LOOKING INSIDE THE LAFFER CURVE: MICROFOUNDATIONS AND EMPIRICAL EVIDENCE APPLIED TO COMPLEX TAX STRUCTURES

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Abstract:

This paper evaluates the microfoundations of the laffer curve. In doing so, the paper discusses a model for the elasticity of tax revenue against changes in the marginal tax rates in the presence of complex tax structures. In particular, the case of schedular multi-rate income taxes with non-genuine allowances is considered. For this type of tax design, analytical expressions for the *Laffer-marginal tax rate* and *Laffer-threshold elasticity* are obtained and discussed. Calculations are conducted for the individual taxpayer and the population aggregate. An empirical analysis applied to the case of the increasing marginal rates of the Spanish individual income tax, which came into effect in 2012, confirms that the "behavioural effect" decreased the potential "mechanical" tax revenue of this regulatory change by more than 2.31 billion euros. This decreased revenue was the result of enforcing the regulatory change when more than 48% of the filed tax returns (9.3 million tax returns) appeared on the "prohibited side" of the Laffer curve.

JEL codes: H21, H24, H31

Keywords: Laffer curve, Taxable income elasticity, tax revenue, Spanish individual income tax

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INTRODUCTION

In the current economic context, which is characterised by a sharp deterioration of public finances, the revenue impact of tax changes is a primary concern of tax authorities. Unfortunately, in the analysis of tax revenue, there is a belief, which is particularly entrenched in politicians and *policy-makers*, that regulatory changes do not affect taxpayer behaviour. This supposed exogeneity between tax regulations and tax behaviour is incompatible with the principle of rationality recognised in economic agents and especially inadequate in the context of progressive taxes because precisely this progressiveness configures an innate endogenous relationship between taxable income and marginal tax rates. This endogenous relationship implies that the size of the taxable income is determined to a greater or lesser extent by the magnitude of the marginal tax rates. Therefore, the revenue capacity of a given tax structure, particularly if it is progressive, requires a measure that would enable the determination of the expected reaction of reported taxable income given the change in marginal tax rates. One such measure is the elasticity of taxable income to marginal tax rates, $\eta_{y,\tau}$, or its more popular equivalent in the literature: the elasticity of taxable income with respect to changes in the net-of-tax marginal tax rate, $\eta_{y,(1-\tau)}$, (ETI). Without this information, the estimated and real revenue of a tax could differ, with the consequent deterioration of a government's reputation – and that of its analysts – accompanied by the "unexpected" effect on the balance of public accounts.

The revenue implications of the ETI for simple tax structures and for subsets of taxpayers – normally from the high-income group – have been analysed by authors such as Feldstein (1995), Goolsbee (1999), Hall (1999), Saez (2004) or Giertz (2009). In Creedy (2011) and Creedy and Gemmell (2011), an extensive analysis is conducted in which the revenue implications of changes in marginal rates are demonstrated to respond to two types of factor: structural, which are linked to the design of the tax, and behavioural, which are identified by the magnitude of the ETI. Similarly, Giertz (2009) relates the ETI to the familiar Laffer curve[1], and in Creedy and Gemmell (2012) an additional analytical effort is proposed related to the ETI and the Laffer curve in a progressive income tax context with increasing marginal rates. In this last work, Creedy and Gemmell coin the suggestive notion of *Laffer-threshold elasticity* ($\mathrm{ETI}^{\mathrm{L}}$), which is defined as the value of ETI that would assure the revenue neutrality of increasing marginal tax rates. That is, ETI^{L} identifies, within a given structure of marginal tax rates, the maximum (peak) of the Laffer curve.

In essence, the corresponding cited literature, which was formally pioneered by Feldstein (1995) and named the *New Tax Responsiveness* by authors such as Goolsbee (1999) and Meghir and Phillips (2010), concludes that given the endogeneity between the marginal rate and taxable income and apart from the static revenue effect (*mechanical effect* or *rate effect*), changes in marginal tax rates generate an additional indirect revenue effect as a consequence of the change of the tax rate on taxable income – *a behavioural effect*. Slemrod (1995, 2001) noted the heterogeneous nature of this behavioural effect and identified its

[1]Although this well-known curve is named after Arthur Laffer, who allegedly drew it on a napkin to convince President Reagan of the disadvantages of high marginal tax rates, its underlying ideas, as recognised by Professor Laffer himself, were presented long before by other economists and thinkers, for example, Adam Smith (1776) or Dupuit (1844).

origins among the types of response from the taxpayer, which from most to least responsive are as follows: *timing responses*, *avoidance responses* and *real responses*. The impact of the behavioural effect on economic efficiency and revenue ultimately depends on the magnitude and type of response(s) that predominates among taxpayers.

In all of the cited papers, revenue analysis has been conducted for traditional taxation systems, which are characterised by taxing income extensively and applying genuine individual and household allowances[2]. However, the proliferation of income tax structures with a taxation form different from that of the traditional structure calls for extending this analysis to other tax realities. The Spanish income tax is an example of one such alternative tax structure. It is characterised by its schedular nature and a *sui generis* form of calculating the total tax amount, which consists of applying the tax schedule to personal and family allowances and subtracting the obtained result from the derivative of applying the same tax schedule to taxpayer's gross income. We refer to this class of allowances as "non-genuine allowances" or "false allowances" because they involve a mechanism with little transparency that converts allowances into tax credits [see Sanz et al. (2009)].

This paper proceeds as follows. In section I, we obtain the analytical expressions of the revenue elasticity to marginal tax rates in a progressive tax structure with non-genuine allowances. The calculations are conducted for two alternative tax structures: one defined with an extensive taxable income and the other with a segmented taxable income (schedular tax). In addition, Section I deconstructs the constituent elements of the revenue elasticity to marginal tax rates and analyses in detail the previously mentioned mechanical and behavioural effects. Continuing in the context of the individual taxpayer, section II characterises the Laffer curve while identifying the marginal rate that maximises the tax bill (the Laffer-marginal tax rate) and the threshold-elasticity of taxable income introduced by Creedy and Gemmell (2012). The third section offers analytical expressions to determine aggregate revenue change from a population of N taxpayers that experiences a modification of one or more marginal rates. Similarly, in the third section, the aggregate Laffer curve is described for a given population and income distribution. Finally, section IV conducts an empirical analysis of the revenue consequences of the most recent increase in marginal tax rates conducted in Spain after the approval of the Royal Decree-Law 20/2011. The empirical part of the study was conducted using microdata from the Tax Board of the Spanish *Institute for Fiscal Studies* (*IEF,* initials in Spanish).

I. THE TAX BILL OF AN INDIVIDUAL TAXPAYER GIVEN CHANGES IN THE MARGINAL TAX RATES

In this first section, we obtain and analyse analytical expressions of the elasticity of the tax bill of an individual taxpayer faced with a Spanish-type tax. As a prior step, we analyse the general case of a tax with extensive taxable income in the manner of Haig-

[2]We say that an income tax applies allowances in a genuine way when the total tax amount is obtained by applying the tax schedule to the taxpayer's income net of the applicable allowances (genuine allowances).

Schanz-Simons, where the taxpayer's income is accumulated and taxed jointly regardless of its origin and condition.

I.1. The case of global taxable income and non-genuine allowances

Let us assume a tax band defined as an increasing sequence of marginal tax rates such as $\zeta = (\tau_1, \dots \tau_K)$, that is applied to the taxpayer's taxable income according to the set of income thresholds defined by the vector $A = (a_1, \dots a_K)$ in such a way that the fiscal burden associated to the level of income y_i will be determined as follows[3]:

$$T(y_i) \quad \begin{cases} \tau_1 \cdot (y_i - a_1) & if \quad a_1 < y_i \le a_2 \\ \tau_1 \cdot (a_2 - a_1) + \tau_2 \cdot (y_i - a_2) & if \quad a_2 < y_i \le a_3 \\ \tau_1 \cdot (a_2 - a_1) + \tau_2 \cdot (a_3 - a_2) + \tau_3 \cdot (y_i - a_3) & if \quad a_3 < y_i \le a_4 \\ \dots & \dots \\ \dots & \dots \\ \tau_1 \cdot (a_2 - a_1) + \cdots \tau_{K-1} \cdot (a_{K-2} - a_{K-1}) + \tau_K \cdot (y_i - a_K) & if \quad y_i > a_K \end{cases}$$

Under such a taxation structure, the tax paid by a taxpayer i with taxable income y_i and entitled to a set of (potential) non-genuine personal and family allowances, M_i^n, will be determined by the following tax function T_i^I:

$$T_i^I = T_i^I(T_i(y_i, \tau_k), \theta_i(M_i, \tau_m)) \qquad [1]$$

where T_i represents the amount resulting from applying the tax band to income level y_i and θ_i the value of the tax savings that corresponds to effective allowances, M_i, meeting the condition that $M_i \le M_i^n$, where M_i^n represents the nominal value of the allowances to which the tax unit is formally entitled and M_i the effective value that the tax code actually allows to apply[4].

Based on Creedy and Gemmell (2006), T_i and θ_i can be explicitly rewritten as follows:

$$T_i = \tau_{k_i} \cdot \left[y_i - a'_{k_i}\right]$$

$$[2]$$

$$\theta_i = \min(\tau_{m_i} \cdot \left[M_i - a'_{m_i}\right], T_i)$$

[3]It should be taken into account that in multi-level territorial estates where the income tax is a decentralised tax, as is the case of Spain, normally, the marginal tax rate τ levied on y_i is the result of summing the marginal rates established by the central and regional governments. If C and R denote the central and regional government, respectively, then $\forall \quad \tau \in \zeta \quad \Rightarrow \quad \tau = \tau^C + \tau^R$.

