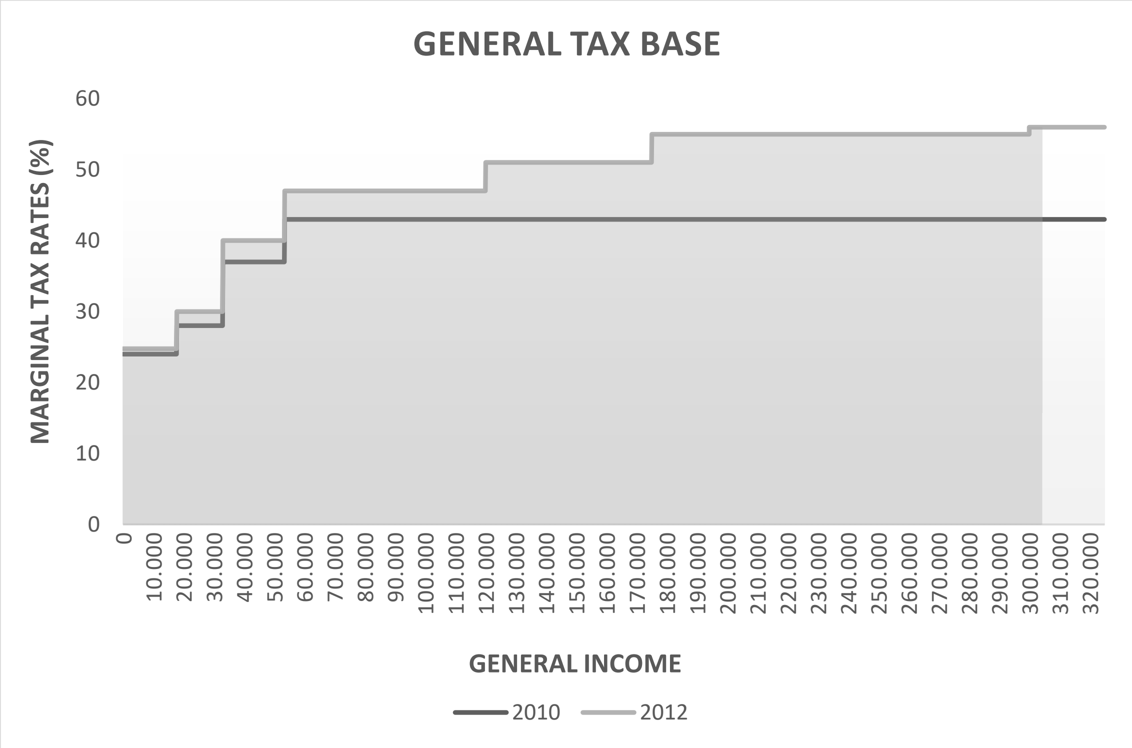
One of the main increases in taxes was applied to the income tax, which experienced several MTR increases for both the general and the special (or savings) tax base. The increases happened mainly in the part of the tax controlled by the Spanish government but also with a further increase at the top introduced by the Catalan government.

In the case of the general tax base, in 2011, two new brackets were introduced at the top. Until that moment, the top marginal tax rate was 43% for any income above 53,407 euros. These two new brackets affected incomes from 120,000 euros until 175,000, and incomes above 175,000, which increased from the previous 43% until 46% and 49%, respectively.

In 2012, a bigger reform introduced by the Spanish government took place, affecting all incomes. There was an increase in marginal tax rates for all the brackets in the tax schedule, and the introduction of still another new bracket at the top of the income distribution. The tax rate increases were of different magnitudes, being smaller for the lower incomes and larger increases for higher incomes, following a progressive increase with income. The taxable incomes taxed at the first bracket (taxable incomes up to 17,707) experienced only an increase of 0,75 percentage points in their MTR, going from a 24% to a 24,75%. The increase for the incomes from 17,707 euros until 33,007 was of two points, going up from 28% to 30%. Taxable incomes from 33,007 until 53,407 went up three points, from a marginal tax rate of 37% to a 40%. Incomes from 53,407 until 120,000 went up 4 points, from 43% until 47%. The bracket from 120,000 until 175,000 increased 5 additional percentage points -on top of the increase already introduced in the previous year in that segment- going from 46% until 51%. The incomes from 175,000 until 300,000 were increased another 6 percentage points, going from a 49% until a 55%. Finally, the new bracket taxing incomes above 300,000 euros implied an increase for the top earners of 7 percentage points, reaching an historically high top marginal tax rate of 56%.

The combined changes from the reforms in 2011 and 2012 in the tax schedule for the general income tax base are represented in Figure 6.1 below.

