MICROSIMULATION TOOLS FOR THE EVALUATION OF FISCAL POLICY REFORMS AT THE BANCO DE ESPAÑA

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Abstract

This paper presents the microsimulation models developed at the Banco de España for the study of fiscal reforms, describing the tool used to evaluate changes in the Spanish personal income tax and also the one for the value added tax and excise duties. In both cases the structure, data and output of the model are detailed and its capabilities are illustrated using simple examples of hypothetical tax reforms, presented only to illustrate the use of these simulation tools.

Keywords: microsimulation, Spain, personal income tax, value added tax, excise duties.

JEL Classification: C81, D12, H20.

Resumen

Este documento presenta los modelos de microsimulación desarrollados por el Banco de España para el estudio de reformas fiscales. Por un lado, describe la herramienta de microsimulación que evalúa cambios en el impuesto sobre la renta de las personas físicas (IRPF). Por otro lado, explica la herramienta del impuesto sobre el valor añadido (IVA) y los impuestos especiales. Para cada una de estas dos herramientas, el documento detalla cómo se estructura, los datos usados y los resultados que genera. También se muestran las capacidades de estas herramientas mediante ejemplos sencillos de reformas fiscales hipotéticas, presentadas exclusivamente para ilustrar el uso de estos simuladores.

Palabras clave: microsimulación, España, IRPF, IVA, impuestos especiales.

Códigos JEL: C81, D12, H20.

INDEX

1 Introduction

This paper presents the microsimulation models developed at the Banco de España (BdE) for the study of fiscal reforms involving changes in personal income taxation (PIT) and indirect taxation (VAT and excise duties). The aim of the paper is to present the main features of the tools and illustrate their capabilities using simple examples of tax reforms.

Microsimulation models are tools that simulate the effect of a reform on a representative sample of individual agents (taxpayers, households, firms, etc.). They allow the aggregate and the distributional effects of tax reforms to be studied, taking into account the heterogeneity among individuals. As a consequence, they are a powerful tool for the development of decision-support models in order to simulate and evaluate the impact of public policies.

Spurred by the availability of micro data and computer power, the use of microsimulation methods to perform ex-ante and ex-post evaluation of fiscal reforms is becoming more and more widespread. Currently, there is an extensive array of policy and research institutions in Europe that have developed and maintain such models, such as the Institute for Fiscal Studies in the UK (TAXBEN), the *Institut des Politiques Publiques* in France (TAXIPP), the CPB Netherlands Bureau for Economic Policy Analysis (MIMOSI) and the Institute for Social and Economic Research at the University of Essex, in collaboration with national teams (EUROMOD, the European Commission sponsored tax-benefit microsimulation model), to name a few. Microsimulation techniques can contribute to current fiscal policy debates and, especially when it comes to modelling behavioural responses triggered by tax reforms, they have attracted a lot of attention from the academic community.

The microsimulation model of direct taxation developed at the Banco de España allows morning-after (first-round) aggregate and distributional effects of reforms in the Spanish personal income tax *(Impuesto sobre la Renta de las Personas Físicas* or *IRPF)* to be simulated. It allows a wide range of reforms stemming from changes in the parameters of the tax code to be evaluated, in the absence of any behavioural reaction by agents.

In Spain, the first arithmetic microsimulation model of direct taxation was MOSIR *(Modelo de Simulación del Impuesto sobre la Renta)* developed by Castañer and Santos (1992) at the *Instituto de Estudios Fiscales* (IEF) using administrative records. Levy et al. (2001) presented ESPASIM, a microsimulation model of direct taxation, as well as of social contributions, indirect taxation and excise duties. The database for the microsimulator of direct taxation was the ECHP. In the early 2000s the IEF created a microsimulation unit that built SIRPIEF, which performed both arithmetic and behavioural simulations based on survey data from the ECHP. A summary of this tool is contained in Sanz et al. (2004) and their labour supply model borrows from Labeaga and Sanz (2001). Oliver and Spadaro (2004) developed GLADHISPANIA, a combined arithmetic-behavioural tool based on data from the ECHP. Also at the IEF, Moreno et al. (2010) developed Microsim-IEF, and Onrubia et al. (2013) developed MODELAIR, both arithmetic models using administrative records. There are many other applications of microsimulation that use Spanish direct-taxation data as well as tax-benefit models. Some examples are presented by García et al. (1997), Badenes et al. (1998) and García and Suárez (2002, 2003).

The Banco de España microsimulation model for indirect taxation allows changes in the value added tax *(Impuesto sobre el Valor Añadido* or *IVA)* and excise duties *(impuestos especiales)* to be simulated. In addition to morning-after effects, it captures the behavioural response of households through the estimation of a demand system. Therefore, in addition to first-round effects, the tool allows households' behavioural reaction to price changes stemming from a tax reform (second-round effects) to be predicted.

In Spain, the first tool for indirect taxation was developed by Labeaga and López (1995), whose complete demand model was presented in Labeaga and López (1994). The microsimulation unit at the IEF also developed a tool for indirect taxation, SINDIEF *(Simulador de Impuestos Indirectos del Instituto de Estudios Fiscales)*. Sanz et al. (2003) provide a summary of its functioning. Examples of microsimulation papers dealing with indirect taxes and excise duties are Labeaga and López (1997) and Labandeira and Labeaga (1999). An overall discussion of microsimulation can be found in Bourguignon and Spadaro (2006), while a summary for Spain is contained in Ayala et al. (2004).

The models for PIT and for VAT and excise duties both provide a comprehensive evaluation of tax reforms, by accounting for the effects relating to tax collection, effective tax rates, winners and losers and inequality indices. These effects are disaggregated by income decile and age group. Moreover, the model for indirect taxation provides results for welfare changes.

The rest of this paper presents the two microsimulation models, starting with the personal income tax model and afterwards the VAT and excise duties model.[1]

1 Both tools are accompanied by a User Guide that explains how to execute them in order to simulate different policies.

2 The Banco de España Personal Income Tax Microsimulation Model

This model simulates the tax liabilities stemming from the Spanish personal income tax *(Impuesto sobre la Renta de las Personas Físicas* or *IRPF)* for a large representative sample of taxpayers. The model incorporates most of the tax code specificities that determine the calculation of tax liabilities. Therefore, it allows a wide range of reforms, such as those involving marginal tax rates, tax deductions, tax credits, and exemptions, to be simulated.

The model is an arithmetic tool that provides morning-after effects of the reform being simulated insofar as behavioural effects, such as the variation in employment status or hours worked, are not taken into account. The outcome of the model includes an estimation of total tax revenues, winners and losers, and changes in average tax rates by income decile and age group. Furthermore, it provides measures of inequality and redistribution. It also allows the simulated micro data to be saved for the performance of further analysis.

2.1 The data

The data used by the model is a (stratified) random sample of 2013 tax returns namely, the *MUESTRA IRPF 2013 IEF-AEAT (Declarantes)*. As more recent data become available they will be incorporated into the model updates. The sample size (in 2013) is about 2.2 million tax returns, which corresponds roughly to 11% of the population. They pertain to the 15 regions with a common tax regime and the two autonomous cities of Ceuta and Melilla. Therefore, they exclude the two regions with special tax regimes (the Basque Country and Navarre). For a detailed description of this dataset see López et al. (2016).

The dataset contains most of the fiscal variables and socio-demographic characteristics included in the tax return *(modelo 100)*. Therefore, it contains very precise information on income sources and tax benefits, as well as some family characteristics, such as the number of dependent children, other dependent relatives, disability and location. The detailed information in the dataset allows individual tax liabilities to be accurately simulated and a wide range of reforms to be modelled. Yet the fact that no information on the employment status of the taxpayer is provided prevents the modelling of behavioural responses following tax reforms.

Tax returns are of two types: single tax returns, filed at the individual level, and joint tax returns, filed by (mainly) married couples. In joint tax returns, incomes are pooled together and are eligible for an additional deduction on top of those available for single tax returns. Apart from these and other small differences, the computation of tax liabilities is similar. The decision on which type to choose is taken by the taxpayer. In general, joint tax returns benefit couples when one spouse earns little or no income, as well as single-parent families when the children do not have any income.[2] The model abstracts from the choice between single or joint tax returns, taking it as given. In 2013, around 79% of tax returns were single tax returns, the rest being joint ones.

Table 1 reproduces some of the items included in Table 2 of López et al. (2016). It shows that the sample aggregates constructed from the micro data provide an accurate representation of the population aggregates, the differences being smaller than 1.5% in all cases, except that of save income stemming from gains and losses.

2 Single parents can file a joint tax return despite being only one individual, benefiting from the corresponding deduction.

