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PERSONAL INCOME TAX REFORMS AND THE ELASTICITY OF REPORTED INCOME TO MARGINAL TAX RATES: AN EMPIRICAL ANALYSIS APPLIED TO SPAIN

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Abstract

This paper shows the utility of the elasticity of reported income to assess tax reforms in detail from the perspectives of tax revenue and well-being. We provide evidence of the value of the elasticity of reported income in Spain given the variations in marginal rates of the Personal Income Tax. The mean value of this parameter for the entire Spanish territory is 1,541. Nevertheless, we confirm the existence of considerable heterogeneity in the value of this elasticity depending on taxpayers' characteristics. Based on these estimated elasticities, we make a detailed assessment of the impact of the recent increase in marginal tax rates that Spain approved in 2012.

JEL codes: H21, H24, H31

Keywords: Personal income tax, taxable income elasticity, excess burden, tax inefficiency.

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1. INTRODUCTION

Economists have always been very interested in studying the effects of tax policies on the behavior of economic agents, as such policies can generate important distortions in the economy. In addition, the current debate on the opportunity to raise taxes to reduce public deficits has bestowed significant importance on the economic analysis of tax reforms.

Traditionally, the response of individuals to changes in tax rates in the Personal Income Tax (PIT) has been assessed based solely on the effect on labor supply. However, in recent years, a new literature has emerged, known as *New Tax Responsiveness*, which considers this approach limited and incomplete because it does not account for many aspects of taxpayers' behavior. As opposed to this partial analysis, which seeks only to study the effects on labor supply, this new literature seeks to measure the global response of economic agents to tax changes. Based on the pioneering work of Lindsey (1987) and Feldstein (1995), a whole range of papers has been created with the main objective of measuring responses of reported income to changes in marginal tax rates. Special mention must be made of Feldstein's (1999) work, which shows how this elasticity allows the determination of tax revenue and efficiency implications due to tax rate alterations.

Although there is extensive empirical literature aimed at determining this parameter in the United States[2], there is scarce evidence for the case of Spain. Therefore, the aim of this research is to provide evidence related to the Spanish economy on the value of this elasticity. Likewise, the estimates obtained are used to illustrate the usefulness of this parameter for a detailed evaluation of PIT reforms. Specifically, we assess the effects of Spain's 2012 PIT reform. To estimate this elasticity, we use microdata from the Taxpayers Panel for PIT, which was compiled by the Tax Agency and the Institute for Fiscal Studies, corresponding to fiscal years 2006 and 2007. Those years were chosen for methodological reasons related to the need to identify two moments in time during which an exogenous change in tax rates occurred. This variability existed in 2006 and

[2] An exhaustive review of the literature on this subject has been conducted by Slemrod (1998), Giertz (2004) and Saez, Slemrod and Giertz (2012).

2007, resulting from implementation of Law 35/2006, which has been in force since January 2007. That tax reform is the most recent one for which microdata are available.

This paper has four additional sections. The second section presents the empirical model and the database. Section three reports the main results obtained in estimating the income elasticity. Section four uses elasticity estimates to assess the impact of Spain's most recent PIT reform. Section five concludes.

2. EMPIRICAL MODEL AND DATA

In this section, we present the empirical model used in estimating the elasticity of reported income along with the data used.

2.1. Empirical Model

The empirical model used was proposed by Gruber and Saez (2002), with subsequent modifications suggested by Bakos, Benczúr and Benedek (2008). The empirical model can be expressed as follows:

$$\Delta \log(y_i) = \beta^C \Delta \log(1-\tau_i) + \eta \Delta \log(1-TME_i) + \alpha Z_i^{'} + u_i \qquad [1]$$

where Δ represents the difference in the variable between 2007 and 2006, i.e., the year when the reform was implemented and the previous year. The variable y_i represents reported income, τ denotes the marginal tax rate, TME stands for the average tax rate, Z_i' is a vector of control variables that include other characteristics of the individual that may have an effect on the size of his or her reported income, and u_i represents the error term. The elasticity of reported income is $\beta^C + \eta$, where β^C is the compensated elasticity and η is the income effect[3].

In line with the proposal of Auten and Carroll (1999), the control variables contained in

[3] Creedy (2014a) has highlighted that the specification in equation [1], extensively used in the empirical literature, relies on the strong assumption that virtual income can be neglected in the computation of the proportional change induce by a tax reform on the average tax rates. Creedy demonstrates that this assumption as highly unrealistic as it implies that marginal and average tax rates are equal.

Z_i' include demographic variables (i.e., individual's sex, age and age square), household characteristics (i.e., number of children, presence of handicapped persons and type of return) and other variables, including the origin and nature of income (i.e., whether taxpayer is a business owner or derives income primarily from wages). In addition, dummies were included that identified taxpayers' regions of residence. This entire set of variables attempted to capture changes in reported income not caused by the marginal tax rate change.

Thus, to control for the problem of mean reversion, the logarithm of the gross income from the *pre-reform* year (2006) was included as an additional regressor. If we had not controlled for the mean reversion, the estimation results could have been contaminated. Mean reversion arises when income fluctuates throughout a taxpayer's life cycle in such a way that an unusually low or high income subsequently returns to its normal path. This return to the mean can be confused with a response to tax rates. Moreover, mean reversion is usually more pronounced at the tails of the income distribution, and therefore, as in other papers, to avoid biases in the estimates of the elasticity, we eliminated the lowest-income individuals.

As is common in the literature, due to the endogeneity of the marginal and the average tax rates, equation [1] was estimated by Two-Stage Least Squares using as instruments what, in the literature, have been called the *virtual marginal tax rate* and the *virtual average tax rate*. These virtual tax rates are those paid by the taxpayer in the post-reform year (2007) if his or her income coincided in real terms with the one obtained in the pre-reform year (2006). Appendix I describes how actual marginal and average tax rates together with their corresponding "virtual versions" have been constructed. As we show in the mentioned Appendix, the calculation of the tax rates has been conducted taking into account the peculiarities of Spain's PIT[4].

[4] Using the dynamics of taxable income over a period that involves no tax changes, Carey, Creedy, Gemmel and Teng (2012) suggest two attractive alternative tax rate instruments. Firstly, conditional on income in two periods before the tax change, the tax rate each taxpayer would face if income were equal to "expected income". Secondly, the "expected tax rate" derived from the form of the conditional distribution of income. Initially we considered the implementation of these two other instruments but it was not viable for the reform under study, as in 2003 and 2004 Spain undertook additional tax changes that made them unsuitable.

2.2. Data

We use tax return microdata for fiscal years 2006 and 2007, collected and prepared by the Spanish Tax Agency and the Institute for Fiscal Studies. We chose those years because, to be able to identify econometrically the elasticity sought, an exogenous change in the marginal tax rates is required. In our case, this tax change occurred in 2007 with the implementation of Law 35/2006. To summarize, the most relevant aspects of this reform are as follows[5]:

i. Family and personal circumstances became treated as tax deductions rather than personal and family allowances.

ii. The dual structure of the tax was changed by modifying the taxable income definition. Specifically, before 2006, income was accumulated in two distinct taxable incomes: the *special taxable income,* which included capital gains generated during more than one year –taxed at a rate of 15%-, and the *general taxable income*, which included all other types of income (salaries, savings income, real estate capital, business income, income allocation and capital gains generated during a period of less than one year). With the 2006 reform, the *special taxable income* became known as the *savings taxable income* which included all yields from savings as well as all capital gains, regardless of when they were generated. This extended *savings taxable income* was taxed at a single rate, which rose from 15% to 18%.

Table 1 summarizes the tax schedules and definitions of the taxable incomes for 2006 and 2007. As can be observed, apart from the different taxable income definitions, the 2007 tax band has three fundamental differences from its 2006 counterpart. First, the number of income brackets was reduced from five to four. Second, the minimum marginal tax rate rose from 15% to 24%, while the maximum marginal tax rate dropped from 45% to 43%. Nevertheless, both rates are not directly comparable because they were applied, as mentioned above, to different legal definitions of income.