Figure 6.1. Changes in marginal tax rates in the general tax base



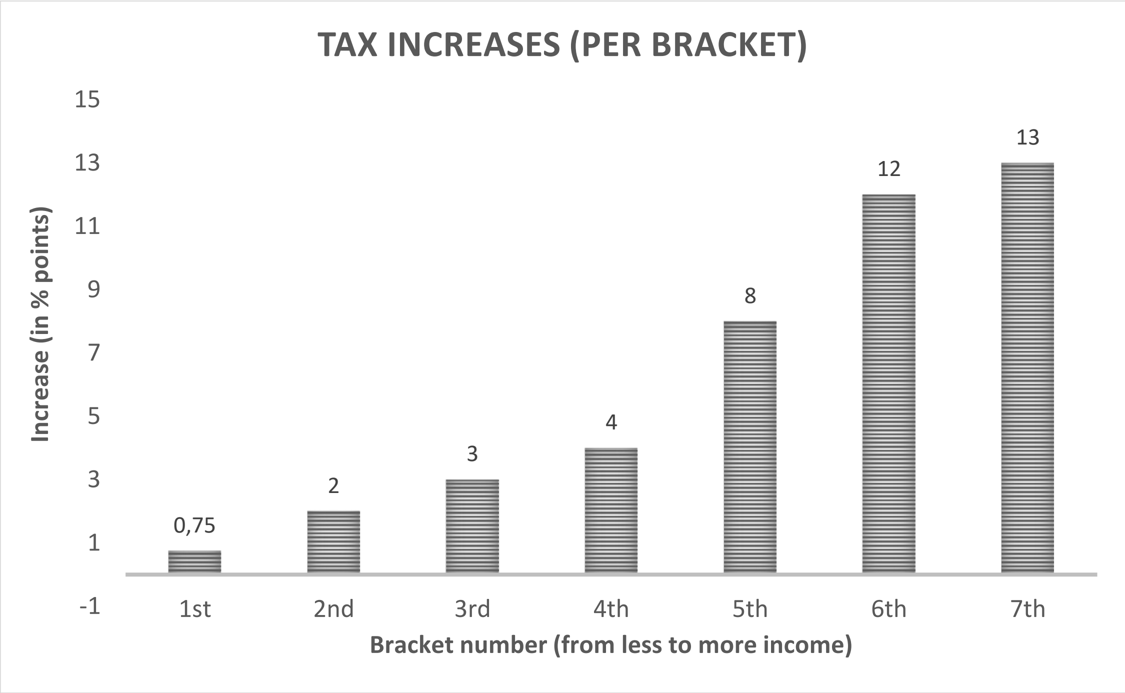
Own elaboration using tax authority information.

As a consequence of this heterogeneous tax increase, with higher incomes bearing much higher increases than lower incomes, the tax schedule for the general income became more progressive.

Taking into consideration the combined reforms from 2011 and 2012, the top earners included in the new three higher brackets were paying 8, 12 and 13 percentage points more in their last euro earned in 2012 compared to 2010.

Figure 6.2 below shows the increase in the tax rates per bracket, in percentage points, in which it is possible to appreciate the progressive nature of the increase in marginal tax rates, and the intensity of the increases at the top of the income distribution.

Figure 6.2. Marginal tax rates increase per brackets.

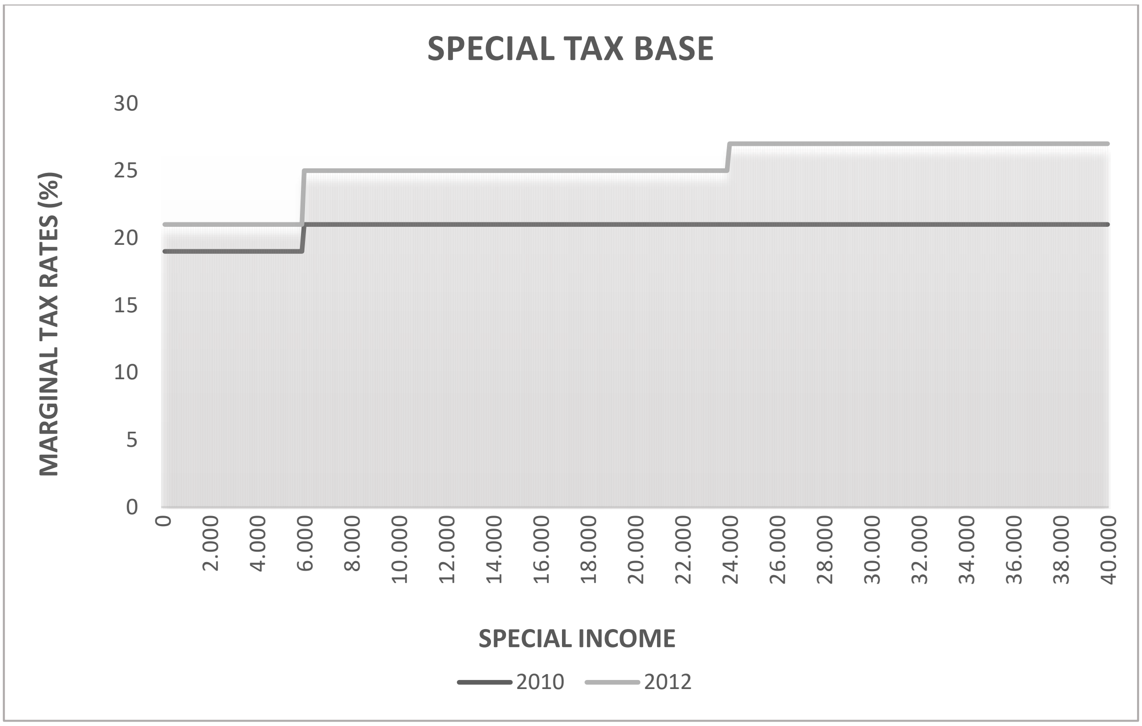


Own elaboration using tax authority information.

On the other hand, the special tax base, composed by the incomes obtained from invested savings, was also affected by these reforms. These changes introduced to the savings tax base by the tax reforms in that period are represented in the Figure 6.3 below.

While in 2010 there were only two brackets, one covering capital incomes from 0 until 6,000 euros at a marginal rate of 19%, and another one covering incomes above 6,000 euros at a rate of 21%. The reform included both the introduction of a new top bracket for capital incomes above 24,000 euros (at a rate of 27%) and a MTR increase for the two existing brackets: rising from 19% to 21% (first bracket) and from 21% to 25% (second bracket).

Figure 6.3. Changes in marginal tax rates in the savings tax base.



Own elaboration using tax authority information.