ACCURACY OF THE PERSONAL INCOME TAX MICRO DATA — TABLE 1

€bn	Tax form box	Sample aggregate	Population aggregate	Difference
Gross monetary labour income	1	375.7	375.5	0.0%
Gross capital income	28+38	18.4	18.4	0.0%
Self-employment income	125+150+180	22.5	22.4	0.4%
Income from gains and losses	361+368	8.0	8.4	-4.8%
General taxable income	415	327.1	327.0	0.0%
Savings taxable income	419	24.7	25.0	-1.4%
Family allowance (general and savings income)	439+440	109.7	109.8	-0.2%
Tax liabilities (gross of working mother tax credit)	511	67.0	67.1	-0.2%

SOURCE: López et al. (2016).

The sample of tax returns is complemented by an additional dataset containing information on taxes withheld at source corresponding to people with no obligation to file a tax return and who do not do so, even though they would very likely obtain a refund. This dataset, known as *"no obligados, no declarantes"*, is not included in the microsimulation model and therefore this population is excluded from the simulations. In 2013 it amounted to 2.3 million persons and €2.1 billion of withholdings.

2.2 Framework of the Banco de España Personal Income Tax Microsimulation Model

2.2.1 THE SPANISH PERSONAL INCOME TAX

The model follows the personal income tax code in order to simulate the tax liabilities of each taxpayer. Many specific parameters of the tax code are left free in order to allow reforms to be simulated. When these parameters take the actual value of the tax code, the model replicates (approximately)[3] the actual tax liability data.

Figure 1 provides a simplified diagram of the tax code in 2013. Gross income subject to the tax can be of several types: labour income, capital income (both financial and real-estate) and self-employment income. Certain deductible expenses can be subtracted from gross income, including, for example, the social security contributions paid by the employee, a given amount for labour income earners, and economic expenses associated with the business activity.

Gross income net of deductible expenses is classified into two groups, which are subsequently taxed at different rates. On the one hand, "general income" comprises mainly labour income, self-employment income and some capital income. On the other hand, "savings income" includes the largest portion of capital income. To each type of income a set of deductions is applied. For example, to general income a deduction for joint filing as well as one for contributions to private pension plans, among others, can be applied. If the taxpayer is entitled to deduct an amount exceeding her general income, she can apply the remainder

3 Some small deviations between the actual data and the simulation may occur due to rare instances in which deductions exceed the maximum amount entitled by law or there exist slight discrepancies between the reported data and the result of the application of the tax code. Also, some tax benefits depend on variables that are either not observed or are only partially observed, hence some assumptions were made in order to ease the simulation. For example, siblings filing individual tax returns may be entitled to share the family allowance for parents living with the taxpayer, depending on the number of months of cohabitation, a variable that is not observed. Hence, a value of 12 months of cohabitation was assumed. Moreover, since some tax benefits depend also on previous variables of the tax code, errors may accumulate or cancel each other.

of some deductions to her savings income. Income minus deductions is the general taxable income and the savings taxable income.

Two different tax schedules are applied to each type of income, a state schedule and a regional schedule. This stems from the fact that around 50% of the personal income tax revenue is transferred to the regions, which are entitled to modify their own tax schedule and to introduce their own tax credits. In 2013, the general state schedule consisted of 7 tax bands and a top marginal rate of 30.5%. On top of this, as mentioned, the regional general tax schedule is applied. For example, that of the Madrid region comprised four tax bands and a top marginal rate of 21.4%; that of Catalonia had 6 tax bands and a top marginal tax rate of 25.5%. Madrid taxpayers therefore faced a top marginal rate of 51.9%, while taxpayers in Catalonia were subject to a top marginal tax rate of 56%.

The savings tax schedule is much less progressive. In 2013 the state part consisted of 3 bands and a top marginal rate of 16.5%, whereas the regional part consisted of 2 bands and a top rate of 10.5%. In this case, the savings regional tax schedule did not vary across regions.

Once the general income tax liabilities are computed (state and regional components), they are reduced by the family allowance (again, with state and regional variability, although in this case they are all similar). The family allowance is computed by applying the general tax schedule to an amount that depends on the characteristics of the taxpayer and her family, such as her age, number of dependent children, number of dependent parents, and disability of the taxpayer and of the dependent members of her family.

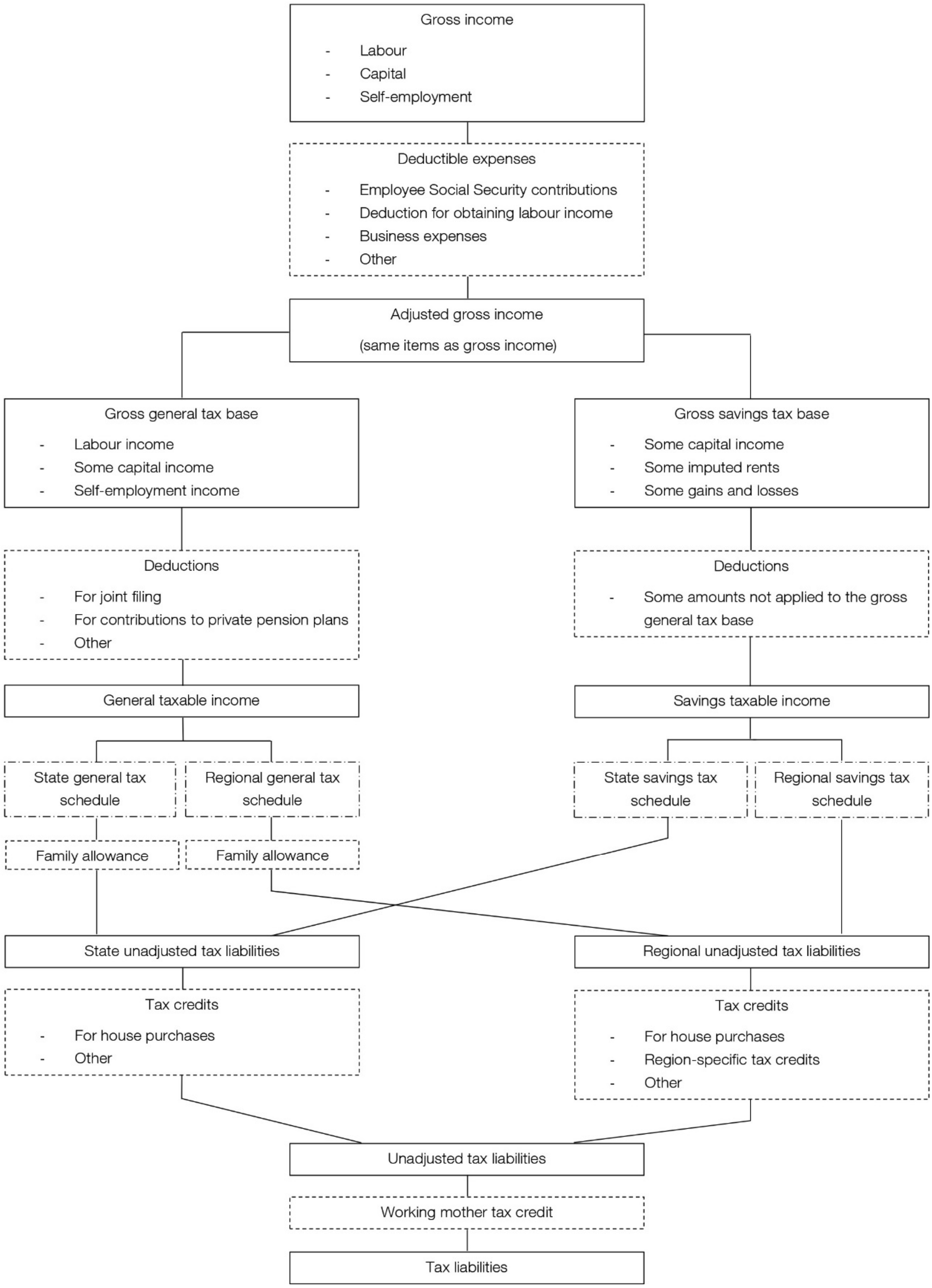
After subtracting the family allowance, the state general income and state savings income tax liabilities are pooled together. Similarly, the regional general income and regional savings income tax liabilities are added together.

To these two types of tax liabilities a set of tax credits is applied, some of which are state or region specific and some of which pertain to both. Among them are the tax credit on house purchases (if they were made before 2013), the large set of regional tax credits and a tax credit for low labour income earners. The state and regional tax liabilities net of these and the other tax credits are then pooled together.

Finally, to these pooled tax liabilities, which cannot be below zero, a refundable tax credit is applied in the case of employed mothers with children below the age of three. The final tax liabilities are obtained after the subtraction of this tax credit.