[5]In addition to the changes to the PIT for residents, Law 35/2006 incorporated partial changes to Corporation Tax and to PIT of Non-Residents. This research does not address those changes.

Table 1. Tax schedules and taxable income definitions in 2006 and 2007

TAX YEAR 2006			
Taxable income taxed progressively: labour income; alimony; self-employment income; income from property, income from savings, short-term capital gains and income applications to shareholders proceeding from corporations under the fiscal transparency regime.			
Income Threshold (€)	Central Govt MTR	Regional Govt MTR	Total MTR
0	0.0906	0.0594	0.15
4,161.60	0.1584	0.0816	0.24
14,357.52	0.1868	0.0932	0.28
26,842.32	0.2471	0.1229	0.37
46,818.00	0.2916	0.1584	0.45
Taxable income taxed proportionally: long-term capital gains (those generated in one year or more)			
0	0.0906	0.0594	0.15
TAX YEAR 2007			
Taxable income taxed progressively: labour income; alimony; self-employment income; income from property and income applications to shareholders proceeding from corporations under the fiscal transparency regime.			
Income Threshold (€s)	Central Govt MTR	Regional Govt MTR	Total MTR
0	0.1566	0.0834	0.24
17,360	0.1827	0.0973	0.28
32,360	0.2414	0.1286	0.37
52,360	0.2713	0.1587	0.43
Taxable income taxed proportionally: capital gains of any type and any form of income derived from financial savings, such as interest rates from bank accounts and deposits, share dividends, bond interest or any other type of yield earned from debt saving instruments.			
0	0.111	0.069	0.18

It should be noted that although the scenarios before and after the reform share a single definition of gross income, their definitions for taxable income differ significantly. Thus, for reforms such as the one analyzed here, in which the definition of the taxable income before and after the reform differs importantly, Kopczuk (2005) and Saez, Slemrod and Giertz (2012) suggest applying the broadest possible definition of income. Therefore, in this paper, we estimated the gross income elasticity (GIE) rather than the taxable income elasticity (TIE). If we had opted to estimate the TIE, our results would be less robust because TIE is a concept of income that is contaminated by the differences in the legal definition in the years before and after the reform.

The database consists of 288,902 tax returns, with detailed information about reported income, tax due and socioeconomic characteristics of the tax unit[6]. The sample only

[6]To reduce the impact generated by the problem of mean reversion, we eliminated from the study those individuals whose 2006 income was below the *Public Income Indicator of Multiple Effects* (PIIME), which was 5,749.20 Euros.

includes taxpayers with a positive gross income as well as a positive taxable income in both years[7]. Table 2 and Figure 1 show, by income deciles, the impact of the 2007 reform on actual and virtual marginal tax rates. The results demonstrate that the reform raised the marginal tax rates of the lowest-income individuals, as opposed to what we observe for individuals who had the highest incomes. Likewise, for 2007, Figure 2 shows sizeable differences between actual and virtual marginal tax rates. The illustration suggests that individuals changed their behavior to reduce the impact of the reform. This is particularly true in top-decile taxpayers, for whom substantial negative differences exist between actual and virtual marginal tax rates.

Table 2. Average actual and virtual marginal tax rates by gross income decile

Decile	(I) Actual Marginal Tax Rate 2006	(II) Actual Marginal Tax Rate 2007	(III) Virtual Marginal Tax Rate
1	0.154	0.223	0.234
2	0.178	0.234	0.230
3	0.215	0.239	0.234
4	0.235	0.247	0.243
5	0.260	0.266	0.266
6	0.274	0.277	0.275
7	0.318	0.311	0.312
8	0.354	0.341	0.351
9	0.411	0.374	0.397
10	0.404	0.362	0.404

[7]In Appendix II, we include the definitions of the variables used.

Figure 1

Difference in marginal tax rates 2007-2006 by gross income deciles (2006)

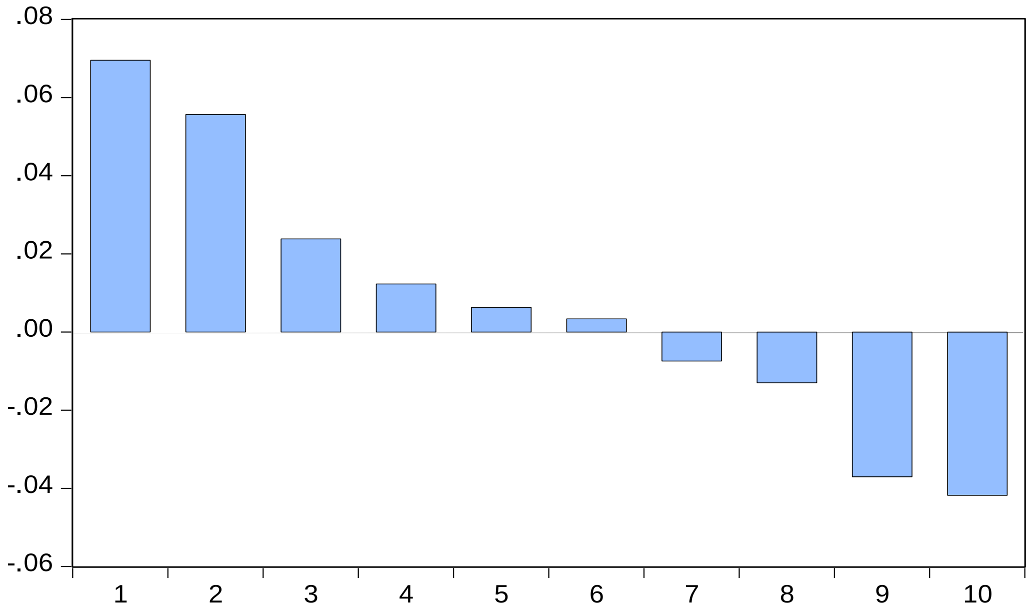
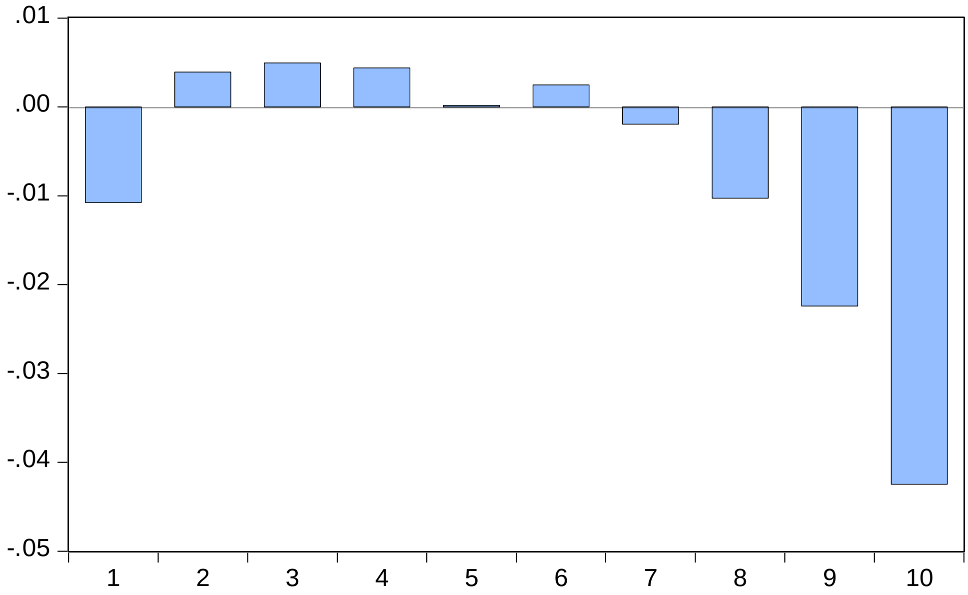


Figure 2

Difference between actual and virtual marginal tax rates in post-reform year (2007)



3. RESULTS

As commented above, using the virtual versions of marginal and average tax rates as instruments (see Appendix I), the empirical model was estimated by Two-Stage Least Squares. Tests for these instruments -both the partial-R^2 and F on excluded instruments- allowed us to accept their validity. As is typical of this literature, all estimates were obtained using sample weights.