[4]Therefore, $\theta_i(M_i, \tau_m) \le \theta_i(M_i^n, \tau_m)$. It is important to note that in a system of non-genuine allowances, as the one defined, although the tax rate applied to the taxable income and the allowances is the same, the relevant marginal tax rates of T_i and θ_i do not have to coincide. This is so because y_i and M_i will usually not fall within the same tax bracket of the tax schedule.

where τ_{k_i} and τ_{m_i} represent the maximum marginal tax rates associated with the values y_i and M_i, respectively, and where a'_{k_i} and a'_{m_i} denote the *effective thresholds* for y_i and M_i, which are defined as follows:

$$a'_k = \frac{1}{\tau_{k_i}} \cdot \sum_{j=1}^{K} a_j \cdot (\tau_j - \tau_{j-1})$$
$$a'_m = \frac{1}{\tau_{m_i}} \cdot \sum_{j=1}^{M} a_j \cdot (\tau_j - \tau_{j-1}) \qquad [3]$$

In short, equations [2] and [3] state that for any progressive tax band with increasing marginal rates it is possible to find an equivalent single tax rate (which will coincide with the maximum marginal rate of the taxpayer) that generates the same amount when applied to income or allowances measured in excess of a single threshold (effective threshold). In this context, taking into account [2], the marginal effect of a change in the tax rate τ on revenue will be given as follows:

$$\frac{dT_i^I}{d\tau} = \frac{\partial T_i^I}{\partial T_i} \cdot \frac{dT_i}{d\tau} + \frac{\partial T_i^I}{\partial \theta_i} \cdot \frac{d\theta_i}{d\tau} \qquad [4]$$

which reduces to

$$\frac{dT_i^I}{d\tau} = \frac{dT_i}{d\tau} - \frac{d\theta_i}{d\tau} \qquad [5]$$

if we assume that $T_i^I = T_i - \theta_i$.

Equation [5] can be rewritten in elasticity form as indicated in [6], where $\alpha_i = \frac{\theta_i}{T_i}$ such that $\forall \ T_i > 0 \Rightarrow 0 \le \alpha_i \le 1$ and, therefore, $1 \le \frac{1}{1-\alpha_i} \le \infty$ [5].

$$\eta_{T_i^I,\tau} = \frac{1}{1-\alpha_i} \cdot \left[\eta_{T_i,\tau} - \eta_{\theta_i,\tau} \cdot \alpha_i\right] \qquad [6]$$

which developing $\eta_{T_i,\tau}$ and $\eta_{\theta_i,\tau}$ is transformed into[6]

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[5] Note that $\frac{1}{1-\alpha_i} = \infty$ if $\tau_{m_i} \cdot [M_i - a'_m] \ge \tau_{k_i} \cdot [y_i - a'_k]$. This condition is met by taxpayers with very low income who have a null tax bill and, therefore, the modification of any of the marginal rates does not affect the payment of their taxes, which is to say for those who meet $\eta_{T^I,\tau} = 0$. The only change in the marginal tax rates that could potentially affect this type of taxpayers would be those that would reverse this condition, i.e. $\tau_{m_i} \cdot [M_i - a'_m] < \tau_{k_i} \cdot [y_i - a'_k]$. However, given the workings of the Spanish personal income tax for non-paying taxpayers, $\tau_{m_i} = \tau_{k_i}$ and that $a'_m = a'_k$. Therefore, for this type of taxpayer, changes in the tax band are harmless, and they could only be affected by changes in fiscal regulations that would influence the definition of the taxable income base in a way that $M_i < y_i$. One possibility would be to eliminate exemptions and reductions in the definition of the tax base. Another possibility would be to reduce the magnitude of the entitled allowance.

$$\eta_{T_i^I,\tau} = \frac{1}{1-\alpha_i} \cdot \left\{\left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) - \left(\eta'_{T_i,y_i} \cdot \eta_{y_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,M_i} \cdot \eta_{M_i,\tau}\right)\right\} \qquad [7]$$

where the first term of [7] represents the direct effect, known as the tax rate or mechanical effect, whereas the second term quantifies the indirect effect, known as the behavioural effect.

Under the reasonable assumption, at least in the short term, that the amount of the basic allowances is exogenous to the changes of the marginal rates $(\eta'_{M_i,\tau} = 0)$, the revenue elasticity of an extensive income tax with non-genuine allowances will be given by the following expression:

$$\eta_{T_i^I,\tau} = \frac{1}{1-\alpha_i} \cdot \left\{\left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) - \eta'_{T_i,y_i} \cdot \eta_{y_i,\tau}\right\} \qquad [8]$$

which becomes

$$\eta_{T_i^I,\tau} = \frac{1}{1-\alpha_i} \cdot \left\{\left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) - \left(\frac{y_i}{y_i - a'_k}\right) \cdot \frac{\tau}{1-\tau} \cdot \eta_{y_i,1-\tau}\right\} \qquad [9]$$

if we assume, as demonstrated by Creedy and Gemmell (2006), that $\eta_{y_i,1-\tau} = -\left(\frac{1-\tau}{\tau}\right) \cdot \eta_{y_i,\tau}$ and that $\eta'_{T_i,y_i} = \left(\frac{y_i}{y_i - a'_k}\right)$.

The explicit form of [9] will ultimately depend on $\eta'_{T_i,\tau}$ and $\eta'_{\theta_i,\tau}$, whose values will be determined by the relative ranking between the modified marginal tax rate and the marginal rates relevant to the taxpayer. That is, the magnitudes of $\eta_{y_i,1-\tau}$ and $\eta'_{\theta_i,\tau}$ will depend on whether τ_h, is equal to, less or greater than τ_{k_i} and τ_{m_i}. Therefore,

$$\eta'_{T_i,\tau_h} = \begin{cases} \dfrac{\left(y_i - a_{k_i}\right)}{\left(y_i - a'_{k_i}\right)} & si\ \tau_h = \tau_{k_i} \\[2ex] \dfrac{\tau_h}{\tau_{k_i}} \cdot \dfrac{(a_{h+1} - a_h)}{\left(y_i - a'_{k_i}\right)} & si\ \tau_h < \tau_{k_i} \\[2ex] 0 & si\ \tau_h > \tau_{k_i} \end{cases}$$

$$\eta'_{\theta_i,\tau_h} = \begin{cases} \dfrac{\left(M_i - a_{m_i}\right)}{\left(M_i - a'_{m_i}\right)} & si\ \tau_h = \tau_{m_i} \\[2ex] \dfrac{\tau_h}{\tau_{m_i}} \cdot \dfrac{(a_{h+1} - a_h)}{\left(y_i - a'_{m_i}\right)} & si\ \tau_h < \tau_{m_i} \\[2ex] 0 & si\ \tau_h > \tau_{m_i} \end{cases} \qquad [10]$$

[6]In the following mathematical formalism, the following notation is used: $\eta'_{a,b}$ expresses the partial elasticity of b over a and is generically referred to as $\eta'_{a,b} = \frac{\partial a}{\partial b} \cdot \frac{b}{a}$; meanwhile, $\eta_{a,b}$ is the total elasticity of b to a, whose generic notation is $\eta_{a,b} = \frac{da}{db} \cdot \frac{b}{a}$.

I.2. Generalisation to the case of schedular taxes with non-genuine allowances

In the more general case of schedular income taxes with non-genuine allowances, where the total taxable income is divided into b different sections taxed according to their respective marginal rate vectors $\zeta^b = (\tau_1^b, \dots, \tau_K^b)$ and specific thresholds $A^b = (a_1^b, \dots, a_K^b)$, the relevant tax function of a taxpaying unit i will be as follows:

$$T_i^I = \sum_{b=1}^{B} T_i^b - \sum_{b=1}^{B} \theta_i^b \qquad where \;\; b = 1, 2, \dots B \qquad [11]$$

where T_i^b and θ_i^b will be determined by

$$\begin{aligned} T_i^b &= \tau_{k_i}^b \cdot \left[y_i^b - a_{k_i}^{b'}\right] \\ \theta_i^b &= \tau_{m_i}^b \cdot \left[M_i^b - a_{m_i}^{b'}\right] \end{aligned} \qquad [12]$$

in such a way that $y_i = \sum y_i^b$ and $M_i = \sum M_i^b$.

Thus, under the schedular system of taxation of the Spanish income tax with false allowances, the elasticity of the tax bill of tax unit i given a change in $\tau^b \in \zeta^b$ will be given as follows:

$$\eta_{T_i^I, \tau_{b_i}} = \mu_i^b \cdot \left[\eta_{T_{b_i}, \tau_{b_i}} - \eta_{\theta_{b_i}, \tau_{b_i}} \cdot \alpha_i^b\right] \qquad [13]$$

where α_i^b expresses the proportion of tax savings associated with applicable allowances with regard to the tax due derived from taxable income b, $\alpha_i^b = \frac{\theta_i^b}{T_i^b}$ and μ_i^b denotes the ratio of the tax due from segment b to total revenue from the tax unit, $\mu_i^b = \frac{T_i^b}{T_i^I}$. Thus, the elasticity of the tax bill of the tax unit i given a change in τ_i^b in a context of a schedular tax with non-genuine allowances will be determined as follows:

$$\eta_{T_i^I, \tau_i^b} = \mu_i^b \cdot \left\{ \left(\eta'_{T_i^b, \tau_i^b} - \alpha_i^b \cdot \eta'_{\theta_i^b, \tau_i^b}\right) - \left(\frac{y_i^b}{y_i^b - a_{k_i}^{b'}}\right) \cdot \frac{\tau_i^b}{1-\tau_i^b} \cdot \eta_{y_i^b, 1-\tau_i^b} \right\} \qquad [14]$$

where the value of the partial elasticity of the schedular amount b,$\eta'_{T_i^b, \tau_i^b}$, and the partial elasticity of tax savings, $\eta'_{\theta_i^b, \tau_i^b}$, will depend, as in [9], on whether the modified marginal tax rate, τ_h^b, is equal to, less or greater than the maximum marginal rates relevant to the taxpayer, according to the tax band ζ^b.