It must be noted that when running the microsimulation model, the baseline scenario (against which the reform scenario is compared) is in general the 2015 tax code. As we explain later, this forces some adjustments to be made to the data. Specifically, we update the sample weights and the income data by using information on the number of taxpayers by region and on aggregate income growth by income source, respectively. Moreover, we apply the 2015 tax code to the adjusted data. This is very relevant, because in 2015 a tax reform was implemented, involving important changes in the tax code. For example, the number of state tax bands was reduced from 7 to 5, and the state tax rates were significantly reduced. For instance, the top state marginal tax rate was reduced from 30.5% to 22.5%. Moreover, some regions changed their tax schedules. Also, the family allowance was increased and new refundable tax credits associated with family characteristics were granted. Regarding deductions, some of them were reduced, for example, the one for labour income earners and that for contributions to private pension plans. All these changes are modelled, whenever possible, in the microsimulation tool.

SIMPLIFIED DIAGRAM OF THE PERSONAL INCOME TAX CODE (2013) FIGURE 1



2.2.2 PARAMETERS

The microsimulation model considers a large set of parameters that characterise the tax code and therefore determine the computation of tax liabilities. The number of parameters incorporated in the microsimulation tool is around 1,500, including many specific to each region. Currently, the personal income tax codes of 2013, 2014 and 2015 are modelled. The simulation exercise consists in modifying this set of parameters in order to obtain the resulting tax liabilities under alternative tax codes. Some examples of possible reforms that the model can simulate are the following.

a) Switching tax benefits off and on

Almost every tax deduction and tax credit is associated with a binary parameter that determines whether it is applied or not. Therefore, the model can simulate, for example, a restriction on certain tax benefits. Furthermore, the model can simulate the conversion of some tax deductions (subtracted from the tax base) to tax credits (subtracted from the tax liabilities). Also, it allows the form of application of some tax benefits to be changed, for instance from being a fraction of a particular variable to being a fixed amount.

b) Changing the upper and lower bounds of tax benefits

The amounts of many tax benefits are restricted by fixed quantities or by a fraction of other variable(s). As long as the microsimulation includes these restrictions, it allows them to be modified. It must be stressed that the micro data already incorporate the actual restrictions, so that the model cannot simulate increases in many tax benefits. This is the case when the underlying variable giving rise to the benefit is unobserved. For example, the deduction on the amount of charity donations is capped at €500. Insofar as the total amount donated is unobserved, an increase in this tax benefit to, say, €600 cannot be simulated, since it is not possible to know for which taxpayers the actual restriction is relevant. In these cases, only a reduction (or complete elimination) of the tax benefit can be simulated.

c) Adjusting the monetary values of tax benefits

For those tax benefits that consist of a fixed monetary value or that depend on observable characteristics of the taxpayer, the model allows the value of the tax benefit to be freely adjusted. This is the case, for example, of the large set of family allowances.

d) Changing the classification of income sources

The model allows changes in the classification of some income sources between general income and savings income, or their exclusion from taxable income. This is useful in order to simulate reforms to the manner in which each type of income is taxed. For example, a change in the way in which capital (savings) income is taxed to make it the same as for labour income could be simulated.

e) Modifying the tax schedules

The model readily permits modification of the state and regional tax schedules, both for general income and savings income.

2.2.3 ADJUSTMENT OF THE DATA IN ORDER TO CONSTRUCT THE 2015 BASELINE SCENARIO

In the current version of the microsimulation model, the baseline scenario, against which the reform scenario is compared, usually corresponds to 2015. Given that the data pertain to the year 2013, this requires an update of the data. In this regard, two adjustments are carried out. First, the sample weights are adjusted by considering the changes in the number of taxpayers by region. Second, the income data are adjusted using aggregate income changes by income source. The source of these aggregate changes is the AEAT.[4] Then, in order to construct the 2015 baseline scenario, the microsimulation model with the parameters characterising the 2015 tax code is run on the adjusted micro data. Note also that a similar procedure is carried out if the baseline scenario chosen is the 2014 tax code. If the baseline is 2013, no adjustment to the data is performed.

2.2.4 THE OUTPUT OF THE MODEL

The model simulates the set of variables comprising the tax return of each sampled taxpayer in both the baseline and the reform scenarios. It then aggregates certain variables either by income decile or age group in order to perform some comparisons. Specifically, it provides information on total revenue, average tax rates, winners and losers, and several inequality measures, such as the distribution of after-tax income, Lorenz curve, Gini coefficient and some percentile ratios. A standard output from the model can be observed in the example presented in Section 2.3. The program also allows the simulated micro dataset to be saved, so that further analysis can be performed.

2.2.5 THE ACCURACY OF THE MODEL

In this section we compare some aggregates produced by the microsimulation model for the tax legislation of 2013, 2014 and 2015 with the corresponding aggregates reported by the Spanish Tax Agency (AEAT). Note that for 2014 and 2015 the data have been updated as described above. The results are reported in Table 2.[5]

As can be seen, for each single item the sample aggregate is very close to the population aggregate, the largest deviation being only 0.8%. This suggests that the model yields an accurate description of overall income and tax liabilities.

SAMPLE AGGREGATES FROM THE MICROSIMULATION MODEL COMPARED WITH POPULATION AGGREGATES **TABLE 2**

€bn	Model			AEAT			Difference (%)		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of tax-payers (million)	19.2	19.3	19.5	19.2	19.4	19.5	-0.1	-0.1	-0.1
Income ("Rendimientos")	421.4	428.2	447.0	421.8	428.6	447.0	-0.1	-0.1	0.0
Tax Base ("Base Liquidable")	351.8	358.0	375.7	352.2	357.2	375.3	-0.1	0.2	0.1
Tax Liabilities before Tax Credits ("Cuota Íntegra")	72.0	73.5	71.0	72.1	73.2	71.0	-0.1	0.4	0.0
Tax Liabilities before Refundable Tax Credits ("Cuota Resultante de la Autoliquidación")	67.0	68.5	66.9	67.1	68.4	67.0	-0.2	0.0	-0.2
Tax Liabilities after Refundable Tax Credits	66.2	67.7	65.1	66.4	67.7	65.6	-0.2	0.0	-0.8

SOURCE: BdE PIT Microsimulation Model.

4 *Estadísticas de los declarantes del Impuesto sobre la Renta de las Personas Físicas* (IRPF).

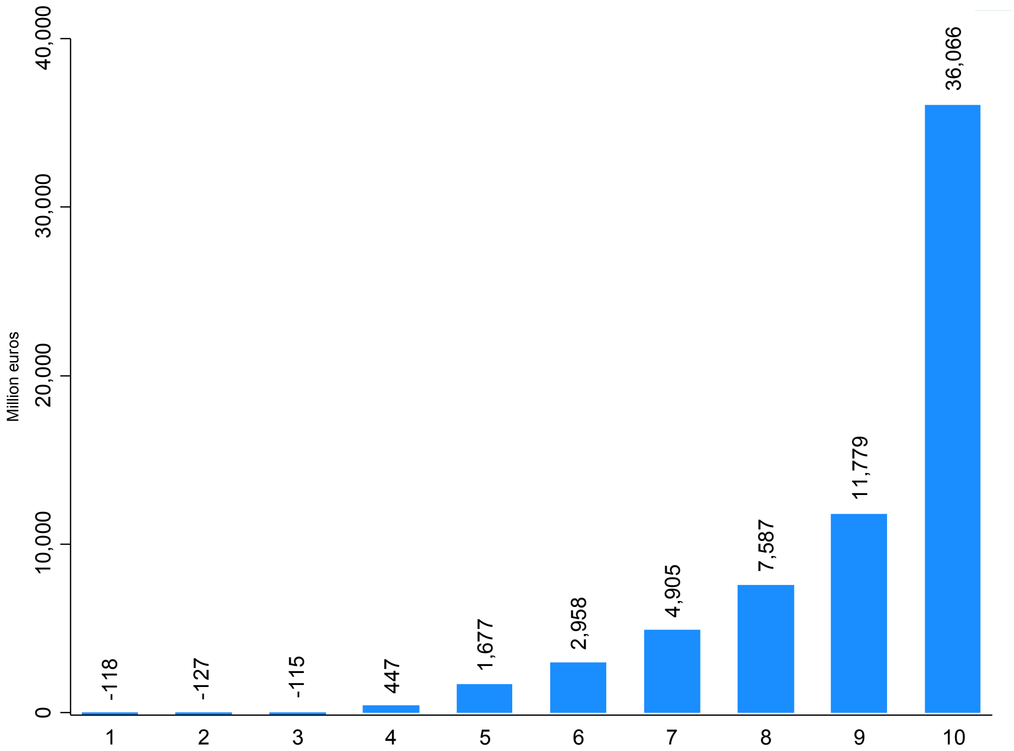
5 Table 2 does not include the withholdings from persons under no obligation to file a tax return and who decide not to do so.