In columns (I)-(IV) of Table 3, we present the results of estimating the model without including the *income effect*. Gruber and Sáez (2002) is the first work to consider that the function of income depends on virtual income and thus they include the *income effect.* They find that this effect is not significantly different from zero. Therefore, previous literature does not include the income effect because compensated and non-compensated elasticities are considered equal[8] ($ERB = \beta^C$). In column (I), we present the basic model including neither demographic variables nor the base-year income. In the model reported in column (II), the base year income is incorporated to control for mean reversion. As in Gruber and Saez (2002), Aarbu and Thoresen (2001) and Heim (2009), we observe that when the logarithm of the *pre-reform* income is not included a lower elasticity is obtained. This could be caused by the effect of the mean reversion.

[8] Some works that include the income effect are Gottfried and Schellhorn (2004), Kopczuk (2005), Bakos, Benczúr and Benedek (2008), Gottfried and Witczak (2009), Kleven and Schultz (2012) and, for the case of Spain, Díaz (2004).

Table 3. Results of model estimation

Controls	(I) None	(II) Mean reversion	(III) Mean reversión + Individual characteristics	(IV) Mean Reversion by Deciles + Individual characteristics	(V) Income Effect	(VI) Income Effect + Individual characteristics
Intercept	0.046 (0,001)	2.119 (0.028)	2.174 (0.029)	4.126 (0.132)	2.108 (0.027)	2.174 (0.028)
Δ log(1-τ)	0.775 (0,019)	1.503 (0.027)	1.541 (0.028)	1.393 (0.027)	1.537 (0.035)	1.540 (0.036)
log(y_{t-1})	-	-0.204 (0.003)	-0.224 (0.003)	-0.431 (0.015)	-0.202 (0.003)	-0.224 (0.003)
Δ log(1-TME)	-	-	-	-	-0.238 (0.113)	0.007(*) (0.119)
Age	-	-	0.006 (0.0004)	0.004 (0.0004)	-	0.006 (0.0004)
Age^2	-	-	-0.00005 (3.5×10^{-6})	-0.00003 (3.4×10^{-6})	-	-0.00005 (3.7×10^{-6})
Joint	-	-	-0.036 (0.002)	-0.032 (0.002)	-	-0.036 (0.002)
Self-Employed	-	-	-0.027 (0.002)	-0.023 (0.002)	-	-0.027 (0.002)
Man	-	-	0.041 (0.002)	0.041 (0.002)	-	0.041 (0.002)
Number of Children	-	-	0.035 (0.001)	0.033 (0.001)	-	0.035 (0.001)
Disabled	-	-	0.010 (0.003)	0.006 (0.003)	-	0.009 (0.003)
Source	-	-	-0.044 (0.006)	-0.018 (0.006)	-	-0.044 (0.006)
Region	-	-	Included	Included	-	Included
Mean reversion by deciles	-	-	-	Included	-	-
χ^2_k Overall significance (p-valor)	1,026.68 (0.00)	5,529.78 (0.00)	6,729.14 (0.00)	8,547.00 (0,00)	5,725.59 (0.00)	6,796.64 (0.00)
Standard error of regression	0.408	0.403	0.400	0.394	0.396	0.400
First stage:						
Partial R^2:						
Δlog(1-τ)	0.489	0.447	0.434	0.402	0.459	0.446
Δ log(1-TME)	-	-	-	-	0.084	0.077
F on excluded instruments:						
Δlog(1-τ)	193,194	160,344	148,818	131,664	82,672.9	76,314
Δ log(1-TME)	-	-	-	-	7,400.97	6,482.69
N	288,902	288,902	285,272	285,272	288,897	285,267

Note: Robust standard errors in parenthesis**.** (*) Non significant at 10%

When 2006 income is included -column (II)-, a positive elasticity of 1.503 is obtained. This value is greater than that obtained in other papers that have used the same specification. For example, Auten and Carroll (1999) have obtained elasticities ranging from 0.45 to 0.7, depending on the sample used and the control variables included. In Gruber and Saez (2002), elasticity fluctuates between 0.12 and 0.61, according to the explained variable and the method of controlling for mean reversion. Our results are in line with the values from Moffitt and Wilhelm (2000), who obtained elasticities between 1.76 and 1.99 when using the Feldstein (1995) procedure. This also occurs in Kopczuk (2005), who gets an elasticity of 1.44 when controlling for mean reversion. With respect to Spain, our results are in line with those of Badenes (2001) and Díaz (2004). In Badenes (2001) the elasticity range is between 0.3 and 1.34 for the primary income earner in a marriage and between 0.71 and 2.08 for the second income earner. Díaz (2004) obtains maximum elasticities of up to 2.2 when using the Feldstein procedure. Conversely, Sanmartín (2007) and Díaz (2004) get much lower elasticities (between 0.1 and 0.7) when using Two-Stage Least Squares. The negative sign in *pre-reform* income coincides with results in prior works such as Auten and Carroll (1999), Sillamaa and Veall (2001), Gruber and Saez (2002), Hansson (2007) and, for the case of Spain, Díaz (2004) and Sanmartín (2007).

Column (III) shows the results of a model analogous to that in column (II) but including demographic variables, the type of income source and a set of region-of-residence dummies. The inclusion of these variables barely changes the elasticity, whose value becomes 1.541. From the estimation results it can be inferred that the higher the number of children, the number of handicapped people and the individual's age, the greater the variation in income. The number of children is included to control for its effect on income growth, and a positive sign implies that with a larger number of children income variation is greater. This positive effect coincides with results obtained by a majority of the literature, including Auten and Carroll (1999), Sillamaa and Veall (2001), Gottfried and Schellhorn (2004), Auten, Carroll and Gee (2008), Heim (2009) and, for the case of Spain, Díaz (2004) and Sanmartín (2007). Age and its square value control for life cycle effects. A positive sign for age and a negative sign for its square imply that when age increases, so does income variation, but this positive effect diminishes with age. This behavior can be explained by the fact that income rises more during the first years of an individual's career and becomes more stable over time. This result is consistent with Sillammaa and Veall (2001), Auten, Carroll and Gee (2008), Bakos, Benczur and Benedek (2008) and, for Spain, Díaz (2004). With respect to gender, the evidence shows that as in Giertz (2007), income variation is greater for men than for women. Likewise, income variation is lower in married couples that file jointly than for those who file separately. This is most likely because joint filing is more frequent in households with only one breadwinner, which show lower income variations.

For control variables that represent income source, self-employed individuals or those whose main source of income is labour show a lower variation in income. With respect to self-employed individuals both, Gottfried and Witczak (2009) and Sanmartín (2007), obtain the same results as in this paper. Additionally, regional dummies are jointly significant, as income variation is influenced by the behavior of the regional economy.

In column (IV), the model is extended to include the interaction between the base-year income and income-decile dummies. According to Gruber and Saez (2002), this procedure allows to determine whether the mean reversion effect is non-linear, varying with income decile. As in Gruber and Saez (2002) and Giertz (2007) and Heim (2009), elasticity diminishes when we introduce these differences by income decile, amounting to 1.393. This fall in the estimated elasticity suggests that the variations in the level and in the distribution of income, related with other causes than tax variation, could cause an upward bias.

In line with Gruber and Saez (2002) and Bakos, Benczúr and Benedek (2008), the variation $\log(1-TME)$ is included in columns V and VI[9]. This variable separates the income effect from the substitution effect. We obtain a negative income effect, however, as in Gruber and Saez (2002), this effect is not statistically significant when control variables are considered -column VI-. In the literature, the empirical evidence on the sign and size of this income effect is not conclusive, as the results vary depending on the group of individuals analyzed. Thus, for example, Bakos, Benczúr and Benedek (2008) differentiate the income effect by income brackets and find that it is only significant, with a negative sign, in the highest income ranges. In Gottfried and Witczak (2009) and Kleven and Schultz (2012), the income effect is significant and negative but only for wage earners, whereas it is positive and non-significant for the self-employed. In addition, it is worth noting that, in the absence of control variables, the compensated elasticity is 1.503 whereas it reaches 1.54 when they are included. Moreover, as can be seen, all control variables are significant and have the same signs as those shown in column (III).