The first term in the sum of equation [14] reflects the mechanical effect, ME, which computes income effects associated with the change of the marginal rate. For its part, the second term of [14] quantifies the behavioural effect, BE, which informs us regarding the generated substitution effects. Both effects move in opposite directions.

The mechanical effect

As for ME, it is worth noting that two elements can be discerned:

a. The mechanical effect associated with the taxpayers whose taxable income falls in the bracket of the modified marginal tax rate h, $ME^{(h)}$, -the *within* mechanical effect-.

b. The mechanical effect which affects taxpayers located in brackets above the modified marginal tax rate, ME^{h+}, -the *outside* mechanical effect- .

Given any change in $\tau_h^b \in \zeta^b$, both components, the within and the outside mechanical effects, will meet the following conditions:

$$
\begin{array}{llll}
ME_i^{(h)} > 0 & \text{and} \quad ME_i^{h+} = 0 & \text{if} & a_h^b > y_i^b \leq a_{h+1}^b \\
ME_i^{(h)} = 0 & \text{and} \quad ME_i^{h+} > 0 & \text{if} & y_i^b \geq a_{h+1}^b \\
ME_i^{(h)} = ME_i^{h+} = 0 & & \text{if} & y_i^b < a_h^b
\end{array}
$$

Both elements, $ME^{(h)}$ and ME^{h+}, present different behaviour with regard to the evolution of taxable income: while $ME^{(h)}$describes an increasing and downwardly concave profile $\left(\frac{\partial ME^{(h)}}{\partial y_i} > 0, \frac{\partial^2 ME^{(h)}}{\partial y_i^2} < 0\right)$, ME^{h+} traces a falling and upwardly concave trajectory $\left(\frac{\partial ME^{h+}}{\partial y_i} < 0,\ \frac{\partial^2 ME^{h+}}{\partial y_i^2} > 0\right)$.

For each of the six marginal tax rates for income other than savings existing in 2011, Figures 1, 2 and 3 illustrate the total mechanical effect and its components. Specifically, Figure 1 shows ME, Figure 2 exhibits the ME^{h+} component and Figure 3 depicts the contour of $ME^{(h)}$.

The behavioural effect

The second term in the sum that appears in equation [14] represents the behavioural effect, BE, which is responsible for the efficiency costs caused by the marginal tax rate change. Its magnitude is determined by the interaction of four factors: the elasticity of taxable income, the marginal rate, the revenue elasticity and the segmentation of the taxable income. The impact of these four elements on BE is shown in panel (1) of Figure 4, assuming that $ETI = 0.6$. Panel (2) shows different profiles of BE given variations in the value of ETI. As can be observed in Figure 5, unlike in ME, BE only occurs when the maximum marginal rate of the taxpayer, τ_k, coincides with the modified marginal rate, τ_h, while amounting to zero for all other taxpayers.

Finally, Figure 6 shows the profile of total elasticity, $\eta_{T_i^I, \tau_i^b}$, in each of the six marginal tax rates simultaneously taking into account ME and BE.

Figure 1: Total mechanical effects, ME, induced by existing marginal tax rates in 2011.

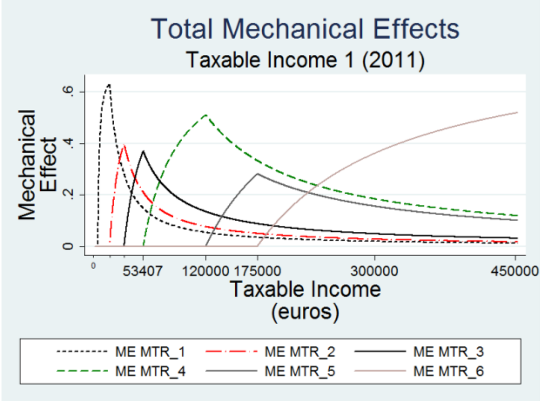


Figure 2: Outside mechanical effects, ME^{h+}, induced in upper brackets by existing marginal tax rates in 2011.

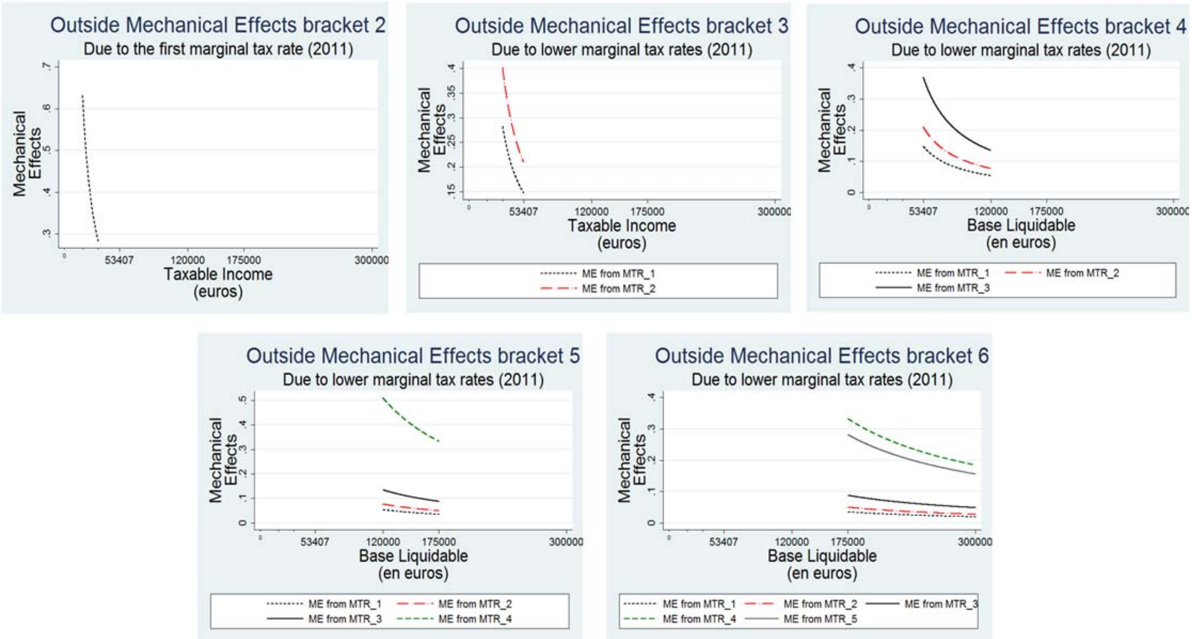


Figure 3: Contour of the within mechanical effects, $EM^{(h)}$, induced by existing marginal tax rates in 2011.

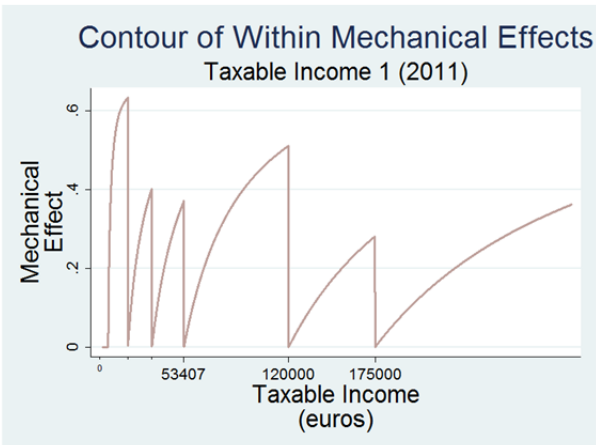


Figura 4: The components of the behavioural effect and its contour for alternative values of the Elasticity of Taxable Income (ETI).

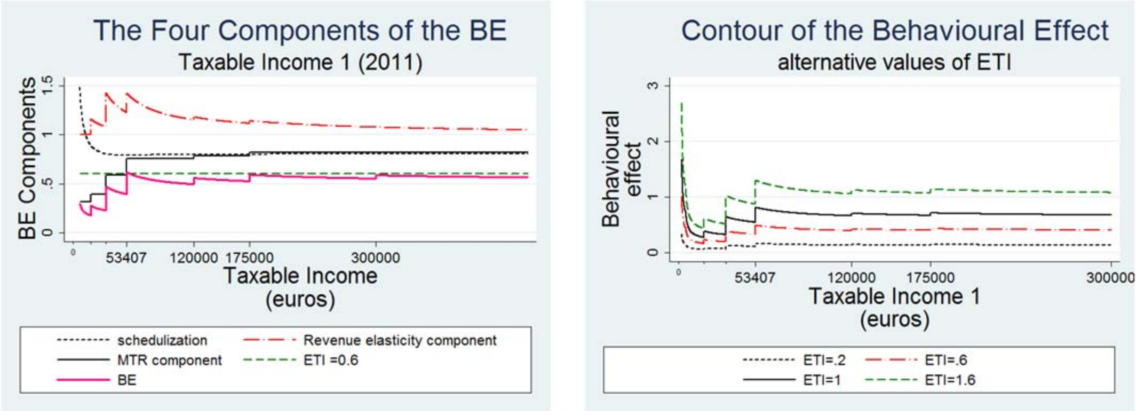


Figura 5: Behavioural effects induced by each of the six marginal tax rates existing before the marginal tax rate increase (2011).