2.2.6 BASELINE RESULTS: PERSONAL INCOME TAX REVENUES AND THE DISTRIBUTION OF TAX LIABILITIES UNDER THE 2015 LEGISLATION

This section presents an overview of the distribution of revenue and average effective tax rates across income deciles, as simulated by the model under the 2015 legislation.

Figure 2 shows the distribution of the PIT revenue by income decile. Total revenue, amounting to €65.1 billion, is very unevenly distributed, as expected from a progressive tax. The first three deciles barely contribute to tax revenue, while the top 10% accounts for more than half of it.

PIT REVENUE BY INCOME DECILE (2015) **FIGURE 2**

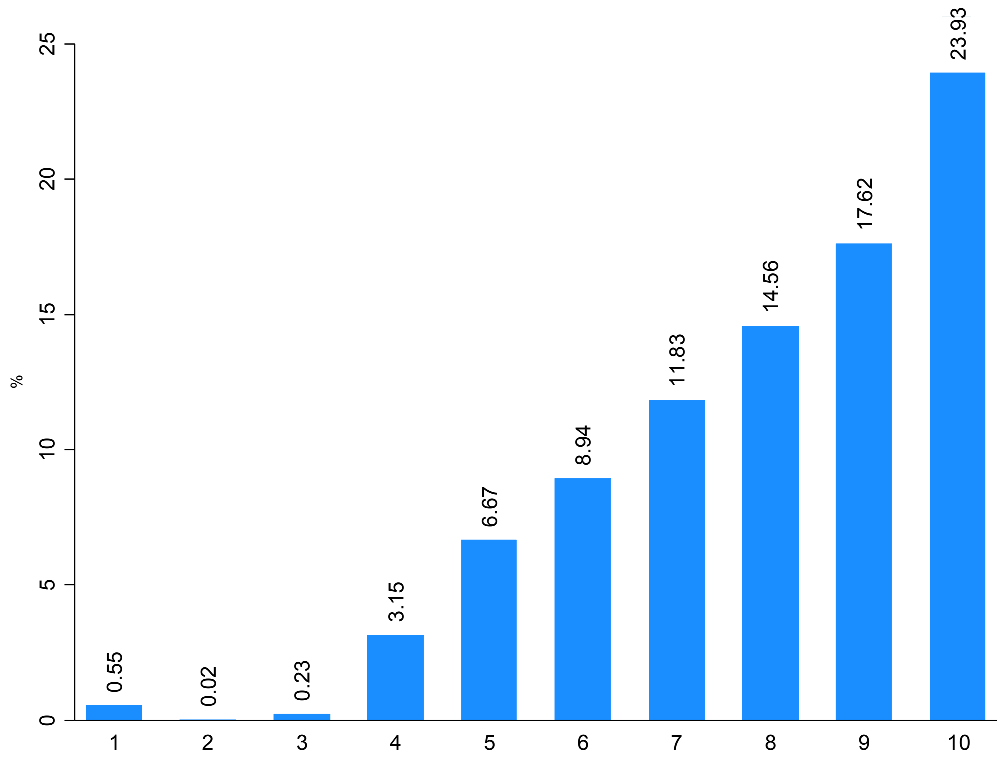


SOURCE: BdE PIT Microsimulation Model.

Figure 3 displays the average effective tax rates by income decile, that is, the ratio of tax liabilities minus tax credits to gross income net of some deductions (base imponible). We use this variable in the denominator because we do not observe gross income from some income sources, such as self-employment income. Also, note that taxpayers whose tax liabilities are negative are assigned a zero tax rate. As can be observed, the mean average effective tax rates increase with income.[6] The bottom 30% of taxpayers face rates of virtually 0%, while tax rates for the well-off are around 24%, on average.

6 Average tax rates in respect of (observed) gross income are, on average, around two percentage points higher for deciles 4 to 10 and 0.1 percentage points higher for deciles 1 to 3.

MEAN AVERAGE EFFECTIVE TAX RATE BY INCOME DECILE (2015) FIGURE 3



SOURCE: BdE PIT Microsimulation Model.

2.3 Simulation example

In this section, we illustrate the outcome produced by the BdE PIT Microsimulation Tool by simulating a hypothetical reform that should not be considered to be proposed by the Banco de España. This consists of converting the tax benefit stemming from contributions to private pension plans from a tax deduction (subtracted from the tax base, the current situation or baseline scenario) to a (non-refundable) tax credit (subtracted from tax liabilities, the reform scenario).

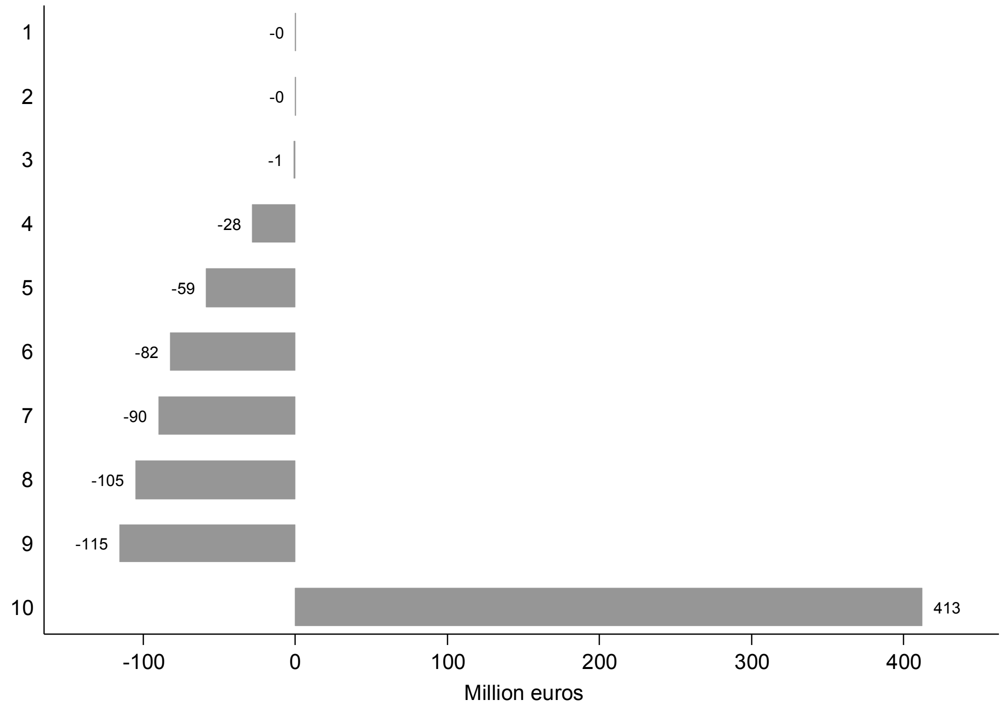
Under the 2015 legislation, the contributions made by taxpayers to private pension plans could be deducted from the tax base, with limits set at €8,000 or €2,500 when the plan's beneficiary is herself or her spouse, respectively. The reform we simulate, instead applies this tax benefit directly to tax liabilities, which cannot turn negative as a result (non-refundable tax credit). We set the amount of the tax credit in order to roughly generate a revenue-neutral reform. Specifically, the maximum amounts are set at €600 for contributions to own pension plans and €300 for contributions to a spouse's pension plan.

As a result of this hypothetical reform, set out for the purposes of illustration, we estimate that total revenue would decrease by €68 million, the well-off being the hardest-hit on aggregate (see Figure 4).[7] The aggregate tax liabilities of the bottom 30% would hardly change, since the incidence of this tax benefit on this part of the income distribution is very low. The tax revenue raised from deciles 4 to 9 would decrease by around €480 million, which would be partially offset by an increase in the tax raised from the top decile.

7 Note that this reform does not affect withholdings. Policy actions that do change them would entail an additional change in revenue from individuals whose income is withheld at source but who do not file a tax return.

Figure 5 shows the percentage of winners and losers by income decile, while Table 3 summarises the quantitative effects of the reform. From deciles 4 to 9 almost all taxpayers are better off, while in the top decile those affected by the reform are roughly evenly split between winners and losers. Note that winners are those whose tax liabilities decrease as a result of the tax change, while losers are those whose tax liabilities increase.[8] On average, winners in deciles 5 to 10 pay around €300 less in taxes while losers in the top decile face an increase of around €1,500 in tax liabilities.