[9] Column V exhibits the model without control variables whereas column VI reports results with control variables as those used in column III.

3.1 Sensitivity Analysis

In order to analyze whether there are differences in the elasticity of declared income among individuals, we estimate this elasticity by income levels, region of residence, age group, income source, gender, return type and category of primary income source. The results are presented in Table 4[10].

As for the estimates of gross income elasticity by income quartiles, the elasticity is 0.664 for the first quartile, for the second, it is 1.002, 1.365 for the third, and 2.717 for the last one. Differences among these elasticities are statistically significant. Namely, we confirm that reported income elasticity is positively related to income level[11]. This pattern is found in most of the literature (see, e.g., Gruber and Saez (2002), Giertz (2010) and Claus, Creedy and Teng (2012)). This result is expected as, to a large extent, the design of tax strategies are positively correlated with income. Conversely, in the low-income groups, in which labor is the main source of income, tax planning is less prone. Therefore, as found in Heim (2009), low-income groups have elasticities that are lower and even non-significant. In the case of Spain, Diaz (2004) and Badenes (2001) find that the elasticity varies by income level, but they do not find the same clear upward trend as this paper does.

In block B of Table 4, we present estimates of elasticity of gross income by region of residence. The results show that the elasticity estimated for Madrid is 1.641. Only Catalonia, Murcia and Valencia have greater elasticities (1.70, 1.807 and 1.722, respectively) although there are no significant differences[12]. For the rest of the regions, elasticities range from 0.818 for Ceuta and Melilla to 1.453 for Andalucía. The results suggest that the richest regions (Madrid, Catalonia and Valencia) have the largest elasticities.

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[10] Although models such as those from columns (III) and (VI) of Table 3 were estimated, we only present the results assuming that the income effect is nil, because it was not significant in any case. The results of the estimates are presented in Appendix III.

[11] See column (I), Table A.III.1, Appendix III.

[12] See column (II), Table A.III.1, Appendix III.

Table 4. Sensitivity analysis: Elasticities by individual characteristics

	Elasticities
Basic Model	1.541
A.-Income:	
First quartil	0.664
Second quartil	1.002
Third quartil	1.364
Fourth quartil	2.717
B.- Region:	
Andalusia	1.453
Aragon	1.304
Asturias	1.424
Balearic Islands	1.597
Canary Islands	1.396
Cantabria	1.192
Castile-La Mancha	1.276
Castile-Leon	1.285
Catalonia	1.700
Extremadura	1.267
Galicia	1.435
Madrid	1.641
Murcia	1.807
Rioja	1.473
Valencia	1.722
Ceutaand Melilla	0.818
C.- Age:	
under 35	1.118
between 36 and 55	1.654
between 56 and 65	1.590
over 65	1.588
D.- Income source:	
Labor	0.524
Other	1.548
E.- Gender:	
Men	1.510
Women	1.598
F.- Self-Employed:	
Self-Employed	1.632
Other	1.501
G.- Type of tax return:	
Separately	1.582
Jointly	1.450

In relation to age groups, we estimate the elasticity for the following age segments: under 35, between 36 and 55, between 56 and 65 and over 65. The estimated elasticity for people under 35 years of age is 1.118. The differences among this youngest group and the rest of the age segments are statistically significant. To be specific: the elasticity reaches 1.654 for taxpayers between 36 and 55, 1.59 for people between 56 and 65 and 1.588 for individuals over 65[13]. However, we find no significant differences in elasticities among individuals over 35 years of age[14]. In other words, our results show that before 35 years of age, elasticity is lower. This result can be explained by the fact that labor income is the most relevant source of income in this youngest group of taxpayers. This heterogeneity due to age segments is in line with Diaz (2004) for Spain and Hansson (2007) for Sweden.

As in Diaz (2004) and Carey, Creedy, Gemmel and Teng (2012), elasticities according to income source are estimated[15] –block D-. Results show that individuals whose main source of income is labor have an elasticity equal to 0.524, as opposed to an elasticity of 1.548 for other sources of income[16]. This difference may be caused by the fact that labor income is more difficult to manipulate for fiscal purposes. In other words, the only way to adjust wages is to modify hours of work, but empirical evidence shows that hours of work are quite rigid.

As to gender, results indicate that women are slightly more sensitive to tax variations than men -1.598 and 1.510, respectively-[17]. This is an expected outcome as, in Spain, women are normally the second income-earners within the household. This result coincides with Blomquist and Selin (2010) for Sweden and Badenes (2001) for Spain.

In block F, elasticity estimates for self-employed separated from the rest of the taxpayers are reported. The self-employed have a slightly higher elasticity, 1.632 as

[13]See column (III), Table A.III.1, Appendix III.

[14]When conducting the equality contrast for elasticities in individuals over 35 years of age, we obtain a Wald statistic of 1.95 with a p-value of 0.376.

[15]See the results of the model estimates in column (IV), Table A.III.1, Appendix III.

[16]Carey, Creedy, Gemmel and Teng (2012) estimate for New Zealand an elasticity of 0.414 for individuals whose prime source of income is labor income and 0.909 for others, whereas Diaz (2004) finds for Spain that the elasticity for individuals whose income is derived primarily from work is approximately half of the elasticity for others.

[17]See column (V), Table A.III.1, Appendix III.

opposed to 1.501, with a statistically significant difference[18]. This is an expected result as self-employed have more "flexibility" than wage earners to adjust their taxable income to changes in tax rates. This finding coincides with Sillamaa and Veall (2001) for Canada and Díaz (2004) for Spain.

Finally, we present estimates by type of tax return. As we can see, the elasticity of taxpayers who file separately is greater than that of those who file jointly[19]-1.582 as opposed to 1.450-. This result is not easy to interpret because the individuals who choose to file separately include both single and married people, who normally file separate returns. Nevertheless, when the model is estimated only for married individuals, the same results are obtained. This indicates that the response to tax changes is lower for marriages in which the spouses file jointly than for those who file separately. The reason for this may be that the option to file jointly is only chosen by tax units that have only one income earner or where there are two or more earners with a significant difference in spousal incomes.

3.2. Broadening the Sample: Individuals with a Zero Taxable Income in 2006

Taxpayers with zero taxable income in one of the analyzed years are usually excluded from the estimates. This was the procedure followed to obtain the results shown in previous sections. Nevertheless, our database includes tax returns with a zero taxable income in 2006 but not in 2007. Therefore, we considered it interesting to estimate the model with a broader sample to include these taxpayers, for an additional 20,339 tax returns. In Table 5, we present the results of the model without including the income effect. In column (I), we estimate a single common elasticity for all individuals, whereas in column (II), we estimate elasticities by income quartiles. As we see in column (I), the elasticity estimate is very sensitive to the inclusion of these taxpayers and changes from 1.541 to 0.602. In column (II), we obtain an elasticity of 0.189 for the first quartile, 0.499 for the second, 1.302 for the third and 2.705 for the fourth. If we compare these elasticities with those obtained from the restricted sample (0.664, 1.002, 1.364 and 2.717), we observe that the inclusion of these *zero-tax base* returns really has an effect on the elasticity estimates for the lower and middle-income groups. This analysis

[18]See column (VI), Table A.III.1, Appendix III.
[19] See column (VII), Table A.III.1, Appendix III.

reflects the enormous sensitivity of the estimated elasticities to sample selection, which is reflected in the broadly available evidence -Gruber and Saez (2002), Kopczuk (2005), Heim (2009) or Giertz (2010)-.