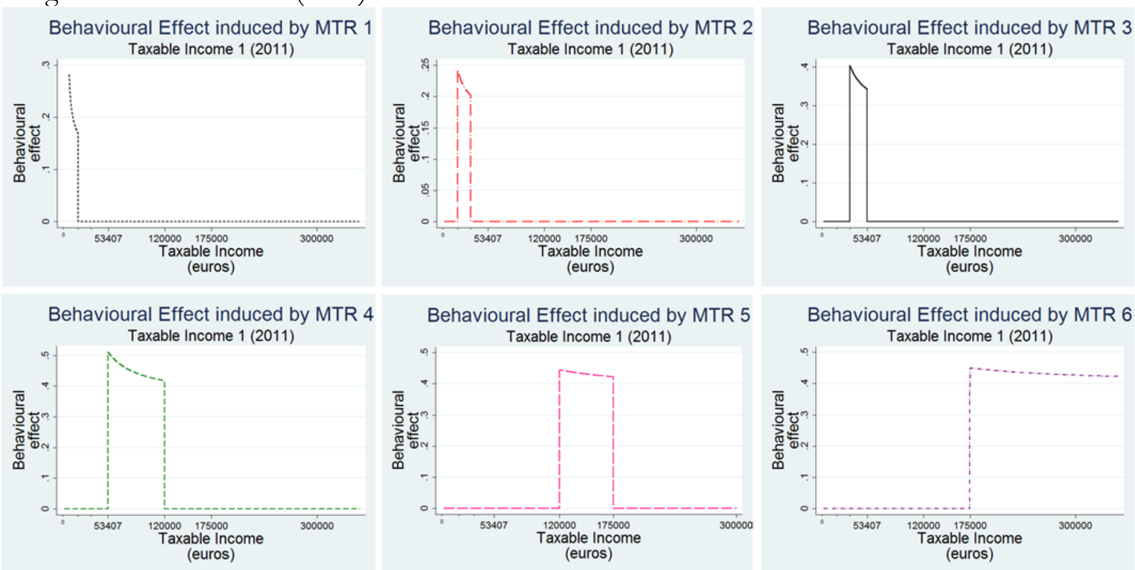
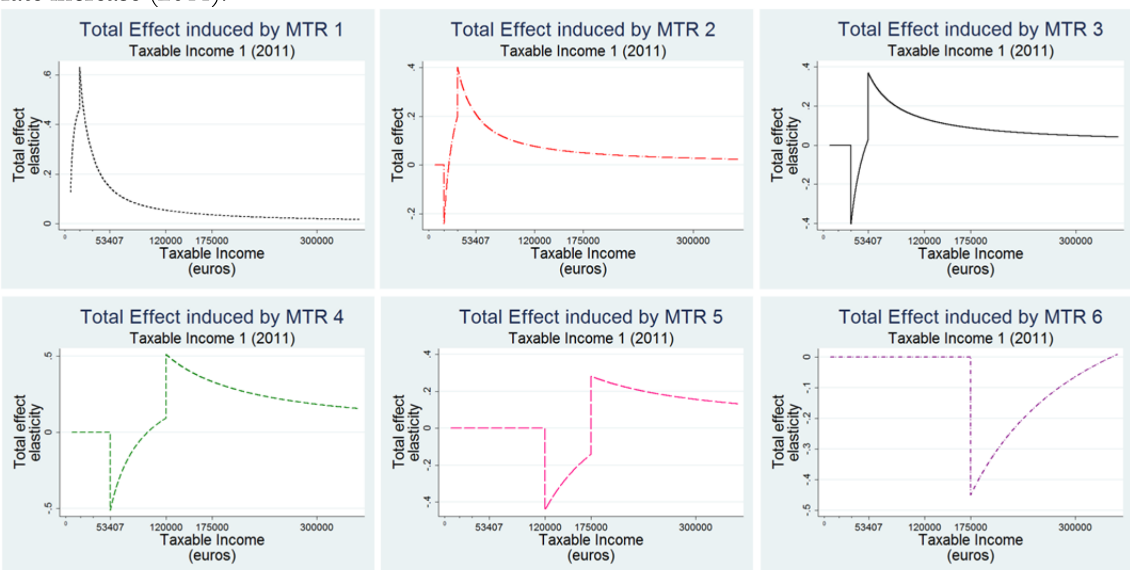


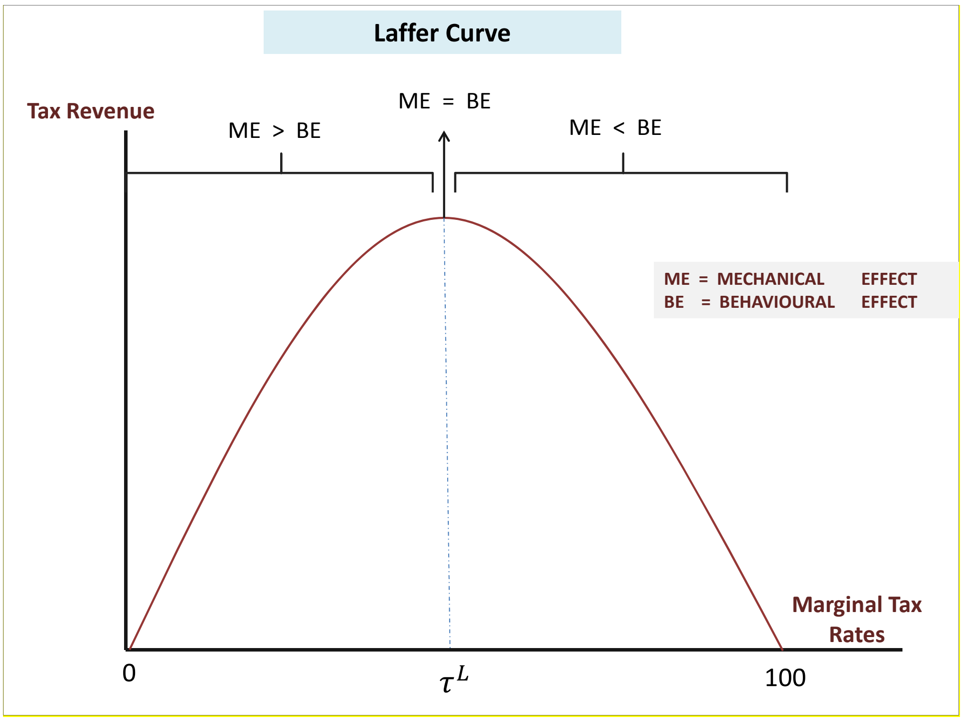
Figura 6: Total effect induced by each of the six marginal tax rates existing before the marginal tax rate increase (2011).



II. CHARACTERISATION OF THE LAFFER CURVE OF AN INDIVIDUAL TAXPAYER

The well-known Laffer curve, popularised by Arthur Laffer in the 1980s, illustrates the relationship between revenue and marginal tax rates. This curve is characterised by the presentation of a revenue peak, which would be achieved for a value of the marginal rate and which in the literature is usually referred to as the *Laffer-marginal tax rate*, τ^L. The microeconomic foundation that validates the Laffer curve is found precisely in the interaction of the mechanical effect with the behavioural effect presented in the previous section. In fact, if we take into account that the maximum of the Laffer curve is characterised by having zero revenue elasticity, the mechanical effect and behavioural effect suffice to correctly characterise the Laffer curve and quantify the value of τ^L. As shown in Figure 7, rising section of the Laffer curve is characterised by a mechanical effect greater than the behavioural effect. In the maximum of the curve, the mechanical effect is equal to the behavioural effect, whereas in the prohibited, or decreasing, section, the behavioural effect is greater than the mechanical effect.

Figure 7: Laffer Curve Characterisation.



Thus, the relevant Laffer marginal tax rate for an individual taxpayer who is faced with a schedular income tax with false allowances can be computed using equation [14]. Taking into account that at the maximum of the Laffer curve the condition $\eta_{T_i^I,\tau} = 0$ is met, , we obtain the following expression for τ_i^L:

$$\tau_i^L = \frac{\left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) \cdot (y_i - a'_k)}{y_i \cdot \eta_{y_i,1-\tau} + \left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) \cdot (y_i - a'_k)} \qquad [17]$$

Following the same economic reasoning that is used to calculate τ_i^L, if the objective of the tax authority is to modify tax rates to achieve a revenue response of magnitude R, other than zero, equation [17] will be transformed into the following:

$$\tau_i^R = \frac{(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau} - R) \cdot (y_i - a'_k)}{y_i \cdot \eta_{y_i,1-\tau} + (\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau} - R) \cdot (y_i - a'_k)} \qquad [18]$$

which identifies the maximum value of the marginal tax rate compatible with the objective $\eta_{T_i^I,\tau} = R$.