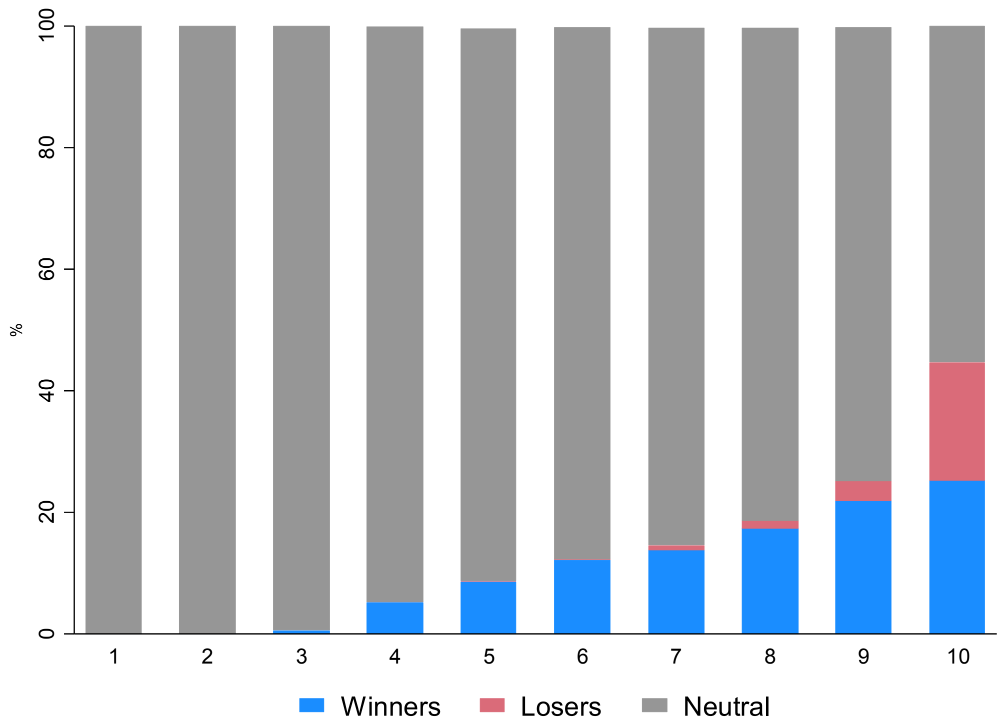
REVENUE CHANGE BY INCOME DECILE FIGURE 4



SOURCE: BdE PIT Microsimulation Model

8 Tax increases and decreases are defined to occur when tax liabilities change by more than €1 or 0.001%.

PERCENTAGE OF WINNERS AND LOSERS BY INCOME DECILE FIGURE 5



SOURCE: BdE PIT Microsimulation Model.

Table 3 presents the numbers behind Figure 5, including the number of individuals in each category for each income decile, as well as the total and average revenue change within each category and decile.

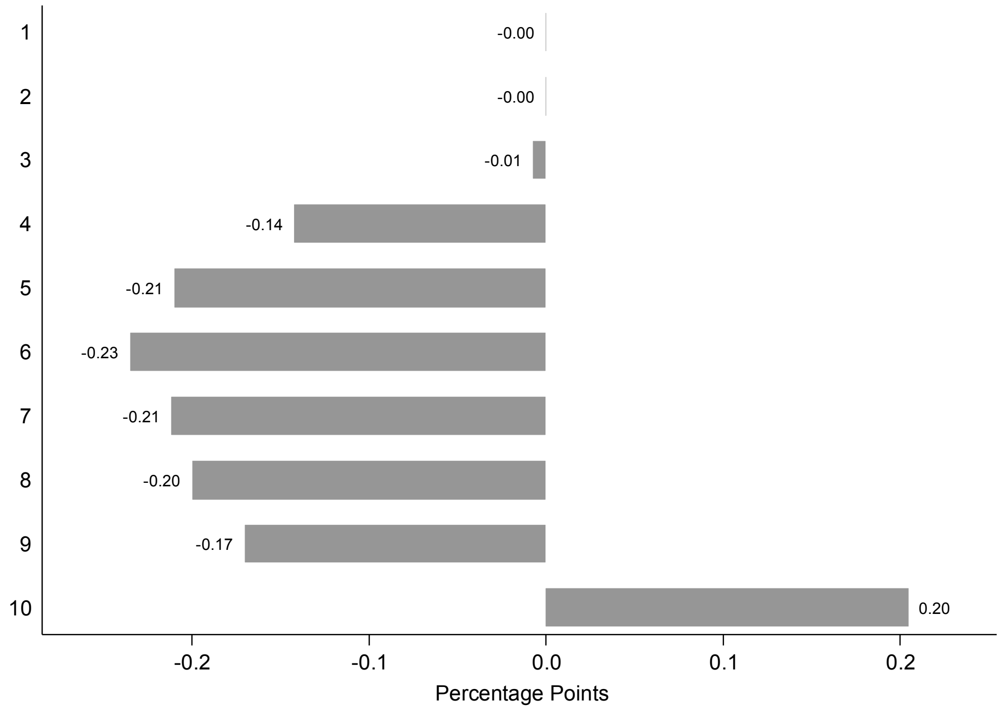
WINNERS AND LOSERS TABLE 3

	Total			Winners			Losers			Neutral	
Deciles	Population	Gain (+) or loss (-)	Avg. gain or loss	Number	%	Avg. gain	Number	%	Avg loss	Number	%
	millions	million €	€	millions		€	millions		€	millions	
1	1.9	0	0.0	0.0	0.0	546.9	0.0	0.0	0.0	1.9	100.0
2	1.9	0	0.0	0.0	0.0	463.9	0.0	0.0	0.0	1.9	100.0
3	1.9	1	0.5	0.0	0.5	89.8	0.0	0.0	0.0	1.9	99.5
4	1.9	28	14.5	0.1	5.3	275.1	0.0	0.0	119.6	1.8	94.6
5	1.9	59	30.1	0.2	8.9	338.7	0.0	0.1	148.5	1.8	91.0
6	1.9	82	42.3	0.2	12.3	346.9	0.0	0.3	160.0	1.7	87.4
7	1.9	90	46.2	0.3	14.1	343.7	0.0	0.7	357.8	1.7	85.2
8	1.9	105	54.0	0.3	17.6	339.9	0.0	1.3	473.3	1.6	81.1
9	1.9	115	59.3	0.4	22.1	339.8	0.1	3.3	483.7	1.5	74.6
10	1.9	-413	-212.2	0.5	25.3	320.0	0.4	19.5	1,506.7	1.1	55.3
Total	19.5	68	3.5	2.1	10.6	333.8	0.5	2.5	1,266.9	16.9	86.9

SOURCE: BdE PIT Microsimulation Model.

Figure 6 shows the change in the (mean) average tax rate by income decile. The top decile experiences a 0.2 percentage point increase in average tax rates, while the 8th decile undergoes a similar effect of the opposite sign. The average tax rates of deciles 5 to 7 diminish by slightly more than 0.2 percentage points.

CHANGE IN THE EFFECTIVE AVERAGE TAX RATE BY INCOME DECILE FIGURE 6



SOURCE: BdE PIT Microsimulation Model.

Table 4 shows different measures of inequality of after-tax income before and after the reform. Since the worse-off are concentrated in the well-off group, the Gini coefficient slightly decreases. However, most of the other inequality indices increase, especially the 50/10 and the 75/25 ratios, since there is a non-negligible amount of winners concentrated in the middle of the income distribution. It is worth noting nevertheless that the changes in the inequality indices are rather small.[9]

9 The model produces additional outputs, such as histograms of after-tax income and Lorenz curves. Moreover, it allows the effects of the reform to be simulated by age group, rather than by income decile. These outputs are not presented for space considerations.

MEASURES OF INEQUALITY OF AFTER-TAX INCOME **TABLE 4**

Indices	Pre-Reform	Post-Reform	Change (pp)
90/10	6.3	6.3	0.0014
90/50	2.1	2.1	-0.0034
50/10	3.1	3.1	0.0057
75/25	2.4	2.5	0.0039
75/50	1.5	1.5	0.0001
50/25	1.6	1.6	0.0025
Gini	0.38	0.38	-0.0007

SOURCE: BdE PIT Microsimulation Model.

3 The Banco de España Indirect Tax Microsimulation Model

This section introduces the microsimulation tool that calculates the Spanish VAT and excise duties *(IVA and impuestos especiales)*. The tool allows for changes in VAT on up to 119 different non-durable goods and for changes in the excise duties levied on four goods. These reforms can be implemented jointly, which is especially useful, since, in the case of goods subject to both VAT and excise duties, these taxes interact with each other. The tool allows for morning-after effects of reforms, but it can also simulate hypothetical reforms taking into account households' behavioural reaction to price changes, given a level of expenditure on non-durable goods, through the parameters estimated for a complete demand system.

3.1 The data

The main data used for this microsimulation tool are obtained from the Spanish Household Expenditure Survey *(Encuesta de Presupuestos Familiares, EPF).* The sample contains 22,000 households per year with information on household expenditure for 255 commodities, accounting for 78% of the expenditure according to the National Accounts in 2015. The dataset also includes a large set of socio-demographic variables. The month in which the survey was answered can be observed,[10] which allows the expenditure of each household to be linked to the monthly prices for a particular commodity. The interviews of households are uniformly distributed across each year.