Table 5. Results of Model Estimation (Extended sample)

	(I)	(II)
Intercept	1.992 (0.028)	1.912 (0.027)
Δ log(1-τ)	0.602 (0.019)	0.189 (0.019)
Δ log(1-τ)*quartil-2	-	0.310 (0.033)
Δ log(1-τ)*quartil-3	-	1.113 (0.055)
Δ log(1-τ)*quartil-4	-	2.516 (0.050)
log(y_{t-1})	-0.207 (0.003)	-0.201 (0.003)
χ_k^2 overall significance (p-value)	6,854.8 (0.000)	9,055.40 (0.000)
Standard error of regression	0.399	0.403
First stage:		
Partial R^2:		
Δ log(1-τ)	0.647	0.649
Δ log(1-τ)*quartil-2	-	0.617
Δ log(1-τ)*quartil-3	-	0.249
Δ log(1-τ)*quartil-4	-	0.463
F on excluded instruments:		
Δ log(1-τ)	484,134	156,074
Δ log(1-τ)*quartil-2	-	34,519.2
Δ log(1-τ)*quartil-3	-	4,867.57
Δ log(1-τ)*quartil-4	-	14,147.5
N	305,611	305,611

Note: Robust standard errors in parenthesis**.** (*) Non significant at 10%. Models include as regressors: age and square, joint, self-employed, man, number of children, disabled, source and region of residence.

4. APPLICATIONS FOR THE ANALYSIS OF PERSONAL INCOME TAX REFORMS

The income elasticity to marginal tax rates has become an indispensable element for assessing tax reforms, especially in the case of the PIT. According to the findings of Saez (2004), Giert (2009) and Creedy (2011), the use of income elasticity does not limit the study of tax reform to revenue effects but extends it to the analysis of well-being and efficiency, allowing, for example, quantification of the *Equivalent Variation* or the change in the excess burden of taxation. In this section, the elasticities estimated in previous sections are used to analyze the impact of Royal Decree-Law 20/2011, which Spain implemented in January 2012 and caused a very significant rise in the marginal tax rates. As we have seen, beginning in January 2007, the Spanish PIT has had a dual structure that categorizes taxpayers' savings income separately from other types of income. As illustrated in Table 6, the implementation of Royal Decree-Law 20/2011 significantly raised marginal tax rates applicable to both the general tax base and to the savings tax base. Namely, marginal tax rates grew steadily for both tax bases. Specifically, in the general tax base, the marginal tax rate of the first income bracket was raised by 0.75 percentage points, while the last income segment saw its rate raised by seven percentage points. That is, in relative terms, marginal rates were raised between 3.13% for taxpayers in the lowest bracket to 15.56% for taxpayers in the highest band. With respect to savings tax base, the increasing range went from two points in the lowest bracket (10.52%) to six points in the highest band (28.57%).

Table 6. Increase in marginal tax rates approved by the Royal Decree-Law 20/2011

GENERAL TAXABLE INCOME			
Tax Brackets (in €)	Marginal Tax Rate 2011 (%)	Marginal Tax Rate 2012 (%)	Change in Marginal Tax Rates
0 - 17,707.20	24	24.75	3.13%
17,707.20 - 33,007.20	28	30	7.14%
33,007.20 - 53,407.20	37	40	8.11%
53,407.20 - 120,000	43	47	9.30%
120,000 - 175,000	44	49	11.36%
175,000 - 300,000	45	51	13.33%
> 300.000	45	52	15.56%
SAVINGS TAXABLE INCOME			
Tax Brackets (in €)	Marginal Tax Rate 2011 (%)	Marginal Tax Rate 2012 (%)	Change in Marginal Tax Rates
0 - 6,000	19	21	10.52%
6,000 - 24,000	21	25	19.05%
> 24,000	21	27	28.57%

Taking 2012 as the reference year, in the empirical analysis below, we show some empirical applications of the tax base elasticity in analyzing tax reforms. Specifically, based on the estimated elasticities, we determine, for Royal Decree-Law 20/2011, the decrease that it caused in the reported tax base, the effective revenue effect, the impact on well-being, the efficiency costs and the distribution of marginal tax rates that would have maximized revenue in the *pre-reform* scenario (i.e., *Laffer marginal tax rate*). To do so, we simulated this regulatory change using a sample of 1,928,494 tax returns, representative of a population of 19,315,353 tax returns. The calculations were conducted based on the estimated regional gross income elasticities compiled in Table 4. The conversion of gross income elasticities into tax base elasticities is explained in Appendix IV.

4.1 Impact on Reported Taxable Income

Taxable income elasticity other than zero implies that changes in the marginal tax rate induce modifications to the size of taxpayers' reported tax bases. This is a consequence of the existing endogeneity between reported taxable income and marginal tax rates. Therefore, the first natural application of the estimated elasticities is to determine the variation in the magnitude of the reported taxable income that would be expected with implementation of Royal Decree-Law 20/2011. This calculation can be conducted individually for each taxpayer, and subsequently, the individual responses can be added up to obtain the population value. Specifically, for a given taxpayer i the expected reduction in his or her taxable income as a consequence of raising his or her maximum marginal tax rate, τ_h, is provided by the following expression:

$$\nabla x_i = x_{0_i} \cdot \eta^i_{x_{0,(1-\tau_h)}} \cdot d\tau_h \qquad [2]$$

where x_{0_i} represents the *pre-reform* tax base, $\eta^i_{x_{0,(1-\tau_h)}}$ indicates the elasticity of the tax base of taxpayer i and $d\tau_h$ represents the variation, in percentage points, of τ_h. For the aggregated population, equation [2] becomes

$$\nabla X = N_h \cdot \bar{x}_{0_h} \cdot \tilde{\eta}_{x_{0_h},(1-\tau_h)} \cdot d\tau_h \qquad [3]$$

where $\bar{x}_{0_h}$ denotes the mean taxable income of the N_h taxpayers whose taxable income is within the bracket h with $\tilde{\eta}_{x_{0_h},(1-\tau_h)}$ representing the mean value of the elasticity of the taxable income characterizing these taxpayers.

Table 7 compiles the impact on the size of the reported taxable income. In population terms, the total reduction in the reported tax base for non-saving income is 24,118 billion Euros, whereas the reduction in the savings taxable income is 8,475 billion Euros. As can be observed, the most significant relative decrease in taxable income occurs in the final bracket. However, relative to overall taxable income the highest reduction happens in the initial and intermediate brackets. This is so because these non-top brackets contain a larger number of taxpayers.

Table 7. Change in reported taxable incomes induced by Royal Decree-Law 20/2011

GENERAL TAXABLE INCOME			
	Absolute reduction (billions €)	Relative reduction (%) In the bracket	Over Total
bracket 1	-2,992	-3.01	-0.86
bracket 2	-8,377	-7.14	-2.42
bracket 3	-5,465	-8.26	-1.58
bracket 4	- 4,468	-9.84	-1.29
bracket 5	-843	-12.54	-0.24
bracket 6	-1,973	-16.91	-0.57
Total Taxable Income	**-24,118**	**- 6.96**	
SAVINGS TAXABLE INCOME			
	Absolute reduction (billions €)	Relative reduction (%) In the bracket	Over Total
bracket 1	-1,019	-10.40	-2.72
bracket 2	-7,455	-26.96	-19.90
Total Taxable Income	**-8,475**	**-22.62**	