Apart from τ^L and τ^R, it is interesting to examine the concept of *threshold elasticity* introduced by Creedy and Gemmell (2012), which is defined as the value of ETI that would assure revenue neutrality given an increase in marginal tax rates. Rather than focusing on the magnitude of the marginal rate, these authors seek the maximum value of the elasticity of the taxable income compatible with the desired revenue response, given a determined tax schedule. Thus, if the objective is $\eta_{T_i^I,\tau} = 0$, we will face the *Laffer-threshold elasticity*, $\eta_{y_i,1-\tau}^L$, and if, on the contrary, the goal is to obtain a value R other than zero, $\eta_{T_i^I,\tau} = R$, we will be faced with a *R-threshold elasticity*, $\eta_{y_i,1-\tau}^R$. The generic expressions of these threshold-elasticities are represented in [19] and [20].

$$\eta_{y_i,1-\tau}^L = \left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau}\right) \cdot \left(\frac{y_i - a'_k}{y_i}\right) \cdot \frac{1-\tau}{\tau} \qquad [19]$$

$$\eta_{y_i,1-\tau}^R = \left(\eta'_{T_i,\tau} - \alpha_i \cdot \eta'_{\theta_i,\tau} - R\right) \cdot \left(\frac{y_i - a'_k}{y_i}\right) \cdot \frac{1-\tau}{\tau} \qquad [20]$$

Both τ_i^L and $\eta_{y_i,1-\tau}^L$ are useful concepts to characterise the Laffer curve because they enable the identification of the section in which the taxpayer is located. Specifically, the following holds true:

- Ascending area (an increase in the marginal tax rate will increase the taxpayer's bill):

$$BE < ME \quad \Rightarrow \quad \tau_i < \tau_i^L \quad \Rightarrow \quad \hat{\eta}_{y_i,(1-\tau)} < \eta_{y_i,(1-\tau)}^L$$

- Prohibited area (an increase in the marginal rate will diminish the taxpayer's bill):

$$BE > ME \quad \Rightarrow \quad \tau_i > \tau_i^L \quad \Rightarrow \quad \hat{\eta}_{y_i,(1-\tau)} > \eta_{y_i,(1-\tau)}^L$$

where $\hat{\eta}_{y_i,(1-\tau)}$ denotes the estimated ETI regarded as governing the behaviour of the taxpayer´s taxable income.

III. AGGREGATE REVENUE CHANGE AND MARGINAL TAX RATES

After studying the impact of a change in the marginal tax rates on the individual tax bill, in this section we examine the incidence on aggregate tax revenue. Specifically, we offer analytical expressions to determine the expected revenue change given a change of one or more marginal tax rates in a population of N taxpayers. As in the prior section, the calculations are conducted for a tax with an extensive base as well as for a schedular one.

Global taxable income with non-genuine allowances

Based on [5], the absolute change in aggregate revenue from a population of taxpayers caused by a modification of $\tau_h \mid \tau_h \in \zeta$ will be determined as follows:

$$dT^I = \left\{\left(\frac{\partial T}{\partial \tau_h} - \frac{\partial \theta}{\partial \tau_h}\right) + \frac{\partial T}{\partial Y} \cdot \frac{dY}{d\tau_h}\right\} \cdot d\tau_h \tag{21}$$

where $T^I = \sum_{i=1}^{N} T_i^I$, $T = \sum_{i=1}^{N} T_i$ y $\theta = \sum_{i=1}^{N} \theta_i$, with N being the total number of taxpayers affected by the change in the marginal tax rate. Therefore, the revenue variation associated with the modification of marginal rate τ_h will be determined by the sum of revenue variations for taxpayers whose taxable income falls within bracket h in addition to those taxpayers whose taxable income is greater than a_{h+1}:

$$dT^I = \sum_{i=1_h}^{N_h} dT_i^I + \sum_{j=N_{h+1}}^{N_K} dT_j^I \tag{22}$$

such that in consideration of [2], [3] and [10], the population revenue change that the modification of marginal tax rate τ_h will induce in an extensive income tax will be given by the following expression:

$$dT^I = \Big\{\Big([(\bar{y}_h - a_h) \cdot N_h + (a_{h+1} - a_h) \cdot N_h^+] - \big[(\bar{M}_h - a_h) \cdot N_h^m + (a_{h+1} - a_h) \cdot N_h^{m^+}\big]\Big) - \frac{\tau_h}{1-\tau_h} \cdot \tilde{\eta}_{Y_h,1-\tau_h} \cdot \bar{y}_h \cdot N_h\Big\} \cdot d\tau_h \tag{23}$$

where $\tilde{\eta}_{Y_h,1-\tau_h}$ denotes mean elasticity – weighted by income – of the taxable income of taxpayers in bracket h, and $\bar{y}_h$and $\bar{M}_h$ the arithmetic mean – within the bracket – of the tax bases and effective allowances falling within bracket h. The population size affected by the change in the marginal tax rate is represented by N_h, N_h^+, N_h^m and $N_h^{m^+}$, where N_h denotes the number of taxpayers whose taxable income falls within range h and N_h^+ the number of taxpayers with taxable income greater than a_{h+1}. For their part, N_h^m and $N_h^{m^+}$ indicate the same population concepts but referred to the value of the entitled allowances.

Schedular income tax with non-genuine allowances

In a schedular income tax with non-genuine allowances, a population revenue change generated by a change in marginal rate τ_h^b will coincide with [23] particularised to the taxable income b affected by the tax rate modification. Formally:

$$dT^I = dT^{I^b} = \Big\{\Big([(\bar{y}_h^b - a_h) \cdot N_h^b + (a_{h+1} - a_h) \cdot N_h^{b^+}] - \big[(\bar{M}_h^b - a_h) \cdot N_h^{m^b} + (a_{h+1} - a_h) \cdot N_h^{m^{b^+}}\big]\Big) - \frac{\tau_h^b}{1-\tau_h^b} \cdot \tilde{\eta}_{Y_h^b,1-\tau_h^b} \cdot \bar{y}_h^b \cdot N_h^b\Big\} \cdot d\tau_h^b \tag{24}$$

III.1. Characterisation of the aggregate Laffer curve

Following the same reasoning as for the case of the individual taxpayer, the aggregate Laffer curve underlying a particular taxation structure that rests on a specific distribution of taxpayers and income can be characterised by identifying the aggregate values of τ_h^L and $\eta_{Y,1-\tau_h}^L$. Thus, equalling the mechanical and behavioural effects reflected in [24] and solving the equation, we obtain the following sought expressions:

$$\tau_h^L = \frac{1}{1+\frac{\tilde{\eta}_{Y_h^b,1-\tau_h^b} \cdot \bar{y}_h^b \cdot N_h^b}{A}} \qquad and \qquad \eta_{Y,1-\tau_h}^L = \frac{A \cdot (1-\tau_h)}{\tau_h \cdot \bar{y}_h^b \cdot N_h^b} \qquad [25]$$

where:

$$A = \left(\left[\left(\bar{y}_h^b - a_h\right) \cdot N_h^b + (a_{h+1} - a_h) \cdot N_h^{b^+}\right] - \left[\left(\bar{M}_h^b - a_h\right) \cdot N_h^{m^b} + (a_{h+1} - a_h) \cdot N_h^{m^{b^+}}\right]\right)$$

IV. REVENUE IMPACT OF THE ROYAL DECREE-LAW 20/2011

Since January 2007, the Spanish income tax is characterised by having a schedular design and the application of non-genuine allowances. Thus, the structure of the Spanish personal income tax fits the modelling presented in the previous sections. In this section, we analyse the revenue impact of the increment in the marginal tax rates with the entrance into force of the Royal Decree-Law 20/2011 in Spain, which was approved in December 2011 and took effect in January 2012. Adopting 2012 as a reference year, we use a sample of 1,928,494 tax returns representing a population of 19,315,353 tax returns. Given that the Spanish income tax levies on savings income separately from other income, in what follows we will denote *taxable income 1* as the taxable income that consists of income other than that from savings and *taxable income 2* as income from savings[7]. By the same token, the applicable tax rates to each of the taxable incomes will be known as tax schedule 1 and tax schedule 2.

The schedular nature of the Spanish income tax is incorporated into our modelling with the parameters α_i^b and μ_i^b. The basic figures of the population distribution of α_i^1,α_i^2,μ_i^1 and,μ_i^2 are shown in Tables A1 and A2 of the appendix. As can be observed, the figures of α^1 are systematically greater than those of α^2. This relationship between α^1 and α^2 confirms an expected pattern: tax savings associated with allowances are fundamentally absorbed by taxable income 1. In addition, tax savings are more important in the first tax brackets of the tax schedule than in the last tax brackets – this happens in tax schedules 1 and 2. The relationship between parameters $\mu^1$and μ^2 indicates a greater quantitative relevance of taxable income 1 than taxable income 2.

[7]Given that in Spain the regulatory capacity over the Spanish income tax is shared between the autonomous governments and the central government, the applicable rates for 2012 present a significant regional divergence. This divergence results from the fact that the increase in the state tax rates was uniform for all communities, whereas simultaneously certain autonomous governments modified their regional marginal tax rates. In our simulations, we assume the representative tax rate to be the autonomous tax rate of the communities that in 2012 had not modified their regional marginal tax rates.

As shown in Table 1, the entrance into force of the Royal Decree-Law significantly increased the marginal tax rates in all the tax brackets of tax schedules 1 and 2. Likewise, both tax schedules added one additional tax bracket to the previously existing ones. As a consequence, tax schedule 1 ended up with a total of seven ranges and tax schedule 2 with a total of three tax brackets. Additionally, the combination of these modifications altered the nominal and effective tax thresholds (Figure A1 of the appendix).

Table 1. Central Government Tax Schedules for years 2011 and 2012.