In particular, the most recent wave of the survey is used for simulation purposes (2015), and the pooled cross-sectional sample of the years 2006-2015 is used to estimate the coefficients of the demand system. The sample contains a total of 217,000 observations. The aggregation of goods into expenditure groups for the demand system is mainly driven by heterogeneity among goods but also by the structure of Spanish indirect taxation. Each good subject to excise duties is maintained as a separate group in the system (with the exception of electricity) but is estimated jointly with the other groups of goods.

The second dataset used is the Spanish Consumer Price Index *(Índice de Precios del Consumo, IPC)* containing monthly time series of price indices at national and regional level.

For the estimation of the demand system, monthly price indices by region *(comunidad autónoma)* are used to obtain as much variation in prices as possible. In this case, the prices are disaggregated into 37 goods, which are then aggregated into the 13 expenditure groups of the demand system (described below). Official price indices assume a common consumption basket across regions and therefore take the same value in the base year (2005). To correct for this, a factor is applied to account for differences in price levels across regions, using the estimations of Costa et al. (2015) for 2012. Hence, there are 17 x 10 x 12 (regions x years x months) different prices for each commodity (i.e. 2,040).

For the simulation, the 2015 price index at national level is used, which offers a greater disaggregation, into 119 prices.[11] These are the goods for which the microsimulator can simulate changes in tax rates (VAT and excise duties if applicable).

10 This information was obtained under a special request to the Spanish Statistical Office (www.ine.es).

11 The initial disaggregation has 126 goods but some of them are combined due to interruptions and changes in the series.

3.2 Framework of the Banco de España Indirect Taxation Microsimulation Model

The indirect taxation microsimulation model calculates the VAT and excise duties paid by each household. It allows for the behavioural reactions of households to changes in prices arising from taxation. Therefore, in addition to first-round or morning-after effects (changes in prices and tax revenue resulting from changes in taxes keeping each household's expenditure constant for each commodity) we can estimate second-round effects arising from demand adjustments. This adjustment is allowed in the form of substitution between commodities, subject to a constant total level of consumption of non-durable goods. The model can therefore be used for analyses such as running a simulation using the current VAT and excise duty legislation to predict tax liabilities and revenues, making comparisons with hypothetical reforms of the tax legislation (VAT or excise duty rates), and calculating welfare changes.

3.2.1 THE VALUE ADDED TAX AND EXCISE DUTIES

VAT is basically a tax on consumption expenditure. All sales are taxed, but registered traders are allowed to deduct the tax charged on their inputs, so that the tax is effectively levied on the value added at each stage of the production process. The only VAT that cannot be reclaimed is that charged to the final purchaser and, therefore, only final consumption is taxed. Producers can assume part of the increase in prices arising from a tax reform and this can be accounted for in the simulations. A complete pass-through is usually assumed, except when the aim is to obtain the short-run effects of reforms. In any case, the sensitivity of simulations to different rates of pass-through can also be analysed.

Given the way in which VAT functions, the microsimulation model calculates households' tax liabilities for each good consumed before and after a reform. To simulate tax reforms, the tax rates under the current legislation are deducted from the prices, and then the new tax rates are added to obtain new prices. The demand system uses these new prices to predict new shares of consumption of the different goods, allowing for substitution between non-durable goods subject to a given total level of expenditure. As a result, the tax liabilities paid by each household after the reform are obtained, having accounted for behavioural responses to price changes.

3.2.2 PARAMETERS

Three types of parameters are used. First, the VAT tax rates that apply to each of the 119 goods of the national price index disaggregation. Second, 19 parameters that define the different excise duties applied to the four goods subject to excise duties. Finally, the model uses the behavioural parameters estimated by the demand system, explained in Section 3.2.3.

VAT Parameters

The VAT parameters for the 2015 legislation can take four different values, corresponding to the four different tax rates existing: exempt (0%), super-reduced (4%), reduced (10%), and standard (21%). A list of the 119 goods considered in the microsimulator and their corresponding VAT tax rate in 2015 is shown in Table 5.[12] These are the goods for which we can simulate a reform of the VAT rate.

12 For groups of goods taxed at different tax rates, a weighted average has been calculated using the price weights from the IPC.

DISAGGREGATION OF GOODS CONSIDERED IN THE MICROSIMULATOR AND THEIR VAT RATES IN 2015 — TABLE 5

Good	VAT	Good	VAT	Good	VAT	Good	VAT
Arroz	10	Alimentos para bebé	10	Aparatos de calefacción y de aire acondicionado	21	Soporte para el registro de imagen y sonido	21
Pan	4	Café, cacao e infusiones	10	Otros electrodomésticos	21	Juegos y juguetes	21
Pasta alimenticia	10	Agua mineral, refrescos y zumos	10	Reparación de electrodomésticos	21	Grandes equipos deportivos	21
Pastelería, bollería y masas cocinadas	10	Espirituosos y licores	21	Cristalería, vajilla y cubertería	21	Otros artículos recreativos y deportivos	21
Harinas y cereales	4	Vinos	21	Otros utensilios de cocina y menaje	21	Floristería y mascotas	15.5
Carne de vacuno	10	Cerveza	21	Herramientas y accesorios para casa y jardín	21	Servicios recreativos y deportivos	21
Carne de porcino	10	Tabaco	21	Artículos de limpieza para el hogar	21	Servicios culturales	21
Carne de ovino	10	Prendas exteriores de hombre	21	Otros artículos no duraderos para el hogar	21	Libros de entretenimiento y de texto	4
Carne de ave	10	Prendas interiores de hombre	21	Servicio doméstico y otros servicios para el hogar	21	Prensa y revistas	4
Charcutería	10	Prendas exteriores de mujer	21	Medicamentos y otros productos farmacéuticos	4	Material de papelería	21
Preparados de carne	10	Prendas interiores de mujer	21	Material terapéutico	21	Viaje organizado	10
Otras carnes y casquería	10	Prendas de vestir de niño y bebé	21	Servicios médicos y paramédicos no hospitalarios	21	Educación Infantil	0
Pescado	10	Complementos y reparación y limpieza de prendas de vestir	21	Servicios dentales	0	Enseñanza obligatoria	0
Crustáceos y moluscos	10	Calzado de hombre	21	Servicios hospitalarios	0	Bachillerato	0
Pescado en conserva y preparados	10	Calzado de mujer	21	Automóviles	21	Enseñanza superior	0
Leche	4	Calzado de niño y bebé	21	Otros vehículos	21	Otras enseñanzas	0
Otros productos lácteos	10	Reparación de calzado	21	Repuestos y accesorios de mantenimiento	21	Restaurantes, bares y cafeterías y Cantinas	10
Quesos	4	Alquiler de vivienda	0	Carburantes y lubricantes	21	Hoteles y otros alojamientos	10
Huevos	4	Materiales para la conservación de la vivienda	10	Servicios de mantenimiento y reparaciones	21	Servicios para el cuidado personal	21
Mantequilla y margarina	10	Servicios para la conservación de la vivienda	10	Otros servicios relativos a los vehículos	21	Artículos para el cuidado personal	21
Aceites	10	Distribución de agua	10	Transporte por ferrocarril	10	Joyería, bisutería y relojería	21
Frutas frescas	4	Recogida de basuras, alcantarillado y otros	10	Transporte por carretera	10	Otros artículos de uso personal	21
Frutas en conserva y frutos secos	10	Electricidad	21	Transporte aéreo	10	Servicios sociales	0
Legumbres y hortalizas frescas	4	Gas	21	Otros servicios de transporte	10	Seguros para la vivienda	0
Legumbres y hortalizas secas	4	Otros combustibles	21	Servicios postales	0	Seguros médicos	0
Legumbres y hortalizas congeladas y en conserva	4	Muebles	21	Equipos telefónicos	21	Seguros de automóvil	0
Patatas y sus preparados	4	Otros enseres	21	Servicios telefónicos	21	Otros seguros	0
Azúcar	10	Artículos textiles para el hogar	21	Equipos de imagen y sonido	21	Servicios financieros	0
Chocolates y confituras	10	Frigoríficos, lavadoras y lavavajillas	21	Equipos fotográficos y cinematográficos	21	Otros servicios	21
Otros productos alimenticios	10	Cocinas y hornos	21	Equipos informáticos	21		

Notice that these tax rates are the result of combining the different tax rates applicable to each good contained in each category.
SOURCE: Banco de España.

Table 6 shows the evolution of VAT rates in Spain from 1986. It shows that every tax reform implemented from 1986 onwards increased VAT, with the sole exception of the one introduced in 1993.