The tax reform from 2012 was in terms of magnitude, especially for top incomes, one of the most relevant income tax reforms implemented in Spain in the last two decades. It was also the first important reform under the new dual tax system adopted in 2007. Macroeconomically it was also relevant, the ex-ante estimation of tax revenue collection from the 2012 reform represented around a 0.5% of the Spanish GDP that year (Gil *et al*. 2019). However, this estimation would only hold in absence of a behavioural reaction of taxpayers, which is unlikely. Sanz and Romero (2012) estimated that, assuming an ETI of 0.5, the real increase in tax revenues would reduce the expected additional collection by 45%, which would imply important efficiency costs associated with this reform.

It is important to note, however, that the tax reform from 2012 was presented by the Spanish government as a "temporary"[13] tax increase to compensate the extraordinary GDP deficit (more than an 8% of GDP) caused by the impact of the economic crisis. At that time, Spain and other European countries were in the middle of a severe debt crisis

[13]Radiotelevisión española (2011): El Gobierno sube el IRPF y el IBI de forma temporal para 2012 y 2013. https://www.rtve.es/noticias/20111230/gobierno-sube-irpf-ibi-forma-temporal-progresiva-para-2012-2013/486057.shtml

in which their risk premiums were reaching unsustainable levels, with high risk of default or need to apply for a European bailout. This supposedly temporary increase, born mainly by middle and high incomes, was labelled as a solidary contribution of those who could afford it. The tax increase was promised to last only 2 years until the results from the fiscal consolidation plans and the expected economic recovery would allow the public finances to stabilise. The government committed to reduce the tax rates again once this would happen. This temporary nature of the tax increase could have some effect in the perception of taxpayers if the government's commitment were perceived as credible, maybe leading to a lower behavioural response than in the case of a long-term reform.

It is also noteworthy to remark a peculiar characteristic of Spanish fiscal policies over the last two decades, which persists regardless of the political ideology of the government. Contrary to what it would be expected, the main tax reforms introduced by the successive Spanish governments have generally been pro-cyclical. In 2003, and 2007, important tax cuts took place, in a period when the Spanish economy was booming. The tax reforms from 2011-2012 were also pro-cyclical, with big increases in the marginal tax rates in the middle of one of the worst economic crisis in Spanish history. Finally, the Spanish government reduced the PIT marginal tax rates again in 2014, honouring their promise, in a moment when the Spanish economy was finally growing again, and was expected to grow intensely in the following years. One could argue that political economy plays a crucial role in explaining this behaviour, since all tax reductions happened one year before general elections (2004, 2008 and 2015) while the big tax increase was announced in the middle of the Christmas period, only one week after the new government swore in after the elections in the previous month.

7. Results

In this section, the main findings from the baseline specifications of my research are presented and discussed.

To obtain these results, I used the data from the panel described in Section 5. From the whole Spanish sample for the period 1999-2015, only the observations corresponding to Catalonia have been considered. Next, observations with negative (taxable) incomes have been excluded, since the dependent variable is defined as difference of logarithms, and it would not be well defined for negative values. For the main regression analysis, two additional restrictions have been applied to the resulting sample. First, the exclusion of observations with taxable incomes below 12,000 euros per year to mitigate mean reversion as explained in Section 6.2.1. Second, taxpayers older than 65 years old have been excluded since that is the standard retirement age in Spain. The main source of income for retired people is generally their pensions, which do not depend on their decisions and are relatively constant over time. Due to this presumable lack of responsiveness, including retired people could possibly bias the ETI estimates. The relevance of knowing the ETI is to be able to approximate efficiency losses from taxation, in that sense, the main population of interest in this paper are those who are currently active in the labour market and have control over their reported income.

7.1. Descriptive statistics

To contextualise the results, I start by briefly describing the principal variables from my main dataset. The summary statistics of the main variables for this paper are presented in Table 7.1. The table includes, from top to bottom, the gross income of the taxpayers in the sample; my definition of taxable income; the two legal definitions of taxable income, general and savings; the general and savings taxable incomes minus capital gains[14] ; the average weight each source of income represents in the total taxable income (which is needed to compute the weighted overall MTR[15] used to construct the net-of-tax-rate variable); the net-of-tax-rate, which is the main explanatory variable and equals one

[14] By adding up these two variables one obtains the Taxable Income.
[15] This is computed calculating the MTR for each tax base and weighting each resulting MTR with the proportion each type of income represents for each taxpayer's total taxable income.

minus the “overall” marginal tax rate (1-τ). And the average age of the individuals included in the sample.

My definition of Taxable Income (which excludes capital gains) is central for this study, since the dependent variable used in the regressions is the difference in logarithms of Taxable Income between the years 2013 and 2010. In Table 7.1 it is shown how Taxable Income decreases from 44,623 in 2013 to 42,709 in 2010. This is not a surprise because those years Spain experienced a severe recession.

The other central variable in this paper is the net-of-tax-rate. This variable decreases from a 0.715 in 2010 to a 0.695 in 2013, following the increase in MTR adopted in the tax reforms of 2011 and 2012. One would expect that Taxable Income decreases also in reaction to the increase in MTR, beyond the decrease explained by the recession.