	τ_k			a_k		a'_k	
Brackets Taxable Income 1	2011	2012	Δ (%)	2011	2012	2011	2012
0	12,00	12,75	6.25	0	0	0	0
17,707.20	14,00	16,00	14.29	17,707.20	17,707.20	2.529.6	3,098.8
33,007.20	18,50	21,50	16.22	33,007.20	33,007.20	9,943.1	10,576
53,407.20	21,50	25,50	18.60	53,407.20	53,407.20	16,008	16,955
120,000	22,50	27,50	22.22	120,000	120,000	18,371	21,161
175,000	23,50	29,50	25.53	175,000	175,000	21,852	27,194
300,000	23,50	30,50	29.79	175,000	300,000	21,852	32,440
	τ_k			a_k		a'_k	
Brackets Taxable Income 2	2011	2012	Δ (%)	2011	2012	2011	2012
0	9,50	10,50	10.53	0	0	0	0
6,000	10,50	12,50	19.05	6,000	6,000	571,43	960
24,000	10,50	13,50	28.57	6,000	24,000	571,43	2,666.7

Revenue generated by the reform

When announcing this measure, the government estimated a revenue collection of an additional 5.4 billion euros relative to the tax revenue obtained in 2011, which was subsequently reduced to an estimate of 4.1 billion euros when the General Budgets of the State for 2012 were presented. However, as explained in the previous sections, increases in marginal tax rates are susceptible to generating significant efficiency costs, which limits their revenue power. Table 2 summarises the results of the tax simulation[8]. As observed, when only taking into account the mechanical effects, ME, the expected revenue coincides with that initially announced by the government: 5.406 billion euros (4.230 billion from taxable income 1 and 1.176 billion from taxable income 2). However, when we consider the behavioural reactions, 2.311 billion euros are lost because of the efficiency costs, thus limiting the effective increase in revenue from the reform to 3.095 billion euros (2.214 billion from taxable income 1 and 881 million from taxable income

[8]However, the results are strongly dependant on the magnitude of the ETI. Although there is no wide agreement on the value of this elasticity, in general, a review of the available empirical literature establishes a reasonable range for this parameter, which moves between 0.10 and 1, depending on the country and the idea of taxable income on which the calculation is based. For the case of Spain, empirical evidence is nearly non-existent with the exception of the works of Badenes (2001), Diaz (2004) and Sanmartin (2007). In our simulations, we use the elasticity values obtained by Sanz et al. (2013): 0.44 for the general taxable income and 0.67 for savings taxable income.

2). That is, only 57% of the figure initially announced by the tax authorities and 75% of the figure anticipated in the presentation of the General Budgets of the State[9].

If we analyse in more detail the final impact reflected in Table 2, we can observe that increases in the first and second marginal tax rates of tax schedule 1 – from 12% to 12.75% and from 14% to 16% – are the most profitable in terms of revenue, generating a revenue increase compared with a pre-reform scenario of 1.19% and 1.55%, respectively. This result is coherent because the mechanical effects of these marginal tax rates are the highest (1.30 and 1.98), in turn offering moderately reduced behavioural effects (0.11% and 0.43%). Not surprisingly, 77.92% of the total revenue increase achieved by the modification of tax schedule 1 is exclusively explained by increasing its two first marginal rates (35.21% + 42.71%). However, despite an increase of 25.53% and 29.79% of the two highest marginal tax rates of tax band 1, τ_5 and τ_6, , barely increases the revenue obtained from them before the raise (0.08% and 0.28%, respectively), which represents only 6.15% of the total revenue increase coming from the modification of tax band 1. As for tax schedule 2, the increase from two to three tax brackets explains all of the revenue gain from savings income. Additionally, in the case of tax band 2, increasing its first marginal tax rate by one percentage point (from 9.5 to 10.5) decreases the revenue associated with tax schedule 2 by over 11 million euros. For a closer exploration of the forces which have governed the revenue effects of the Royal Decree-Law 20/2011, Tables A3 and A4 of the Appendix present the median values of the distribution of the mechanical (ME), behavioural (BE) and effective $(\eta_{T_i^I,\tau_i^b})$ elasticities.

Table 3 presents the mean value of the actual marginal tax rates, τ, and of the Laffer marginal tax rates, τ^L, before the entrance into force of the Royal Decree-Law 20/2011. The information is presented separately for taxpayers for whom the behavioural effect is greater than the mechanical effect and vice versa. For the former, the additional increase in tax rates results in revenue losses, whereas for the latter, tax revenue increases. Subsequently, we analyse in detail the data that refer to taxpayers for whom $BE > ME$ while leaving it to the interested reader to analyse the rest of the data contained in the table.

Regarding taxable income 1, the number of tax returns in the descending area of the Laffer curve before the increase approved in December 2011 was 48.22% of the total (9,313,863 tax returns), which represents 41.25% of the total taxable income accumulated during the year and 44.42% of the total tax due. For this set of taxpayers, the mean

[9] These calculations exclusively include the mechanical and behavioural effects of the analysed tax change. However, tax reforms are conducted in an environment influenced by the underlying economic cycle. Therefore, to determine real revenues observed after the reform, the prior calculations should be completed with the incorporation of the revenue impact of the economic cycle. Conceptually, the revenue elasticity to gross household income, η_{T,Y_B}, is a good indicator of the endogenous flexibility of the personal income tax and, therefore, a good indicator of the *cycle effect* on tax revenue. Creedy and Sanz (2010) estimate this aggregate elasticity for the Spanish income tax at 1.35. If we take into account that the General Budgets of the State for 2012 assumed a reduction of 3.8% of taxable gross household income, the automatic decrease in revenue associated with the economic cycle during the first year of the Royal Decree-Law 20/2011 would be 5.13%, which is 3.581 billion euros less than in 2011. Ultimately, our estimate of the revenue of the Spanish income tax for 2012, which combines the mechanical and behavioural effects generated by the introduction of the Royal Decree-Law 20/2011 and the cycle effect, is a decrease of 486 million euros compared with the tax revenue collected in 2011.

differential between τ and τ^L was 16.8 points, which in relative terms is equal to saying that the marginal tax rates that would have maximised their tax bills were, on average, 50.36% less than the marginal rates they actually paid. That is, before the increase in marginal tax rates, this set of over 9.3 million tax returns was clearly in the descending zone of the Laffer curve. Thus, the increase in the marginal tax rates actually decreased the revenue generated by this group. If we analyse the data by tax brackets, we can observe that the most severe impact by the number of tax returns affected occurs in the first range (from 0 to 17,707.20 euros), although only 48.52% of the tax returns reported in this range are affected. However, the impact in terms of taxable income and the tax due becomes more severe in ranges 3 to 5. These figures are even more evident for taxable income 2 because for this case the tax returns located in the "prohibited zone" of the Laffer curve amounted to 94.52% of the total number of the tax returns reported in 2011, comprising more than 82% of the tax due obtained from savings income. As observed, this *Laffer effect* on revenue was particularly significant for savers with reported income between 0 and 6,000 euros (first range). An equivalent analysis in terms of Laffer-threshold elasticity is presented in Table 4.

Table 2. Mechanical, Behavioural and Total Effects of the marginal tax rate increase (Royal Decree-Law 20/2011)

Taxable Income 1									
Modified Marginal Tax Rate	Mechanical Effect (ME)			Behavioural Effect (BE)*			Net Impact $(\eta_{T_i^I,\tau_i^b} = ME - BE)$		
	A	B	C	A	B	C	A	B	C
$\boldsymbol{\tau_1}$	883,154,882	1.30	20.88	103,713,913	0.11	5.14	779,440,969	1.19	35.21
$\boldsymbol{\tau_2}$	1,347,414,107	1.98	31.85	401,972,536	0.43	19.93	945,441,571	1.55	42.71
$\boldsymbol{\tau_3}$	793,299,163	1.17	18.75	514,043,031	0.54	25.49	279,256,132	0.62	12.62
$\boldsymbol{\tau_4}$	677,219,640	0.99	16.01	603,922,169	0.64	29.94	73,297,471	0.35	3.31
$\boldsymbol{\tau_5}$	141,226,375	0.21	3.34	116,403,414	0.12	5.77	24,822,961	0.08	1.12
$\boldsymbol{\tau_6}$	388,139,081	0.57	9.17	276,846,152	0.29	13.73	111,292,929	0.28	5.03
Whole Population	**4,230,453,249**			**2,016,901,215**			**2,213,552,033**		
Taxable Income 2									
Modified Marginal Tax Rate	Mechanical Effect (ME)			Behavioural Effect (BE)*			Net Impact $(\eta_{T_i^I,\tau_i^b} = ME - BE)$		
	A	B	C	A	B	C	A	B	C
$\boldsymbol{\tau_1}$	19,492,952	0.29	1.66	30,622,764	0.41	10.418	- 11,129,812	-0.12	- 1.263
$\boldsymbol{\tau_2}$	1,155,848,779	17.05	98.34	263,311,821	3.49	89.582	892,536,958	13.56	101.263
Whole Population	**1,175,341,731**			**293,934,585**			**881,407,146**		
Total Taxable Income	**5,405,794,980**			**2,310,835,800**			**3,094,959,179**		

Notes:
A = Revenue gain in the bracket (euros).
B = Percentage revenue gain within the bracket caused by the increase in the marginal tax rate.
C = Percentage revenue gain caused by the increase in the marginal tax rate of this bracket with respect to total tax revenue gain in the whole population
* A positive behavioural effect indicates a tax revenue fall.