4.2. Revenue Impact: Mechanical and Behavioral Effects

Using estimates of taxable income elasticity, Creedy (2011) and Creedy and Gemmell (2013) analyzes in detail how to determine the revenue impact of a tax change in complex multistep income tax functions. Given a tax change, the existing literature distinguishes two types of responses: (i) a mechanical response and (ii) a behavioral response. The former measures revenue consequences under the unlikely assumption that the process of generating income is independent of the magnitude of the marginal tax rate. The latter includes the revenue effect associated with the existing endogeneity between reported income and the marginal tax rate. The mechanical and behavioral responses move in different directions and together allow quantification of the effective revenue impact that would be expected from a tax reform. Specifically, under the current design of the Spanish PIT, Sanz (2013) determines that the revenue change induced by the modification of marginal rate τ_h can be precisely determined by the following expression:

$$dT = \Big\{\Big([(\bar{x}_h - a_h)\cdot N_h + (a_{h+1} - a_h)\cdot N_h^{+}] - \big[(\bar{M}_h - a_h)\cdot N_h^{m} + (a_{h+1} - a_h)\cdot N_h^{m+}\big]\Big) - \frac{\tau_h}{1-\tau_h}\cdot \tilde{\eta}_{x_h,1-\tau_h}\cdot \bar{x}_h \cdot N_h\Big\}\cdot d\tau_h \qquad [4]$$

where $\tilde{\eta}_{x_h,1-\tau_h}$ is the mean elasticity of the taxable income of taxpayers in bracket h, and a_h y a_{h+1} represent the income thresholds that define bracket h and $\bar{x}_h$ and $\bar{M}_h$ stand for the arithmetic mean of the taxable incomes and applicable allowances. The population size affected by the change of marginal tax rates is included in N_h, N_h^+, N_h^m and $N_h^{m^+}$, where N_h represents the number of taxpayers whose taxable income is within bracket h and N_h^+ indicates the number of taxpayers with taxable incomes over a_{h+1}. N_h^m y $N_h^{m^+}$are the same population items but refer to the value of personal and family allowances.

The first part of equation [4], extracted in equation [5], is the *Mechanical Effect (ME)*, which quantifies the variation in revenue assuming the absence of behavioral changes:

$$ME = ([(\bar{x}_h - a_h) \cdot N_h + (a_{h+1} - a_h) \cdot N_h^+] \\ -[(\bar{M}_h - a_h) \cdot N_h^m + (a_{h+1} - a_h) \cdot N_h^{m^+}]) \cdot d\tau_h \quad [5]$$

The second part of equation [4], which is replicated in equation [6], is the *Behavioral Effect (BE)* which quantifies the part of the mechanical response that is lost as a consequence of the induced behavior changes:

$$BE = - \frac{\tau_h}{1-\tau_h} \cdot \tilde{\eta}_{x_h,1-\tau_h} \cdot \bar{x}_h \cdot N_h \cdot d\tau_h \quad [6]$$

The result of applying equations [5] and [6] to our sample of tax returns is summarized in Table 8. Focusing our attention on the general taxable income, if we analyze the final impact in more detail, we can see that only the increase in the first and second marginal tax rates generates additional revenue. The remainder of the increased marginal tax rates generates revenue losses compared to the pre-reform scenario. With respect to the savings tax schedule, going from two to three brackets explains all of the tax revenue gains associated with this type of income. Furthermore, the increase in the first marginal tax rate reduces tax revenue by nearly 26 million Euros.

Table 8. Tax Revenue Impact induced by Royal Decree-Law 20/2011(mechanical effect, behavioral effect y final effect) –in €-

GENERAL TAXABLE INCOME				
Marginal Tax Rate	Mechanical Effect (ME)	Behavioral Effect* (BE)	BE/ME	Final Effect $(\eta_{T_i^I,\tau_i^b} = ME - BE)$
τ_1	883,062,094	226,731,486	0.2568	656,330,607
τ_2	1,347,231,402	912,213,174	0.6771	435,018,228
τ_3	793,172,269	1,187,554,223	1.4972	- 394,381,953
τ_4	677,096,923	1,449,476,345	2.1407	- 772,379,422
τ_5	141,192,788	291,445,069	2.0642	- 150,252,281
τ_6	388,077,056	725,095,785	1.8684	- 337,018,729
Whole Population	**4,229,832,532**	**4,792,516,082**	1.1330	**- 562,683,550**
SAVINGS TAXABLE INCOME				
Marginal Tax Rate	Mechanical Effect (ME)	Behavioral Effect* (BE)	BE/ME	Final Effect $(\eta_{T_i^I,\tau_i^b} = ME - BE)$
τ_1	19,490,258	45,435,781	2.3312	- 25,945,523
τ_2	1,155,548,867	414,542,478	0.3587	741,006,388
Whole Population	**1,175,039,125**	**459,978,259**	**0.3915**	**715,060,865**
Both Taxable Incomes	**5,404,871,657**	**5,252,494,341**	**0.9718**	**152,377,315**

Note:
* A positive behavioral effect implies a tax revenue reduction

As proven here, when only ME of the reform is considered, tax revenue rises to 5.4 billion Euros: 4.2 billion from the general taxable income and 1.17 billion from the savings tax base. However, when we also consider BE, 5.2 billion Euros are lost due to efficiency losses, resulting in an effective increase in tax revenue of only 152 million Euros (-563 million from non-savings income and 715 million from savings). In other words, 97.18% of the mechanical revenue gains are lost due to inefficiencies generated by the increased marginal tax burden. Contrary to government statements claiming that Royal Decree-Law 20/2011 would lead to revenue gains in 2012 of 5.4 billion Euros, our calculations (152 million Euros) reflect a more trustworthy number as, according to the executed budget in 2012, the PIT revenue reached 815 million Euros. Everything seems to point to the fact that government projections focused their analysis only on the ME, leaving out the BE.

4.3. The Elasticity of the Taxable Income, Well-Being and Efficiency

Economic theory states that increasing the marginal tax burden may lead to important efficiency costs. Feldstein (1995, 1999) suggests that the total deadweight loss (DWL) effectively generated by the PIT should be calculated based on the elasticity of the taxable income, as expressed in equation [7]:

$$DWL = 0.5 \cdot \frac{\bar{\tau}^2}{(1-\bar{\tau})} \cdot \tilde{\eta}_{x_{0_h},(1-\tau_h)} \cdot N_H \cdot \bar{X}_0 \qquad [7]$$

where N_H stands for the total number of taxpayers, $\bar{X}_0$ is the mean taxable income and $\bar{\tau}$ denotes the mean marginal tax rate. Computation of equation [7] indicates that the efficiency cost associated with the Royal Decree-Law 20/2011 reached to 3 billion Euros annually. In addition, authors such as Saez (2004), Giertz (2009) or Creedy (2011 and 2014b) recognize that the decomposition of ME and BE is particularly informative because the value of ME coincides with the *Equivalent Variation*, whereas BE is the variation in the deadweight loss. That is, this decomposition informs us about not only the revenue impact of a tax change but also its allocative effects (efficiency). Considering that fact, the marginal welfare cost (MWC) of a given tax reform, defined as the ratio between the change in the excess burden and the revenue variation, is given by[20]:

$$MWC = \frac{BE}{ME-BE} \qquad [8]$$

Likewise, based on equation [8], it is possible to quantify the *Marginal Cost of Public Funds* ($MCPF$) associated with a tax reform, defined as $1 + MWC$.

4.4. The Revenue-Maximizing Tax Rate

Another application of the taxable income elasticity is the calculation of the marginal tax rate that would maximize tax revenue. As highlighted by Creedy and Gemmell (2014) for the case of New Zealand, this revenue-maximizing marginal tax

[20]This expression is only valid when $ME > BE$ which leads to ${}^{dT}/_{d\tau} > 0$.

rate, known in the literature as the *Laffer marginal tax rate*, is identified with the marginal tax rate that assures a zero revenue variation in function $T = T(\tau)$. This condition is met when ME and BE are equal. Therefore, given the specific features of the Spanish PIT included in equations [5] and [6], we can calculate the Laffer marginal tax rate for each tax unit and study its distribution, along with determining the percentage of tax units and the volume of total taxable income and tax due that are located in the rising or decreasing sections of the Laffer curve. Table 9 presents this information for the reform under study. As can be seen, for the general taxable income, more than 68% of the tax returns are found in the decreasing section of the curve, comprising 72.29% of the reported tax base and 79.92% of net tax collected. For the case of savings these numbers vary significantly: more than 95% of the tax returns are located in the falling section of the Laffer curve affecting a smaller percentage of the reported taxable income (30.53%), albeit a bigger proportion of the tax due (83.82%). Table 9 offers this information broken down by tax brackets.