EVOLUTION OF VAT RATES IN SPAIN — TABLE 6

Dates	Reduced Rate	Standard Rate
01/01/1986	6	12
01/01/1992	6	13
01/08/1992	6	15
01/01/1993	3 | 6	15
01/01/1995	4 | 7	16
01/07/2010	4 | 8	18
01/09/2012	4 | 10	21

SOURCE: European Commission.

Table 7 compares the VAT tax rates across the EU countries. VAT rate structures vary widely within the EU. Most countries do not have a super-reduced rate (that is, a rate below 5%), however many of them have two reduced tax rates.[13]

VAT TAX RATES BY COUNTRY — TABLE 7

Member State	Code	Super-reduced rate	Reduced rate	Standard rate
Belgium	BE	-	6 / 12	21
Bulgaria	BG	-	9	20
Czech Republic	CZ	-	10 / 15	21
Denmark	DK	-	-	25
Germany	DE	-	7	19
Estonia	EE	-	9	20
Ireland	IE	4.8	9 / 13,5	23
Greece	EL	-	6 / 13	24
Spain	ES	4	10	21
France	FR	2.1	5,5 / 10	20
Croatia	HR	-	5 / 13	25
Italy	IT	4	5 / 10	22
Cyprus	CY	-	5 / 9	19
Latvia	LV	-	12	21
Lithuania	LT	-	5 / 9	21
Luxembourg	LU	3	8	17
Hungary	HU	-	5 / 18	27
Malta	MT	-	5 / 7	18
Netherlands	NL	-	6	21
Austria	AT	-	10 / 13	20
Poland	PL	-	5 / 8	23
Portugal	PT	-	6 / 13	23
Romania	RO	-	5 / 9	20
Slovenia	SI	-	9.5	22
Slovakia	SK	-	10	20
Finland	FI	-	10 /14	24
Sweden	SE	-	6 / 12	25
United Kingdom	UK	-	5	20

SOURCE: European Commission.

13 9% of the total consumption of the EPF derives from goods taxed at the super-reduced rate, 31.5% at the reduce rate, 49.2% at the standard rate and 10.4% are exempt.

Excise Duty Parameters

The excise duty legislation applies different taxes to each commodity. In particular, calculation of the after-tax prices requires different types of taxes to be taken into account. Ad valorem tax rates, like VAT tax rates, are charged as a percentage of the price. Ad quantum taxes, in contrast, are calculated on the basis of the quantities of the good (according to the number of cigarettes, litres of alcohol, etc.). Other excise duties considered are the *Recargo de Equivalencia* (a percentage rate added to the VAT rate) and *Comisión de Estanco* (a retail mark-up determined by law). The excise duties charged on each good considered are detailed in Table 8.

SUMMARY OF GOODS SUBJECT TO EXCISE DUTIES **TABLE 8**

<table>
<tr><th>Expenditure groups</th><th>Commodities included</th><th>Taxes</th><th>Value</th><th>Nominal market price (a)</th></tr>
<tr><td rowspan="12">Tobacco</td><td rowspan="4">Cigarettes</td><td>Ad valorem (%)</td><td>0.51</td><td rowspan="12">€4.49</td></tr>
<tr><td>Ad quantum (€ per 20 cigarettes)</td><td>0.482</td></tr>
<tr><td>Recargo de equivalencia (%)</td><td>0.0175</td></tr>
<tr><td>Comisión Estanco (€)</td><td>0.09</td></tr>
<tr><td rowspan="4">Fine-cut</td><td>Ad valorem (%)</td><td>0.415</td></tr>
<tr><td>Ad quantum
(€ per 20 standardised cigarettes)</td><td>0.44</td></tr>
<tr><td>Recargo de equivalencia (%)</td><td>0.0175</td></tr>
<tr><td>Comisión Estanco (€)</td><td>0.085</td></tr>
<tr><td rowspan="4">Others</td><td>Ad valorem (%)</td><td>0.415</td></tr>
<tr><td>Ad quantum
(€ per 20 standardised cigarettes)</td><td>0.44</td></tr>
<tr><td>Recargo de equivalencia (%)</td><td>0.0175</td></tr>
<tr><td>Comisión Estanco (€)</td><td>0.085</td></tr>
<tr><td rowspan="2">Alcohol</td><td>Spirits</td><td>Ad quantum
(€ per litre of pure alcohol)</td><td>9.13</td><td>€12.29</td></tr>
<tr><td>Beer</td><td>Ad quantum (€ per litre of beer)</td><td>0.09</td><td>€1.81</td></tr>
<tr><td rowspan="4">Vehicle fuels</td><td rowspan="2">Petrol</td><td>Estatal general
(ad quantum, cents per litre)</td><td>40.069</td><td rowspan="2">€122.83</td></tr>
<tr><td>Estatal especial
+ Autonómico especial
(ad quantum, cents per litre)</td><td>6.16</td></tr>
<tr><td rowspan="2">Diesel</td><td>Estatal general
(ad quantum, cents per liter)</td><td>30.7</td><td rowspan="2">€111.44</td></tr>
<tr><td>Estatal especial
+ Autonómico especial
(ad quantum, cents per litre)</td><td>6.27</td></tr>
<tr><td>Electricity</td><td>Electricity</td><td>Ad valorem (%)</td><td>5.11269632</td><td>€0.1526</td></tr>
</table>

SOURCE: Own calculations, based on Official State Gazette (BOE) and (a) AEAT annual report.

Because the price information is given in terms of price indices, for the simulation of ad quantum taxes the average market price of the good concerned is needed as a starting point. These prices are taken from the AEAT annual report, which reports average nominal prices for each group of goods considered in this paper, as shown in the last column of Table 8. Then, all the taxes are deducted from these market prices in order to obtain before-tax prices. Finally, we calculate the new after-tax prices using the post-reform tax parameters. This procedure allows us to calculate the percentage difference between before-tax and after-tax market prices and to extrapolate it to the price index of the corresponding good.

Each group of goods subject to excise duties has its own specific features. Tobacco is broken down into cigarettes *(cigarrillos)*, fine-cut tobacco *(picadura)* and other tobacco *(puros, cigarritos …)*. The formula to calculate the after-tax price is the same for all three goods:

$$p = \frac{(e+q)*(1+i+req)}{1-a*(1+i+req)-c}$$

where p is the after-tax price, q is the before-tax price (the net-of-tax price), a is the ad valorem tax rate, e is the ad quantum tax rate, req is the *Recargo de Equivalencia*, c is the *Comisión de Estanco*, and i is the VAT tax rate. The values of the excise duties, however, are different for the three goods, therefore there are a total of 12 excise duty parameters that can be changed in a simulation.

Excise duties on alcohol also differ according to the product, with spirits and beer taxed at different rates.[14] The formula to apply these taxes is the same for both goods:

$$p = (q + e * sh) * (1+i)$$

where p is the after-tax price, q is the before-tax price (the net-of-tax price), e is the ad quantum tax rate per litre, sh is the share of pure alcohol per litre of spirit (on average), and i is the VAT tax rate.

For vehicle fuels, we distinguish between diesel (*gasóleo*) and petrol (*gasolina*), which again are subject to different excise duties, but according to the same formula:

$$p = (q + eg + ee + ae) * (1+i)$$

where p is the after-tax price, q is the before-tax price, eg is the State general tax rate, ee is the State specific tax rate, ae is the regional specific tax rate, and i is the VAT tax rate. We consider the two specific tax rates (ee and ae) together, as reported by the AEAT.

For electricity, in addition to the VAT, i, there is only one excise duty, the ad valorem tax, a, which is applied to the price using the formula:[15]

$$p = q * (1+a) * (1+i)$$

14 Wine is not subject to any excise duties, but only to VAT at the regular rate of 21%.

15 The law provides for a minimum tax rate of 5.11%, but in most cases the tax rate resulting from the application of the formula below is higher.

3.2.3 THE DEMAND SYSTEM: BEHAVIOUR IN THE BANCO DE ESPAÑA INDIRECT TAXATION MICROSIMULATION MODEL

For the estimation of the behavioural parameters, we aggregate expenditure on the 255 goods of the EPF into 13 groups of non-durable expenditure. We define a 14th group containing durable expenditures, which is not included in the estimation of the demand system, but for which total revenues are calculated. We try to group goods taking into account separability conditions but also differences in their tax treatment. Goods subject to excise duties (underlined below) are also included in the demand system. Notice that wine is not subject to excise duties and electricity is included in the domestic utilities group because it has a share that is too small for it to constitute a group on its own. The groups are:

1. Food and beverages: fresh and processed food and non-alcoholic drinks
2. Alcoholic drinks: spirits, beer and wine
3. Tobacco: cigarettes, fine-cut and others
4. Clothing and footwear: including repairs
5. Domestic utilities: water, electricity, gas, refuse collection
6. Household non-durables: including domestic services
7. Health: pharmaceutical products, dental and private medical services
8. Vehicle fuels: *petrol and diesel*
9. Transport: trains, buses, planes, taxis and related services
10. Communications: postal services and telephone services
11. Leisure and culture: cultural services, books, newspapers and package holidays
12. Hotels and restaurants: restaurants, hotels and other housing services
13. Other non-durables: personal care products and services, insurance and other
14. Durables: furniture and home appliances, cars, electronic equipment, private education services and jewellery

The demand system consists of a set of 13 non-durable goods demand equations, which are estimated jointly. We use the Quadratic Almost Ideal Demand System (QUAIDS) introduced by Banks, Blundell, and Lewbel (1997) as an extension of the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980). This is a useful demand system to evaluate the welfare impact of tax reforms. The reason is that it allows the share of each good in total expenditure to vary in a flexible way with respect to income and prices. In the case of income, the good could be a luxury (elasticity greater than 1) at one level of expenditure and a necessity (elasticity smaller than 1) at another level of expenditure. The model assumes that the utility obtained from the consumption of any good is not affected by the labour supply of any member of the household, except insofar as the estimated equations for each good can be made conditional on labour supply variables.