Table 3. Distribution of τ and τ^L and location within the laffer curve of tax returns, taxable income and tax due in 2011 (before the tax rate increase)

TAXABLE INCOME 1

BE > ME

	$\bar{\tau}$	$\overline{\tau^L}$	$\overline{\tau-\tau^L}$	$\overline{\left(\frac{\tau-\tau^L}{\tau}\right)}$	% Tax Returns In the bracket	% Tax Returns In the total	% Taxable Income In the bracket	% Taxable Income In the total	% Tax Due In the bracket	% Tax Due In the total
bracket 1	0.24	0.0332	20.7	86.16	48.52	30.41	22.73	6.52	12.07	1.66
bracket 2	0.28	0.1581	12.2	43.53	33.83	8.5	27.21	9.2	22.93	7.01
bracket 3	0.37	0.2054	16.5	44.49	76.69	6.54	71.83	13.72	68.97	15.96
bracket 4	0.43	0.2489	18.1	42.13	74.27	2.44	66.02	8.65	62.41	13.23
bracket 5	0.44	0.2365	20.4	46.26	100	0.25	100	1.94	100	3.91
bracket 6	0.45	0.2632	18.7	41.52	60.52	0.1	36.29	1.22	35.54	2.65
Total	0.3476	0.1799	16.8	50.36	48.22		41.25		44.42	

BE < ME

	$\bar{\tau}$	$\overline{\tau^L}$	$\overline{\tau-\tau^L}$	$\overline{\left(\frac{\tau-\tau^L}{\tau}\right)}$	% Tax Returns In the bracket	% Tax Returns In the total	% Taxable Income In the bracket	% Taxable Income In the bracket	% Tax Due In the total	% Tax Due In the bracket
bracket 1	0.24	0.5158	-27.6	-114.92	51.48	32.26	77.27	22.15	87.93	12.09
bracket 2	0.28	0.4243	-14.4	-51.54	66.17	16.62	72.79	24.63	77.07	23.55
bracket 3	0.37	0.42	-5	-13.51	23.31	1.99	28.17	5.38	31.03	7.18
bracket 4	0.43	0.4944	-6.4	-14.98	25.73	0.84	33.98	4.45	37.59	7.97
bracket 5	---	---	---	---	0	0	0	0	0	0
bracket 6	0.45	0.5995	-15	-33.23	39.48	0.07	63.71	2.14	64.46	4.8
Total	0.2907	0.4701	-17.9	-68.51	51.78		58.75		55.58	

TAXABLE INCOME 2

BE > ME

	$\bar{\tau}$	$\overline{\tau^L}$	$\overline{\tau-\tau^L}$	$\overline{\left(\frac{\tau-\tau^L}{\tau}\right)}$	% Tax Returns In the bracket	% Tax Returns In the total	% Taxable Income In the bracket	% Taxable Income In the bracket	% Tax Due In the total	% Tax Due In the bracket
bracket 1	0.19	0.0022	18.8	98.83	98.52	93.42	92.09	24.1	99.88	81.04
bracket 2	0.21	0.0973	11.3	53.64	21.2	1.1	5.29	3.91	8.83	1.67
Total	0.1928	0.0155	17.7	92.53	94.52		28.01		82.71	

BE < ME

	$\bar{\tau}$	$\overline{\tau^L}$	$\overline{\tau-\tau^L}$	$\overline{\left(\frac{\tau-\tau^L}{\tau}\right)}$	% Tax Returns In the bracket	% Tax Returns In the total	% Taxable Income In the bracket	% Taxable Income In the bracket	% Tax Due In the total	% Tax Due In the bracket
bracket 1	0.19	0.4214	-23.1	-121.76	1.48	1.41	7.91	2.07	0.12	0.1
bracket 2	0.21	0.5382	-32.8	-156.27	78.8	4.07	94.71	69.92	91.17	17.2
Total	0.2094	0.5348	-32.5	-155.27	5.48		71.99		17.29	

Notas:

$\bar{\tau}$: average marginal tax rate faced by taxpayers in the bracket.

$\overline{\tau^L}$: average laffer marginal tax rate relevant to taxpayers in the bracket.

$\overline{\tau-\tau^L}$: average difference (in absolute points) between τ and τ^L.

$\overline{\left(\frac{\tau-\tau^L}{\tau}\right)}$: average relative difference (in percentage) between τ and τ^L.

*Columns 6 to 11 indicates the relevance of events $BE > ME$ and $BE < ME$. Computations are reported in terms of the percentage of tax returns, taxable income and tax due involved. Calculations refer to the bracket as well as to the whole taxpaying population.

Tabla 4. Mean values for $\hat{\eta}$ and $\widehat{\eta^L}$ in each tax bracket and for the whole taxpaying population before the tax rate increase (2011)

TAXABLE INCOME 1						
	BE >ME			BE <ME		
	$\overline{\eta^L}$	$\overline{\hat{\eta}-\eta^L}$	$\overline{\left(\frac{\hat{\eta}-\eta^L}{\hat{\eta}}\right)}$	$\overline{\eta^L}$	$\overline{\hat{\eta}-\eta^L}$	$\overline{\left(\frac{\hat{\eta}-\eta^L}{\hat{\eta}}\right)}$
bracket 1	0.0217	41.8996	95.0752	1.5138	-107.311	-243.5012
bracket 2	0.2323	20.8381	47.2842	0.8962	-45.5518	-103.3623
bracket 3	0.2519	18.8829	42.8475	0.5754	-13.4653	-30.5543
bracket 4	0.2235	21.7184	49.2817	0.5802	-13.9506	-31.6556
bracket 5	0.1945	24.6248	55.8767	---	---	---
bracket 6	0.2129	22.7847	51.7012	0.8473	-40.6599	-92.2621
Total	0.2121	22.8558	51.8625	0.7152	-27.4494	-62.286
TAXABLE INCOME 2						
	BE >ME			**BE <ME**		
	$\overline{\eta^L}$	$\overline{\hat{\eta}-\eta^L}$	$\overline{\left(\frac{\hat{\eta}-\eta^L}{\hat{\eta}}\right)}$	$\overline{\eta^L}$	$\overline{\hat{\eta}-\eta^L}$	$\overline{\left(\frac{\hat{\eta}-\eta^L}{\hat{\eta}}\right)}$
bracket 1	0	66.5593	99.999	2.5841	-191.8496	-288.2356
bracket 2	0.341	32.4554	48.7611	2.9281	-226.2493	-339.9178
Total	0.0115	65.4084	98.2698	2.928	-226.2399	-339.9038

Notes:
$\overline{\eta^L}$: mean value for η^L
$\overline{\hat{\eta}-\eta^L}$: average difference (in absolute points) between $\hat{\eta}$ and η^L.
$\overline{\left(\frac{\hat{\eta}-\eta^L}{\hat{\eta}}\right)}$: average relative difference (in percentage) between $\hat{\eta}$ and η^L..

V. CONCLUSIONS

This paper has analysed the tax revenue elasticity given the changes in marginal tax rates in a context of schedular personal income taxes with non-genuine allowances. The analysis was conducted both for the case of an individual taxpayer and for the population aggregate. Identifying the *mechanical effect* and the *behavioural effect* associated with changes in the marginal tax rates has facilitated the characterisation of the Laffer curve and obtaining analytical expressions for the marginal tax rates that maximise revenue and for the *Laffer threshold elasticity*. The empirical application of the model to the recent Spanish experience of increased marginal rates has enabled us to conclude that although the mechanical effect associated with this tax rate increment induced a tax revenue increase of more than 5.4 billion euros, the behavioural effect decreased this revenue potential to only 3.094 billion. That is, the distortions associated with the increment of the marginal tax rates eroded the revenue potential of the Royal Decree-Law by 2.31 billion euros.

References

Badenes, N. (2001). *IRPF, Eficiencia y Equidad: Tres Ejercicios de Microsimulación*. Colección Investigaciones 1/01. Madrid: Instituto de Estudios Fiscales

Creedy, J. and Gemmell, N. (2006) *Modelling Tax Revenue Growth*. Cheltenham: Edward Elgar.

Creedy, J. and Sanz-Sanz J.F. (2010), "Revenue Elasticities in Complex Income Tax Structures: An Application to Spain", *Fiscal Studies* 31: 535-561.

Creedy, J. (2011) *Tax and Transfer Tensions. Designing Direct Tax Structure*. Cheltenham: Edward Elgar.

Creedy, J. y Gemmell, N. (2011) "Tax Rates and Revenue Changes: Behavioural and Structural Factors". Victoria University of Wellington Working Papers in Public Finance, No. 11/05.

Creedy, J. y Gemmell, N. (2012) "Revenue-Maximising Elasticities of Taxable Income in Multi-Rates Income Tax Structures". Victoria University of Wellington Working Papers in Public Finance, No. 05/2012.

Díaz, M. (2004). *La respuesta de los contribuyentes ante las reformas del IRPF, 1987-1994*, Tesina N. 0405, Centro de Estudios Monetarios y Financieros (CEMFI).

Dupuit, Arsène Jules Étienne Juvénal (1844): De la mesure de l'utilité des travaux publics, Annales des ponts et chaussées, Second series, 8. Translated by R.H. Barback as "On the measurement of the utility of public works", International Economic Papers, 1952, 2, 83-110.

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

Giertz S. H. (2009) "The Elasticity of Taxable Income: Influences on Economic Efficiency and Tax Revenues, and Implications for Tax Policy". In *Tax Policy Lessons from the 2000s* Alan D. Viard (editor).

Goolsbee A. (1999) "Evidence on the High-Income Laffer Curve from Six Decades of Tax Reform", *Brookings Papers on Economic Activity, 1999,* 1-64.

Meghir C. and Phillips D. (2010) "Labour Supply and Taxes" in *Dimensions of Tax Design, The Mirrlees Review*, Sir James Mirrlees (editor): 202-274. Oxford: Oxford University Press.

Saez, E. (2004). "Reported Incomes and Marginal Tax Rates, 1960-2000: Evidence and Policy Implications" in *Tax Policy and the Economy*. Vol. 18, James Poterba (editor): 117-173. Cambridge, MA: MIT Press.

Sanmartin, J. (2007). "El efecto de los cambios en los tipos marginales sobre la base imponible del IRPF", Hacienda Pública Española, 182 (3): 9-27.

Sanz J.F., Castaner J.M. and Romero D. (2009). *Análisis de Reformas del Impuesto sobre la Renta Personal a Partir de Microdatos Tributarios. El simulador de la Fundación de las Cajas de Ahorros (FUNCASim).* Colección Estudios de la Fundación. Serie Análisis. Madrid.