The average age of the taxpayers included in the dataset is relatively high, around 51 years old in 2010 and 53 in 2013. In terms of gender, Figure 7.1 shows that the panel is not balanced. Men account for 59% of the total sample in the year 2013:

Figure 7.1. Sample’s Gender Composition

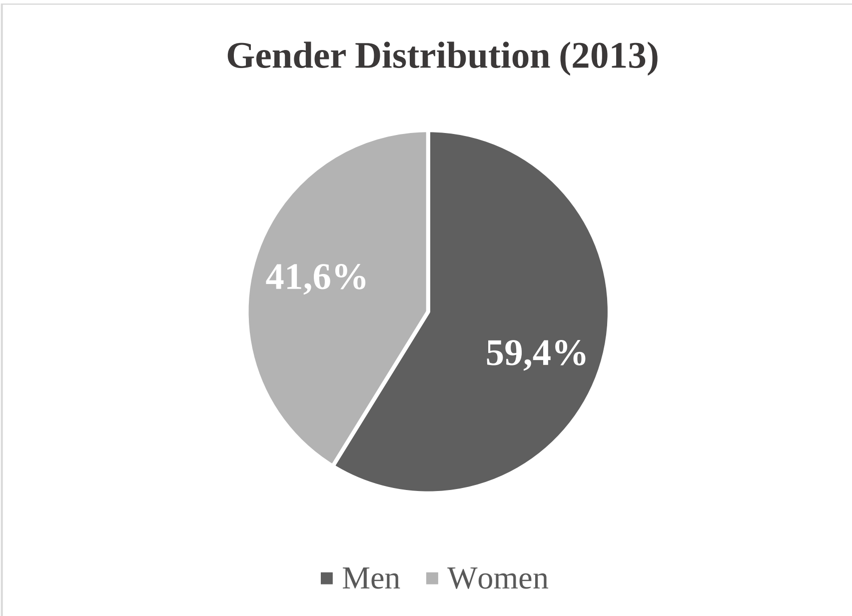


Table 7.1.: Summary Statistics main variables in 2010 and 2013[16].

	2010				2013			
Variables	**Mean**	**Max**	**Min**	**N**	**Mean**	**Max**	**Min**	**N**
Gross Income	52,053	14.31 M	1	97,369	50,856	11.05 M	1	98,511
Taxable Income	44,623	13.90 M	1	97,369	42,709	10.97 M	1	98,511
General Taxable Income	36,815	14.00 M	1	97,369	34,247	8.77 M	1	98,511
Savings Taxable Income	10,601	10.11 M	1	97,369	12,702	30.99 M	1	98,511
General TI (no capital gains)	36,755	14.00 M	1	97,369	33,934	8.77 M	1	98,511
Savings TI (no capital gains)	7,868	8.64 M	1	97,369	8,775	9.17 M	1	98,511
Proportion General Income	0.884	1	0	97,369	0.881	1	0	98,511
Proportion Savings Income	0.116	1	0	97,369	0.119	1	0	98,511
Net-of-tax-rate	0.715	0.902	0.505	97,369	0.695	0.933	0.401	98,511
Age	50.97	110	0	97,369	53.10	113	0	98,511

The monetary values of this table are expressed in euros except for the monetary variables in the column "Max", which are in millions of euros. Age is expressed in years.

[16] These numbers are not representative of the Catalan population as a whole since not all taxpayers are required to fill their tax returns, especially taxpayers with low incomes or young people without descendants often do not fill in their taxes. Therefore, the means in the sample are higher than the average income of the population as a whole.

7.2. Main results

In this subsection, the main estimates of the ETI in Catalonia are presented and discussed. My baseline estimations are constituted by an OLS and two IV regressions following the approach explained in section 6. I start presenting the results of the two first-stage regressions for the IV specifications and the final estimations are discussed below. Both IV specifications include the same set of controls, in particular, age, age squared, base-year income and gender.

First, Table 7.2 presents the results from the first stages of both IV specifications instrumenting for the net-of-tax-rate, the main dependent variable. Column (1) shows the coefficients from the first stage of the IV regression for the specification which does not include virtual income.

The coefficient for the predicted net-of-tax-rate (the instrument) is highly significant, like most of the included controls (age, age squared, base-year income and gender). The large F-statistic indicates a meaningful first stage, which is expected given the nature of the instrument. For the second IV specification, including virtual income, the first stage for the net-of-tax-rate is also meaningful, with a very high F-statistic. However, the significance of the instrument for the net-of-tax-rate disappears. Instead, the virtual income instrument is highly significant. This is surprising since the predicted-net-of-tax-rate is highly correlated with the net-of-tax-rate.

Table 7.2. First stages for the net-of-tax-rate

Variables	**(1) Net-of-tax-rate**	**(2) With virtual income**
Predicted dif. in net-of-tax-rate	0.486***	0.0513
	(0.0152)	(0.0482)
Predicted dif. in virtual income		-0.0971***
		(0.0091)
Age	-0.0009***	-0.0018***
	(0.0003)	(0.0003)
Age^2	1.56e-05***	2.44e-05***
	(3.51e-06)	(3.62e-06)
Base year income	-4.57e-10***	-5.22e-10***
	(7.90e-11)	(1.13e-10)
Gender	0.0015*	0.0029***
(men=1, women=2)	(0.0008)	(0.0008)
Constant	-0.0046	0.0085
	(0.0067)	(0.0068)
Observations (N)	48,743	48,580
F-statistic	294.99	237.87
Prob > F	0.000	0.000
R^2	0.099	0.113

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The fact that adding virtual income as a second explanatory variable leads to an insignificant coefficient of the initial explanatory variable, should not represent a big threat for the identification strategy as both first stages are meaningful and that the instrument is highly correlated with the explanatory variable. The first-stage regression for virtual income is presented in Table 7.3:

Table 7.3. First stage for virtual income

Variables	**(1)**
Predicted dif. in net-of-tax-rate	2.644*** (0.376)
Predicted dif. in virtual-income	1.171*** (0.0816)
Age	-0.0217*** (0.0036)
Age^2	0.0002*** (3.87e-05)
Base year income	9.01e-10** (4.04e-10)
Gender (men=1, women=2)	0.0028 (0.0098)
Constant	0.520*** (0.0782)
Observations (N)	48,580
F-statistic	222.88
Prob > F	0.000
R^2	0.031

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In this case, both the instrument for the net-of-tax-rate and the instrument for virtual income are highly significant, and again the large F-statistic emphasizes a meaningful first stage. As a result, the first-stage findings from both IV specifications validate the relevance of the instruments in my identification strategy.