Table 9. Relevance of the Laffer Effect in terms of the number of tax returns and volume of taxable income and tax due located in the decreasing section of the Laffer Curve by the time Royal Decree-Law 20/2011 came into force.

GENERAL TAXABLE INCOME

	$\bar{\tau}$	τ^L	$\overline{\tau - \tau^L}$	$\overline{\left(\frac{\tau - \tau^L}{\tau}\right)}$	%TAX RETURNS BE > ME		%TAXABLE INCOME BE > ME		%TAX DUE BE > ME	
					in bracket	over total	in bracket	over total	in bracket	over total
bracket 1	0.24	0.2651			57.9	36.3	33.44	9.59	19.2	2.63
bracket 2	0.28	0.2077	7.2	25.82	79.75	20	75.58	25.6	73.1	22.33
bracket 3	0.37	0.1476	22.2	60.11	99.84	8.51	99.79	19.1	99.8	23.09
bracket 4	0.43	0.1878	24.2	56.33	99.67	3.27	99.5	13	99.5	21.09
bracket 5	0.44	0.1191	32.1	72.92	100	0.25	100	1.94	100	3.91
bracket 6	0.45	0.2836	16.6	36.97	97.68	0.17	92.12	3.1	92.2	6.86
All	0.3142	0.2109	10.3	27.25	68.5		72.29		79.92	

SAVINGS TAXABLE INCOME

	$\bar{\tau}$	τ^L	$\overline{\tau - \tau^L}$	$\overline{\left(\frac{\tau - \tau^L}{\tau}\right)}$	%TAX RETURNS BE > ME		%TAXABLE INCOME BE > ME		%TAX DUE BE > ME	
					in bracket	over total	in bracket	over total	in bracket	over total
bracket 1	0.19	0.0288	16.1	84.82	98.68	93.6	93	24.3	99.9	81.05
bracket 2	0.21	0.4149	-21	-97.56	31.61	1.63	8.38	6.18	14.7	2.77
All	0.2048	0.3138	-11	-49.82	95.21		30.53		83.82	

Notes:
$\bar{\tau}$ = average of the actual marginal tax rate.
τ^L=average of the Laffer marginal tax rate.
BE= behavioral effect.
ME= mechanical effect.

5. CONCLUSIONS

The elasticity of reported income to marginal tax rates is an indispensable parameter in the economic analysis of tax reforms. Accurate knowledge of this elasticity allows for evaluating various aspects of a tax change, such as induced variation in reported income, effective revenue impact, efficiency implications and even the marginal tax rate that would maximize tax revenue once behavioral taxpayer reactions are taken into account.

This paper estimates the elasticity of reported income for Spain. The estimated mean value of this key parameter for the whole Spanish territory is 1.541. Nevertheless, a considerable heterogeneity in this elasticity is detected, depending on factors such as taxpayer income level, age, gender, income type, tax return type and region of residence. Accordingly, changes in marginal tax rates will have heterogeneous effects on different individuals. Specifically, we find that the higher the level of income of the taxpayer the higher is the average elasticity (0.664 for individuals in the first quartile compared with 2.717 in the last quartile). Moreover, older individuals, women, those who obtain their income mainly from non-labour sources, the self-employed and taxpayers filing separately demonstrate greater sensitivity. We also find that individuals who live in richer regions (Madrid, Catalonia and Valencia) are, on average, more reactive to marginal tax rates than those who live in poorer regions (Ceuta and Melilla, Extremadura or both Castillas). Armed with these estimated elasticities, the recent increase in the marginal rates approved in Spain in 2012 has been assessed.

Appendix I. Obtaining Marginal and Average Tax Rates

To estimate equation [1], it is necessary to accurately define the notion of marginal tax rate. To do so, we must take into account that the two PIT structures analyzed, for 2006 and 2007, have a schedular multi-rate structure. Both structures distinguish two types of taxable income: (i) savings income, which is subject to a single tax rate, and (ii) other income categories, which are taxed progressively. Nevertheless, the 2007 reform introduced important changes both in the way these two types of income are computed and in the applicable tax schedules. Therefore, for each year considered, we identified two types of relevant marginal tax rates: the marginal tax rate of the progressive tax schedule (τ^{PG}) and the proportional tax rate (τ^{P}). Thus, for each year *t*, each taxpayer *i* would pay an effective weighted marginal tax rate (τ) equal to:

$$\tau_{i,t} = \frac{X_{i,t}^{PG}}{X_{i,t}^{PG} + X_{i,t}^{P}} \tau_{i,t}^{PG} + \frac{X_{i,t}^{P}}{X_{i,t}^{PG} + X_{i,t}^{P}} \tau_{i,t}^{P} \qquad t = 2006,\ 2007 \qquad \text{[A.1]}$$

where $X_{i,t}^{P}$ represents for year *t* the size of the taxable income that is taxed proportionally and $X_{i,t}^{PG}$ represents the taxable income taxed progressively. Given the existing endogeneity between marginal rate and income, we instrument τ based on what is known in the literature as the *virtual marginal tax rate*, τ^{V} . The virtual marginal tax rate is defined as the marginal tax rate applicable for the taxpayer in 2007 for the real constant value of his or her income in 2006. To construct this instrument, τ^{V} , we indexed all 2006 income sources with the corresponding consumption price index published by the National Statistics Institute (INE) that year, which amounted to 4.2%, and recalculated the corresponding amount as if the 2006 indexed income would be taxed according to 2007 regulations. Once we calculated the virtual marginal tax rate for all taxpayers, to obtain a relevant τ^{V} , we applied the same procedure of weighting referred to in [A.1]. The average tax rates applied to individuals were calculated as:

$$ATR_{i,t} = \frac{TD_{i,t}}{y_{i,t}} \qquad t = 2006, 2007 \qquad [A.2]$$

where $TD_{i,t}$ represents for year t the tax due by each individual and $y_{i,t}$ is the gross income. The mean of the average tax rates -actual and virtual- of each individual were constructed using the same procedure as the one described above for marginal tax rates.

Appendix II. Definition of the Variables

Reported gross income:

Total gross income, in both money and in kind, proceeding from any income source of the tax unit. It includes labour income, income from savings and real estate capital income, capital gains and imputed income, and similarly business income.

Marginal tax rate:

Rate of marginal taxation, representative of the tax unit, obtained by the weighting given in equation [A.1].

Virtual marginal tax rate:

Imaginary marginal tax rate constructed for 2006 income (indexed for inflation) when 2007 PIT is applied.

Average Tax Rate: Average tax paid by the tax unit as defined in [A.2] and obtained by using the weighting included in equation [A.1].

Virtual Average Tax Rate:

Figurative average tax rate that would correspond to 2006 income (duly indexed for inflation) when applying 2007 regulations.

Age:

Age in years, on December 31 of the fiscal year, of the head of the tax unit.

Joint:

Dummy variable that identifies whether the tax unit filed jointly or separately, which assumes a value of 1 if filed jointly and 0 if separate.

Self-Employed:

Dummy variable identifying whether the taxpayer unit’s gross income contains income streams derived from professional or business activity. Assumes a value of 1 if there are professional and/or business activities and 0 if there are none.

Man:

Dummy variable identifying the gender of the taxpayer that assumes a value of 1 if the individual is a man and 0 if she is a woman.

Number of Children:

Variable containing the number of children in the tax unit. Children corresponding to marriages in which spouses file separately are imputed at 50%.

Disabled:

Total number of handicapped persons in the tax unit. Handicapped persons corresponding to married couples filing separately are imputed at 50%.

Source:

Dummy variable determining whether labour income is the main source of income of the tax unit. Assumes a value of 1 if the main source is labour income and 0 if the main source is another type of income.