Sanz J.F., Arrazola M., Rueda N. and Romero D. (2013). *Reported Gross Income and Marginal Tax Rates: Estimation of the Behavioural Reactions of Spanish Taxpayers.* Mimeo.

Smith A. (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations,* 1952 edn, Chicago: William Benton.

Slemrod J. (1995). "Income Creation or Income Shifting? Behavioral Responses to the Tax Reform Act of 1986. American Economic Association, papers and proceedings: 175:180.

Slemrod, J. (2001). "A General Model of the Behavioral Response to Taxation". *International Tax and Public Finance*, 8: 119-128.

Appendix

Table A1: basic statistics for the distribution of parameters α_i^1 and μ_i^1

α_i^1

	Weighted by population			Weighted by Taxable Income			range	
	mean	median	interquartile	media	mediana	interquartile	min	max
Total	0.5332497	0.449264	0.6713442	0.3038121	0.2235758	0.2792755	0	1
By Brackets in Tax Schedule 1								
bracket 1	0.7324239	0.7527154	0.5162255	0.61293	0.5465573	0.4041098	0	1
bracket 2	0.2766367	0.2527731	0.1061125	0.2666811	0.2421186	0.0999004	0	1
bracket 3	0.1479219	0.1367521	0.0528286	0.1445765	0.134443	0.052873	0	1
bracket 4	0.0743362	0.0692006	0.0331531	0.0705812	0.0654746	0.0330666	0	1
bracket 5	0.0326332	0.029466	0.0118413	0.0322192	0.0289964	0.0118176	0	0.396775
bracket 6	0.0168148	0.015703	0.0098179	0.012224	0.0110387	0.0121232	0	0.1763053

μ_i^1

	Weighted by population			Weighted by Taxable Income			range	
	mean	median	interquartile	media	mediana	interquartile	min	max
Total	323311.8	1.463518	0.8700534	166529	1.234115	0.4219019	0	1.13E+09
By Brackets in Tax Schedule 1								
bracket 1	421,875.2	1.996971	1.539657	252683.1	1.860277	1.074213	0	1.13E+09
bracket 2	323,190	1.304121	0.190212	282337.8	1.285822	0.1841891	0.0007288	2.93E+08
bracket 3	13,054.74	1.141148	0.0781698	11069.44	1.136753	0.076431	0.0050683	8.79E+08
bracket 4	758.3608	1.061631	0.0462192	697.2442	1.05713	0.0453727	0.0085239	1.39E+08
bracket 5	0.9887981	1.021934	0.0311584	0.988	1.02147	0.0314002	0.0031382	1.65137
bracket 6	0.9703997	1.004942	0.0343187	0.9692864	0.9991256	0.0321075	0.0028268	1.214042

Table A2: basic statistics for the distribution of parameters α_i^2 y μ_i^2

	α_i^2							
	Weighted by population			**Weighted by Taxable Income**			**range**	
	mean	median	interquartile	mean	median	interquartile	mean	median
Total	0.2376949	0	0.1504007	0.1068317	0	0.0008813	0	1
By Brackets in Tax Schedule 2								
bracket 1	0.2453153	0	0.2988711	0.2710685	0	0.722885	0	1
bracket 2	0.1206428	0	0.076527	0.0486019	0	0	0	1

	μ_i^2							
	Weighted by population			**Weighted by Taxable Income**			**range**	
	mean	median	interquartile	mean	median	interquartile	mean	median
Total	784,949.6	0.0027445	0.0505786	2,838,750	0.7208531	0.7125182	7.30E-09	4.68E+09
By Brackets in Tax Schedule 2								
bracket 1	960.9538	0.0015988	0.0297781	2,816.393	0.1283689	0.3097623	7.30E-09	3.63E+07
bracket 2	1.16E+07	0.5674979	0.819038	3,628,200	0.836151	0.5149336	0.0003809	4.68E+09

Figure A.1: Marginal tax rates and thresholds -nominal and effective- for tax schedules before (2011) and after the tax rate increase (2012).

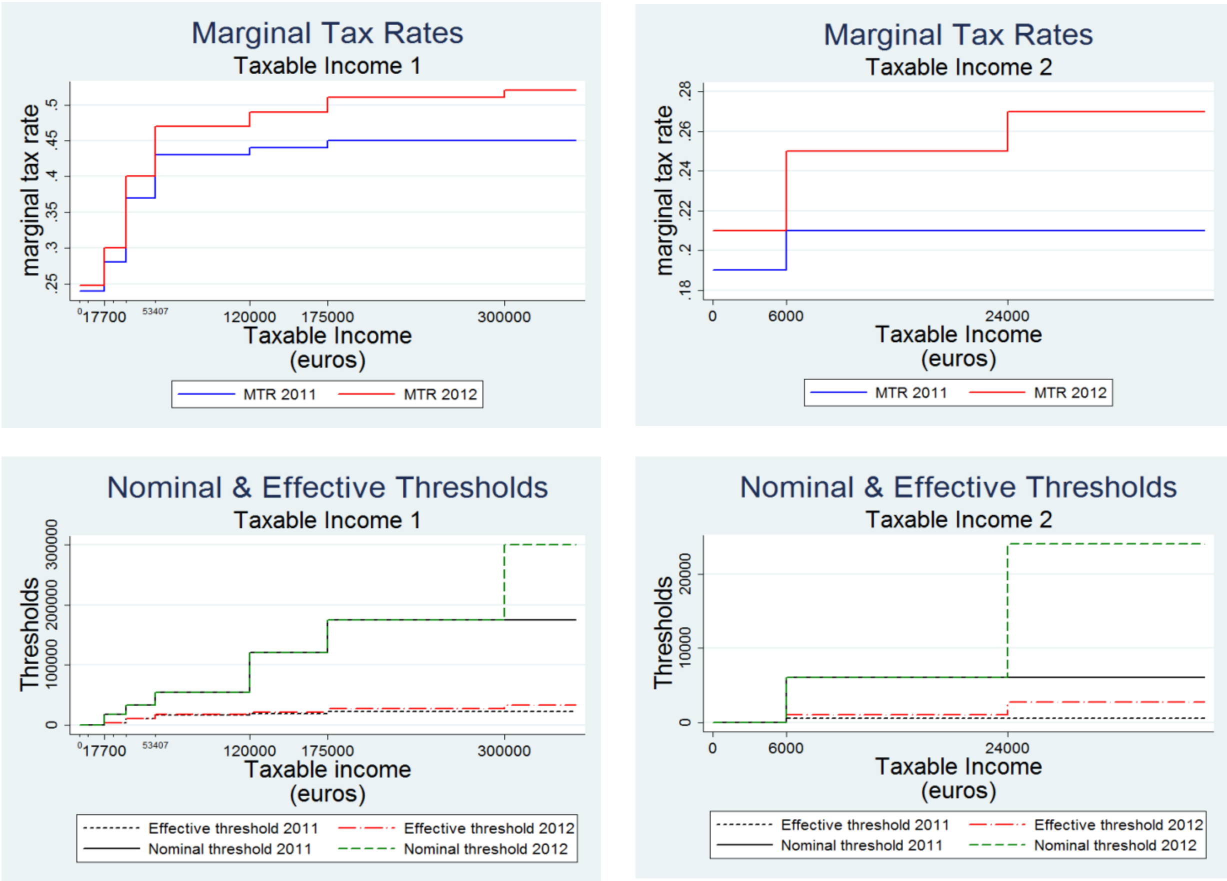


Table A3: Median values for the Mechanical and Behavioural Effects for each marginal tax rate in tax band 1 -revenue impact in each bracket-

	ME						BE	$\eta_{T_i^I,\tau_i^b} = ME - BE$					
brackets	1	2	3	4	5	6		1	2	3	4	5	6
1	0.99855						0.25889	0.68864					
2	0.55023	0.41052					0.24605	0.55023	0.16395				
3	0.26853	0.43458	0.25873				0.39093	0.26853	0.43458	-0.12788			
4	0.11363	0.18839	0.33232	0.32881			0.45091	0.11363	0.18839	0.33232	-0.11317		
5	0.04747	0.07932	0.13995	0.53100	0.16325		0.40456	0.04747	0.07932	0.13995	0.53100	-0.22467	
6	0.01507	0.02737	0.04846	0.18390	0.15542	0.51309	0.37875	0.01507	0.02737	0.04846	0.18390	0.15542	0.14161
Total	0.44670	0.23614	0	0	0	0	0	0.41315	0.13650	0	0	0	0

Notes:
- Calculations computed by weighting the elasticities by taxable income 1.
- Shaded values identify mechanical effects for taxpayers whose taxable income falls in the bracket of the modified marginal tax rate $(ME^{(h)})$
- Values out of the diagonal line identify the mechanical effects corresponding to taxpayers above the modified marginal tax rate (ME^{h+})

Table A4: Median values for the Mechanical and Behavioural Effects for each marginal tax rate in tax band 2 -revenue impact in each bracket-

	ME		BE	$\eta_{T_i^I,\tau_i^b} = ME - BE$	
tramo	1	2		1	2
1	1		0	0.615452	
2	0.0140496	0.7078068	0.1493138	0.0140496	0.5463525
Total	0.0297907	0.5029322	0.1182696	0.0249826	0.3693089

Notes:
- Calculations computed by weighting the elasticities by taxable income 2.
- Shaded values identify mechanical effects for taxpayers whose taxable income falls in the bracket of the modified marginal tax rate $(ME^{(h)})$
- Values out of the diagonal line identify the mechanical effects corresponding to taxpayers above the modified marginal tax rate (ME^{h+})