The summary of the main results and specifications are presented in Table 7.4. This table includes the OLS specification to illustrate why running a simple OLS regression of equation (2) would yield biased results, and the two key IV specifications which constitute our main estimates of interest. My main IV specification, in Column (2), only includes the log-difference between net-of-tax-rates as an explanatory variable for the log-difference in taxable income. The other IV specification in Column (3) accounts for income effects by including both the log-difference in net-of-tax-rate and the log-difference in virtual income as explanatory variables, as defined in Kleven and Schultz (2014). Therefore, this second IV specification consists of two explanatory variables instrumented by their respective predicted versions.

Finally, Table 7.4. reports the main results of the baseline specifications of this paper:

Table 7.4: Baseline estimates ETI in Catalonia.

Variables	**(1) OLS**	**(2) IV: Net-of-tax-rate**	**(3) IV: Virtual Income**
Dif. Net-of-tax-rate	-3.664***	0.864***	0.932*
$\Delta \ln (1-\tau)$	(0.102)	(0.191)	(0.482)
Dif. Virtual income			-0.0016
$\Delta \ln y = \tau \cdot z - T(z)$			(0.0708)
Age	-0.0062**	0.0031	0.0006
	(0.0024)	(0.0029)	(0.004)
Age^2	4.58e-05*	-6.42e-05**	-3.92e-05
	(2.64e-05)	(3.17e-05)	(4.25e-05)
Income base year	-7.52e-09***	-2.90e-09***	-2.97e-09***
	(9.43e-10)	(5.18e-10)	(6.01e-10)
Gender	0.0481***	0.0222***	0.0200***
(men=1, women=2)	(0.0058)	(0.0068)	(0.0067)
Observations (N)	49,011	48,743	48,580
R^2	0.241	.	.
Wald Chi^2	.	299.21	343.07
Prob > chi^2	.	0.0000	0.0000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As illustrated in Table 3, Column (1) shows the results of the naïve OLS regression, which yields an elasticity of the taxable income with respect to the change in the net-of-tax-rate of minus 3.664, which is statistically significant at the 1% level. This ETI coefficient is unrealistically high, with an opposite sign than it would be expected. This result would imply that an increase of 1% in the net-of-tax-rate (therefore, a reduction in the marginal tax rates faced by the taxpayers) would produce a decrease of 3.36% of taxpayers' reported taxable income after the tax reform. This is inconsistent with any microeconomic model, highlighting the expected downward bias caused by the endogeneity issues in a simple OLS design as explained in Section 6.

Column (2) shows the results of the IV specification which only includes the log-change in the net-of-tax-rate as explanatory variable for the log-change in taxable income. This shows that the ETI with respect to the net-of-tax-rate is 0.864, meaning that a reduction of 1% in the net-of-tax-rate (this implies an increase in marginal tax rates) reduces the reported taxable income of taxpayers in 0.86%. This coefficient is highly significant, at the 1% level.

Finally, Column (3) shows the results of the IV specification including both explanatory variables, the log-change in the net-of-tax-rate and the log-change in virtual income. In this case, the coefficient for the net-of-tax-rate is 0.932, which is relatively similar to the coefficient depicted in Column (2). However, its significance is lower; only significant at 10% level of confidence (almost at 5%). This has the same interpretation as before, the taxable income reported by taxpayers decreases a 0.93% on average in response to a decrease of 1% in the net-of-tax-rate. On the other hand, the coefficient for virtual income is almost 0 and not statistically significant. This implies that income effects are not statistically different from 0. This finding is consistent with Almunia and López-Rodríguez (2019), who find very small income effects for Spain, and consistent with other important papers in the ETI literature such as Gruber and Saez (2002) or Kleven and Schultz (2014).

Regarding the controls included in the IV specifications, age does not seem to have a significant effect in explaining the ETI, while the positive and significant coefficient for gender suggests the elasticity is higher for women, which is consistent with the empirical findings from most other countries. The base year income control is in both cases highly significant, suggesting that it is relevant to include it in the regression, which reinforces the idea of the presence of mean reversion and the need to account for it.

The ETI estimates obtained (0.864 and 0.932) are relatively high compared with the average estimates found for Spain in other studies, but they are very close to the only available regional estimate for Catalonia, included in Sanz-Sanz *et al* (2015) which is 0.879.

7.2.1. Compensated and uncompensated elasticity

The most relevant elasticity for welfare analysis is the compensated elasticity, which is the elasticity without income effects. The compensated elasticity represents the substitution effect, which is in the origin of the deadweight loss created by distortionary taxation. Therefore, this is the most interesting parameter for policymakers. The uncompensated elasticity is the overall elasticity, including both income and substitution effects.

Since in the IV specification which includes virtual income I found income effects are practically zero, this means that the uncompensated and the compensated elasticities are roughly equal. This is relevant, and it implies that both ETIs found by the IV regressions presented above have the same interpretation from the point of view of welfare analysis and optimal taxation.

From the social point of view, income effects are not so relevant since they only affect the distribution of income between economic agents (taxpayers and government). Instead, substitution effects alter individuals' behaviour via the modification of the relative cost of leisure and consumption, discouraging the obtention of income, and lowering as a result the overall amount of resources available for society. That is why this loss is considered a social cost, a deadweight loss.

Considering that income effects are negligible, and that both results from the two IV specifications can be equally interpreted as the compensated elasticity of taxable income, I consider the specification (2), which only includes the log-difference in net-of-tax-rate as explanatory variable, my preferred ETI estimation, provided its higher significance level, its wider use in the literature and the insignificant coefficient of the net-of-tax-rate variable in the first stage of specification (3).