Regional Dummy Variables:

Variable that identifies the tax unit's region of residence: 1—Andalucia, 2—Aragon, 3—Principality of Asturias, 4—Balearic Islands, 5—Canary Islands, 6—Cantabria, 7—Castilla-La Mancha, 8—Castilla-Leon, 9—Catalonia, 10—Extremadura, 11—Galicia, 12—Madrid, 13—Murcia, 16—La Rioja, 17—Valencia, 18—Ceuta and Melilla.

Apendix III. Sensibility Analysis: Elasticity of Reported Gross Income by Individual Characteristics

Tabla A. III. 1. Results of model estimation

	(I) Income quartiles (2006) (base: first quartil)	(II) Region (base: Madrid)	(III) Age (base:under 35)	(IV) Income source	(V) Sex	(VI) Self-Employed	(VII) Type tax return
Intercept	2.019 (0.028)	2.173 (0.029)	2.147 (0.029)	2.175 (0.029)	2.174 (0.029)	2.175 (0.029)	2.176 (0.029)
Δ log(1-τ)	0.664 (0.037)	1.641 (0.056)	1.118 (0.058)	1.548 (0.029)	1.598 (0.040)	1.501 (0.030)	1.582 (0.033)
Δ log(1-τ)*quartil-2	0.338 (0.053)	--	--	--	--	--	--
Δ log(1-τ)*quartil-3	0.701 (0.064)	--	--	--	--	--	--
Δ log(1-τ)*quartil-4	2.053 (0.056)	--	--	--	--	--	--
log(y_{t-1})	-0.211 (0.003)	-0.224 (0.003)	-0.225 (0.003)	-0.225 (0.003)	-0.224 (0.003)	-0.225 (0.003)	-0.225 (0.003)
Δ log(1-τ)*Andalusia	--	-0.188 (0.074)	--	--	--	--	--
Δ log(1-τ)*Aragon	--	-0.337 (0.112)	--	--	--	--	--
Δ log(1-τ)*Asturias	--	-0.217(*) (0.142)	--	--	--	--	--
Δ log(1-τ)*Balearic Islands	--	-0.044(*) (0.133)	--	--	--	--	--
Δ log(1-τ)*Canary Islands	--	-0.245 (0.118)	--	--	--	--	--
Δ log(1-τ)*Cantabria	--	-0.449 (0.170)	--	--	--	--	--
Δ log(1-τ)*Cast-Mancha	--	-0.365 (0.128)	--	--	--	--	--
Δ log(1-τ)*Cast-Leon	--	-0.356 (0.093)	--	--	--	--	--
Δ log(1-τ)*Cataluña	--	0.059(*) (0.076)	--	--	--	--	--
Δ log(1-τ)*Extremadura	--	-0.374 (0.117)	--	--	--	--	--
Δ log(1-τ)*Galicia	--	-0.206 (0.091)	--	--	--	--	--
Δ log(1-τ)*Murcia	--	0.166(*) (0.151)	--	--	--	--	--
Δ log(1-τ)*Rioja	--	-0.168(*) (0.215)	--	--	--	--	--
Δ log(1-τ)*Valencia	--	0.081(*) (0.088)	--	--	--	--	--
Δ log(1- τ)*Ceuta-Melilla	--	-0.823 (0.308)	--	--	--	--	--
Δ log(1-τ)*age35-55	--	--	0.536 (0.063)	--	--	--	--
Δ log(1-τ)*age55-65	--	--	0.472 (0.075)	--	--	--	--
Δ log(1-τ)*age+65	--	--	0.470 (0.068)	--	--	--	--
Δ log(1-τ)*source	--	--	--	-1.024 (0.097)	--	--	--
Δ log(1- τ)*man	--	--	--	--	-0.088 (0.044)	--	--
Δ log(1- τ)*selfemployed	--	--	--	--	--	0.131 (0.055)	--
Δ log(1- τ)*joint	--	--	--	--	--	--	-0.132 (0.046)
χ^2_k overall signif. (p-value)	7,904.77 (0.00)	6,827.05 (0.00)	6,817.96 (0.00)	6,736.60 (0.00)	6,729.82 (0.00)	6,753.80 (0.00)	6,752.95(0.00)
Standard error regression	0.397	0.400	0.399	0.400	0.400	0.400	0.400
N	285,272	285,272	285,272	285,272	285,272	285,272	285,272

Note: Robust standard errors in parenthesis**.** (*) Non significant at 10%. Models include as regressors: age and square, joint, self-employed, man, number of children, disabled, source and region of residence.

Appendix IV. Taxable Income Elasticity Versus Gross Income Elasticity

It is worth noting that the estimated elasticities in this paper are gross income elasticities, $\eta_{y,(1-\tau)}$, and not taxable income elasticities, $\eta_{x,(1-\tau)}$, which are the ones traditionally used in empirical work. Consequently, as an essential prior step before applying the estimated elasticities to the analysis of tax reform, conversion from our estimated values of $\eta_{y,(1-\tau)}$ to their equivalents $\eta_{x,(1-\tau)}$ was necessary. In doing so, we took into account the existing relationship among gross income, taxable income and the *net-of-tax* rate shown in Figure 1, which allowed us to conclude that both elasticities are related in the following way: $\eta_{x,(1-\tau)} = \eta_{x,y} \cdot \eta_{y,(1-\tau)}$.

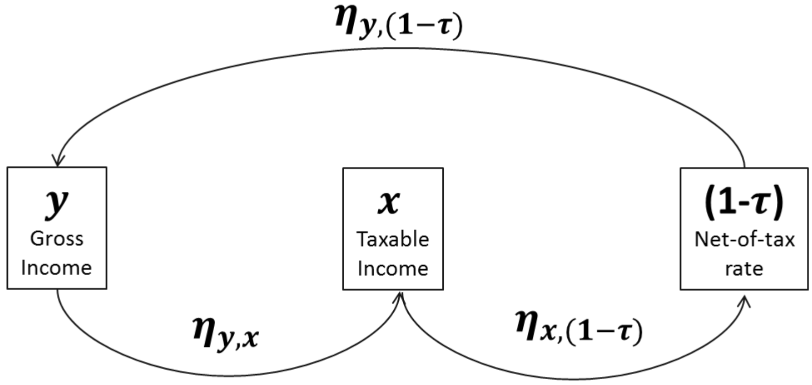

Figure 1

Therefore, to the extent that we can obtain an estimate of $\eta_{x,y}$, we will be able to extract the value of taxable income elasticity emerging from our estimates of gross income elasticities. With this aim, we follow Creedy and Sanz (2010). These authors derive analytical expressions for the revenue elasticity to income defined in alternative ways—gross income, income net of deductible expenditures and taxable income—which allows estimating the regionalized value of $\eta_{x,y}$ as a ratio ${}^{\eta_{T,y}}/_{\eta_{T,x}}$. These values of $\eta_{x,y}$, together with our regionalized estimates of $\eta_{y,(1-\tau)}$, allowed us to obtain the elasticities of the taxable income included in Table A. IV.1, which were used in the empirical exercise.

Table A.IV.1. Taxable Income Elasticities derived from Gross Income Elasticities reported in the main text

	$\eta_{x,y}$ *	$\eta_{y,(1-\tau)}$	$\eta_{x,(1-\tau)}$
National	0.6519	1.541	1.005
Andalucia	0.5460	1.453	0.793
Aragon	0.6148	1.304	0.802
Principality of Asturias	0.6553	1.424	0.933
Balearic Islands	0.6503	1.597	1.038
Canary Islands	0.6137	1.396	0.857
Cantabria	0.6082	1.192	0.725
Castilla-Leon	0.5358	1.285	0.688
Castilla-La Mancha	0.5448	1.276	0.695
Catalonia	0.6853	1.700	1.165
Valencia	0.5999	1.722	1.033
Extremadura	0.4560	1.267	0.578
Galicia	0.5467	1.435	0.784
Madrid	0.8089	1.641	1.327
Murcia	0.5746	1.807	1.038
La Rioja	0.6238	1.473	0.919
Ceuta y Melilla	0.6519	0.818	0.533

* Derived from the revenue elasticities reported by Creedy y Sanz (2010).

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