7.3. Sensitivity analysis

In order to shed more light on the robustness of my results, I perform some additional analyses to examinate further the response of taxpayers to taxation.

To do so, I run several alternative regressions using variations with respect to the baseline specification presented in the section above.

As explained in section 5, there is an additional dataset which complements the main dataset used for the analysis in this paper, consisting of the spouses of the main income earners of the households which decide to report their taxes separately. I merged both panels to obtain a larger and more heterogeneous sample, and I run the three regressions with the same specifications as in Table 7.3. The outputs of these regressions are presented in Table A1 in the Annex. These regressions show similar coefficients for control variables but the estimated ETIs with respect to the net-of-tax-rates in both IV specifications are higher this time (with elasticities higher than one). Income effects are again close to 0 and statistically insignificant.

This higher ETI is consistent with the composition of this supplementary panel and the literature. While the main panel is composed of around 60% men and 40% women, with on average relatively high incomes, in the supplementary panel the proportion of men and women is symmetrically the opposite, 60% women and 40% men, and their incomes are substantially lower. ETI estimations in most countries find a higher elasticity for women and secondary earners. If this also applies to Catalonia, then the higher elasticity found in this sensitivity analysis could be explained by the higher proportion of secondary earners and women in the merged sample.

Returning to the main sample of principal earners, I introduced some changes to my main specification (using only the net-of-tax-rate as explanatory variable) in order to identify relevant differences.

First, I repeated the specification (2) from Table 7.3 but without excluding the individuals older than 65 (mainly retired people) as I did in my baseline specification. This result can be found in Table A2 from the Annex. Notice that this implies a considerable increase of the sample size. Contrary to what one would expect, making this exercise yields a much higher ETI, around 1.6. Yet, this estimate is similar to the ETI found by Caro and Onrubia

(2018). Further analyses would be needed to understand this unexpected phenomenon, but this goes beyond the scope of this study.

Second, I repeated the same IV regression (excluding again individuals older than 65) but without controlling for base year income. The regression results from this sensitivity analysis are included in Table A3 in the Annex. Recall that controlling for base year income was the method proposed by Auten and Carroll (1999) to cope with mean reversion. After eliminating this control, the ETI estimate increases to 1.6. This seems to confirm that mean reversion is present in the data, and not accounting for it would lead to (upwards) biased estimates.

Finally, by modulating the choice of the threshold used to exclude low incomes from the regression I further verified the relevance of mean reversion. In my baseline specification I exclude taxable incomes below 12,000 euros. As presented in Table A4, in the Annex, I repeated the same regression three times, but this time excluding incomes below 10,000; 6,000 and finally without excluding any low-income earners at all. The results point once more to the existence of substantial mean reversion at the bottom of the income distribution. The ETI when excluding incomes below 10,000 is barely the same as the baseline specification, whereas excluding only taxpayers under 6,000, the elasticity grows already until 1.1 and when there is no restriction of low incomes at all, the elasticity dramatically increases until an unlikely 2.6. This seems to confirm the presence of mean reversion, which is highly concentrated at the very bottom of the income distribution.

7.4. Limitations

In this subsection I discuss the limitations and validity of my results.

There are several concerns regarding the different methodologies estimating the ETI. Although most papers in the literature follow similar identification strategies (using instrumental variables), there is no consensus among scholars about the best exact approach. As discussed in section 6, mean reversion and heterogeneous income trends are considered the principal threats for the identification of the ETI.

Considering the results discussed above, mean reversion seems to be a relevant threat for my research. Following the results from my sensitivity analysis, and in accordance with the findings of Almunia and Lopez-Rodriguez (2019), mean reversion is concentrated among the low incomes, and particularly among taxpayers with a taxable income of less than 6,000 euros per year. Their exclusion is not a guarantee for eliminating mean reversion, since it can also be present (although to a lesser extent) in the rest of the sample. As the specification without controlling for base year income shows, this is a likely hypothesis. However, the inclusion of base years income controls is not ideal either, as pointed out by Saez et al. (2012), because those controls can absorb part of the independent variation in the tax rates as the instrument is also a function of the base year income.

Another important limitation of my methodology is the use of only one reform as a source of variation. It is considered better to use several reforms, particularly if they include changes in different directions (increases and decreases of the tax rates) to exploit a richer set of variations for identification.

Moreover, as also raised by Saez et al. (2012) in their comprehensive review about ETI assessment methodologies, the estimations in the literature tend to be sensitive to the choice of the instruments, making methodology on this subject often questionable.

The pro-cyclical nature of the tax reform from 2012 in Spain could also be indicated as an additional concern, since Taxable Income is mainly driven by the performance of the economy, which experienced a recession at that time. The change in tax rates likely pushed Taxable Incomes towards the same direction as the macroeconomic factors, making the isolation of behavioural effects more complicated.

Furthermore, since the income tax reform was announced as a temporary measure which would be reverted after the crisis, this could make taxpayers react less than would otherwise do after a change in taxes expected to be permanent or long-lasting.

Finally, my ETI estimates are relatively high, despite being similar to the only available estimates for Catalonia, and not too different from the estimates for Spain in other papers. This deviation with respect to other ETI estimations from comparable countries could raise questions about the reliability of the elasticities presented in this paper and the potential presence of bias. Nonetheless, there are also reasons that could explain this higher elasticity, such as the use of a relatively recent reform (in a possible context of increasing ETIs over time) or the composition effects of calculating the ETI for a relatively small territory like Catalonia, with more big companies, high-skilled workers and high-income taxpayers (possible drivers of higher elasticities) than the average for Spain.

8. Conclusion and policy implications

Throughout this paper I have discussed the relevance of the elasticity of taxable income for policymaking, particularly for assessing the social costs of taxation. I have computed the ETI for Catalonia using panel data and adopting the standard methodological approach followed by the literature. This approach consists in an IV design using the differences on the net-of-tax-rate before and after the tax reform of 2012 to explain the differences in taxpayers' reported taxable income post and pre-reform.

I found that the most reliable estimations of the ETI with respect to the net-of-tax-rate range between 0.85 and 0.95. These are relatively large elasticities, but in line with other estimations in the literature.

The ETI is an important statistic for welfare analysis, and the interest about it has grown over the last two decades, replacing elasticity of labour supply as the main parameter to approximate efficiency losses of taxation, since it is more comprehensive as it includes tax sheltering activities as well.

Having sound estimations of the ETI should be a priority for policy makers to be able to approximate the distortions produced by income taxation and to include an accurate estimation of the social costs of taxes in their social cost-benefit analysis when making decisions about fiscal policy. Ideally, the ETI should be known for each bracket of the tax schedule, as ETI is likely to differ between income groups.

However, the ETI itself only provides information about the social costs of taxation, which is half of the equation to be solved when making tax policy decisions. There are important social benefits of taxation (since it allows public spending) which need to be considered as well. The welfare gains derived from the provision of public goods, or the social benefits from income redistribution are good examples of this. Many of these social benefits depend on the social preferences of society regarding inequality and are, in consequence, an intrinsically political question which no technical estimation can answer.

It is safe to assume, though, that taxation will occur in most imaginable scenarios of human modern societies. Therefore, distortions and efficiency losses will arise inevitably. In this sense, limiting the social costs of taxation should be of paramount importance for policy makers, with higher priority the more intense their preference for public spending is.

To limit the efficiency costs of taxation, policies aimed to contain the elasticity of taxable income should be adopted. This is not an easy objective to achieve, but there are some actions which can help in constraining the ETI. A common suggestion, among scholars, in that regard, is to broaden the tax bases. The elasticity of Broad Income is generally found to be lower than the ETI and this difference seems to be driven, in many cases, by deductions and other sorts of fiscal benefits allowing taxpayers (particularly high-income earners) to lower their tax burden (Gruber and Saez, 2002). In general, limiting avoidance opportunities, and loopholes in the tax systems would help in reducing the ETI and raising taxes more efficiently.

Acknowledgements: To my friends Tom van der Plas and Guillem Foucault, who helped me overcoming many obstacles and improving the outcomes of my work with their wise advice, comments, and support.

References

Almunia, M., and Lopez-Rodriguez, D. (2019). The elasticity of taxable income in Spain: 1999–2014. *SERIEs*, *10*(3-4), 281-320.

Auten, G., and Carroll, R. (1999). The effect of income taxes on household income. *Review of economics and statistics*, *81*(4), 681-693.

Bakos, P., Benczúr, P., and Benedek, D. (2008). The elasticity of taxable income: estimates and flat tax predictions using the Hungarian tax changes in 2005.

Chetty, R. (2009). Is the taxable income elasticity sufficient to calculate deadweight loss? The implications of evasion and avoidance. *American Economic Journal: Economic Policy*, *1*(2), 31-52.

Generales, E. C. (1978). Constitución Española de 27 de diciembre de 1978.

Díaz-Caro, C., Onrubia Fernández, J. (2018): How do taxable income responses to marginal tax rates differ by sex, marital status and age? Evidence from Spanish dual income tax, *Economics Discussion Papers, No. 2018-48*, Kiel Institute for the World Economy (IfW)

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

El Periódico de Catalunya (2020). España cierra 2019 con 83,7 millones de turistas, un 1,1% más. https://www.elperiodico.com/es/economia/20200203/espana-cierra-2019-record-turistas-837-millones-7833418 Visited on the 25-05-2021.

Feenberg, D. R., and Poterba, J. M. (1993). Income inequality and the incomes of very high-income taxpayers: evidence from tax returns. Tax policy and the economy, 7, 145-177.

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*, *103*(3), 551-572.

Feldstein, M. (1999). Tax avoidance and the deadweight loss of the income tax. *Review of Economics and Statistics*, *81*(4), 674-680.

Gil, P., Martí, F., Morris, R., Pérez, J. J., and Ramos, R. (2019). The output effects of tax changes: narrative evidence from Spain. *SERIEs*, *10*(1), 1-23.

Gruber, J., and Saez, E. (2002). The elasticity of taxable income: evidence and implications. *Journal of public Economics*, *84*(1), 1-32.

Harberger, A. (1964). Taxation, resource allocation, and welfare. In *The role of direct and indirect taxes in the Federal Reserve System* (pp. 25-80). Princeton University Press.

Hooghe, L., Marks, G., and Schakel, A. (2010). *The rise of regional authority: A comparative study of 42 democracies*. Routledge.

IDESCAT (2021). GDP. By components of the demand. At current prices. *Statistical Institute of Catalonia*. https://www.idescat.cat/pub/?id=aecandn=352 visited on the (07/01/2021).

INE (2021). National Statistics Institute. https://www.ine.es/en/index.htm Visited on the (07/01/2021)

Jongen, E. L., and Stoel, M. (2013). Estimating the elasticity of taxable labour income in the Netherlands. *CPB Background Document, The Hague*.

Kleven, H. J., and Schultz, E. A. (2014). Estimating taxable income responses using Danish tax reforms. *American Economic Journal: Economic Policy*, *6*(4), 271-301.

López, C. P., García, J. V., and Muñoz, I. M. (2018). Panel de declarantes de IRPF 1999-2014: metodología, estructura y variables (1. *Documentos-Instituto de Estudios Fiscales*, (5), 1-153.

Ministry of Finance of Spain (2011). El Impuesto sobre la Renta de las Personas Físicas en 2010. Análisis de los datos estadísticos del ejercicio. https://www.hacienda.gob.es/Documentacion/Publico/Tributos/Estadisticas/IRPF/2010/Analisis_estadistico_IRPF_2010.pdf

Ministry of Finance of Spain (2012). El Impuesto sobre la Renta de las Personas Físicas en 2010. Análisis de los datos estadísticos del ejercicio. https://www.hacienda.gob.es/Documentacion/Publico/Tributos/Estadisticas/IRPF/2011/Analisis_estadistico_IRPF_2011.pdf

Ministry of Finance of Spain (2013). El Impuesto sobre la Renta de las Personas Físicas en 2010. Análisis de los datos estadísticos del ejercicio. https://www.hacienda.gob.es/Documentacion/Publico/Tributos/Estadisticas/IRPF/2012/Analisis_estadistico_IRPF_2012.pdf

Ministry of Finance of Spain (2014). El Impuesto sobre la Renta de las Personas Físicas en 2010. Análisis de los datos estadísticos del ejercicio. https://www.hacienda.gob.es/Documentacion/Publico/Tributos/Estadisticas/IRPF/2013/Analisis_estadistico_IRPF_2013.pdf

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *The review of economic studies*, *38*(2), 175-208.

Okun, A.M. (1975). Equality and Efficiency: The Big Trade-off. *The Brookings Institution.* Washington D.C.

Piketty, T. (2014). *Capital in the twenty-first century*. Harvard University Press.

Radiotelevisión española (2011): El Gobierno sube el IRPF y el IBI de forma temporal para 2012 y 2013. https://www.rtve.es/noticias/20111230/gobierno-sube-irpf-ibi-forma-temporal-progresiva-para-2012-2013/486057.shtml

Saez, E., Slemrod, J., and Giertz, S. H. (2012). The elasticity of taxable income with respect to marginal tax rates: A critical review. *Journal of economic literature*, *50*(1), 3-50.

Sanz-Sanz, J. F., Arrazola-Vacas, M., Rueda-López, N., and Romero-Jordán, D. (2015). Reported gross income and marginal tax rates: estimation of the behavioural reactions of Spanish taxpayers. *Applied Economics*, *47*(5), 466-484.

Sanz, J. F., and Romero, D. (2012). Evaluación del impacto recaudatorio de las reformas de IRPF e IVA de 2012 en un contexto de crisis económica. *Papeles de economía española*, *133*, 39-48.

Slemrod, J. (1996). High-Income Families and the Tax Changes of the 1980s: The Anatomy of Behavioral Response.

Sola, J. S. (2007). El efecto de los cambios en los tipos marginales sobre la base imponible del IRPF. *Hacienda Pública Española*, *182*(3), 9-28.

Sørensen, P. B. (2005). Dual income taxation: why and how?. *FinanzArchiv/Public Finance Analysis, 559-586.*

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

Annexes

Table A1. Baseline estimates in the full sample including main secondary earners.

Variables	(1) OLS	(2) IV: Net-of-tax-rate	(3) IV: Virtual Income
Dif. Net-of-tax-rate	-3.612***	1.063***	1.233***
Δln (1-τ)	(0.101)	(0.187)	(0.462)
Dif. Virtual income			0.0229
Δln y = $\tau \cdot$z -T(z)			(0.0696)
Age	-0.0034	0.0057**	0.0045
	(0.0022)	(0.0026)	(0.0036)
Age^2	1.86e-05	-9.04e-05***	-7.78e-05**
	(2.32e-05)	(2.83e-05)	(3.88e-05)
Income base year	-7.73e-09***	-2.91e-09***	-2.96e-09***
	(9.52e-10)	(5.14e-10)	(5.94e-10)
Gender	0.0544***	0.0268***	0.0225***
(men=1, women=2)	(0.0049)	(0.0056)	(0.0056)
Observations (N)	63,707	63,389	63,211
R^2	0.244	.	.
Wald Chi^2	.	371.50	415.02
Prob > chi^2	.	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2. IV specifications including taxpayers older than 65.

Variables	(1) IV regression
Dif. Net-of-tax-rate Δln (1-τ)	1.678*** (0.193)
Age	-0.0095*** (0.0014)
Age^2	8.77e-05*** (1.29e-05)
Income base year	-2.71e-09*** (4.25e-10)
Gender (men=1, women=2)	0.0112* (0.0063)
Observations (N)	59,893
Wald Chi^2	116.12
Prob > chi^2	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3. Specification without base year income control.

Variables	(1) IV regression
Dif. Net-of-tax-rate Δln (1-τ)	1.624*** (0.146)
Age	0.004 (0.003)
Age^2	-8.00e-05** (3.31e-05)
Gender (men=1, women=2)	0.0228*** (0.0071)
Observations (N)	48,743
Wald Chi^2	232.74
Prob > chi^2	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4. Main specification with different thresholds excluding low incomes.

Variables	**(1)** **>10k**	**(2)** **>6k**	**(3)** **All incomes**
Dif. Net-of-tax-rate Δln (1-τ)	0.868*** (0.193)	1.116*** (0.198)	2.596*** (0.258)
Age	0.00265 (0.00292)	-0.00122 (0.00285)	-0.0332*** (0.00463)
Age^2	-5.22e-05 (3.18e-05)	-4.26e-06 (3.11e-05)	0.000340*** (4.96e-05)
Income base year	-2.91e-09*** (5.20e-10)	-2.87e-09*** (5.19e-10)	-3.92e-09*** (6.92e-10)
Gender (men=1, women=2)	0.0149** (0.00687)	0.0105 (0.00695)	-0.0190* (0.0104)
Observations (N)	51,741	57,034	64,603
Wald Chi^2	247.53	260.45	590.10
Prob > chi^2	0.000	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1