Some goods have a high rate of zeroes because they are not consumed by the households (not due to infrequency of purchase). For these we use a two-stage estimation strategy. First, we estimate probit models for tobacco and domestic utilities as in equation (1).

$$I_{it}^{h} = \delta' Z_t^h + \varepsilon_t^h \tag{1}$$

where h denotes household, i is a subscript for goods ($i = 1, \dots, N$), t for time ($t = 1, \dots, T$) and Z is a vector of socio-demographic variables. Then, we obtain the Mill's inverse probability ratios according to expressions (2) for consumers of good i (i = tobacco, vehicle fuels) and (3) for non-consumers:

$$IMR_{it}^{h} = \frac{\phi(\delta' Z_t^h)}{1-\Phi(\delta' Z_t^h)} \quad (2)$$

$$NIMR_{it}^{h} = \frac{-\phi(\delta' Z_t^h)}{\Phi(\delta' Z_t^h)} \quad (3)$$

The QUAIDS is estimated in the second stage, including the inverse Mill's ratios as regressors in all the equations. The demand system is based on the indirect utility function presented in (4):

$$lnV^h = \left[\left(\frac{lnx^h - lba(p)}{b(p)}\right)^{-1} + \lambda(p)\right]^{-1} \quad (4)$$

where $a(p)$, $b(p)$ and $\lambda(p)$ are price indices defined as:

$$lna(p) = \alpha_0 + \sum_{i=1}^{N} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} lnp_i lnp_j \quad (5)$$

$$b(p) = \prod_{i=1}^{N} p_i^{\beta_i} \quad (6)$$

$$ln\lambda(p) = \sum_{i=1}^{N} \lambda_i \mathrm{ln} p_i \quad (7)$$

where j and i both denote number of goods ($i, j = 1, \dots, N$). Maximising (4) subject to the budget constraint, we can express the share of expenditure on each good i, for each household h, in each period t, as:

$$w_{it}^h = \alpha_i + \beta_i ln\left(\frac{x^h}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left[ln\left(\frac{x^h}{a(p)}\right)\right]^2 + \sum_{i=1}^{N} \gamma_{ij} lnp_j \quad (8)$$

We define $\alpha_i = \alpha_i(X_t^h)$ as a function of a vector X_t^h containing a constant, socio-demographic variables (Z_t^h) and the inverse Mill's ratio calculated in the first stage. In fact, this involves modifying equation (5) accordingly, so that its inclusion gives rise to new adding-up conditions that will be taken into account at the estimation stage. The resulting equation is:

$$lna(p) = \alpha_0 + \sum_{i=1}^{N} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} lnp_i lnp_j \quad (9)$$

To perform welfare analysis, we require the resulting demands to be consistent with utility maximisation, thus satisfying theoretical adding-up, homogeneity, symmetry and negativity restrictions. Adding-up is satisfied leaving aside one of the equations in the estimation and homogeneity and symmetry are imposed at the estimation stage. Negativity cannot be imposed but it can be tested for by looking at the Slustky matrix. All these theoretical conditions limply the following linear restrictions on the parameters of the model:

Adding up: $\sum_{i=1}^{N} \alpha_i = 1$; $\sum_{i=1}^{N} \beta_i = 0$; $\sum_{i=1}^{N} \gamma_{ij} = 0$ for all *j*; $\sum_{i=1}^{N} \lambda_i = 0$

Homogeneity: $\sum_{j=1}^{N} \gamma_{ij} = 0$ for all i

Symmetry: $\gamma_{ij} = \gamma_{ji}$

Once the model is estimated, we use the results to evaluate the impact of price changes (following a tax reform) on consumer welfare. We do so using the associated expenditure functions of the QUAIDS. We calculate the compensating variation CV. CV is defined as the change in income a household would require to be indifferent between the original prices and the new prices. So, if $E(.)$ is the expenditure function associated with the model, the CV for household h is:

$$CV^h = E(u^{h*}, p^1) - E(u^{h*}, p^0) \tag{10}$$

u^{h*} is the original value of utility for household h, p^0 is the price vector pre-reform and p^1 is the new price vector following the reform.

The results of the QUAIDS are summarised in the elasticities shown in Table 9 (shares of expenditure, income and uncompensated own-price elasticities) and Table 10 (cross-price elasticities). The income elasticities obtained are close to the results found in the literature using Spanish data (Labeaga and López (1996), Labeaga and Puig (2003) or Christensen (2014)) and even internationally (Banks, Blundell, and Lewbel (1997)). As expected, all income elasticities are positive, and those for necessity goods such as food, domestic utilities and communications have lower values, while those for leisure, household non-durables, and health have the highest values. Food, tobacco, domestic utilities and communications are necessities while clothing and footwear, household non-durables, health, leisure and culture, hotels and restaurants and other non-durables are luxury goods. We cannot reject a unitary elasticity for alcoholic drinks, vehicle fuels and transport. The result for health can be explained because the survey only collects information on private expenditure on this good. Uncompensated own-price elasticities are all negative at average values of the variables, as expected. The most elastic goods are leisure and culture, household non-durables, transport and clothing and footwear, while food and beverages at home are not sensitive to price changes.

OBSERVED (2015) AND PREDICTED SHARES, INCOME AND OWN-PRICE ELASTICITIES **TABLE 9**

	Observed shares	Predicted shares	Income elasticity	Uncompensated own-price elasticity
1. Food and beverages	0.2775	0.2766	0.715***	-0.109
2. Alcoholic drinks	0.0106	0.0114	1.010***	-0.993***
3. Tobacco	0.0219	0.0221	0.846***	-0.833***
4. Clothing and footwear	0.0739	0.0759	1.385***	-1.011***
5. Domestic utilities	0.1370	0.1362	0.538***	-0.525***
6. Household non-durables	0.0402	0.0433	1.548***	-1.969***
7. Health	0.0382	0.0354	1.901***	-0.524***
8. Vehicle fuels	0.0635	0.0652	0.973***	-0.159***
9. Transport	0.0522	0.0520	0.955***	-1.090***
10. Communications	0.0511	0.0479	0.592***	-0.189***
11. Leisure and culture	0.0476	0.0478	1.421***	-2.253***
12. Hotels and restaurants	0.1254	0.1234	1.404***	-0.974***
13. Other non-durables	0.0607	0.0638	1.224***	-0.572*

* p<0.05, **p<0.01, ***p<0.001

SOURCE: BdE VAT Microsimulation Model.

CROSS-PRICE ELASTICITIES

TABLE 10

	1. Food and beverages	2. Alcoholics drinks	3. Tobacco	4. Clothing and footwear	5. Domestic utilities	6. Household non-durables	7. Health	8. Vehicle fuels	9. Transport	10. Communications	11. Leisure and culture	12. Hotels and restaurants	13. Other non-durables
1. Food and beverages	-0.109	0.02	-0.009	0.181***	0.216***	-0.079	-0.179***	-0.224***	-0.142**	0.091**	0.170***	-0.379***	-0.272**
2. Alcoholic drinks	0.487	-0.993***	0.104	0.256***	0.715***	-1.959***	-0.281*	-0.806***	0.711***	0.422**	1.852***	-0.874*	-0.645
3. Tobacco	-0.14	0.046	-0.833***	-0.364***	-0.106	0.456	0.556***	-0.027	0.188	0.427***	0.117	-0.61	-0.556
4. Clothing and footwear	0.449*	0.029	-0.120*	-1.011***	-0.404***	0.076	0.042	-0.158**	0.007	-0.053	0.16	-0.462*	0.061
5. Domestic utilities	0.576***	0.067	-0.014	-0.210***	-0.525***	0.118	-0.577***	0.046	0.062	-0.019	0.056	-0.377***	0.258*
6. Household non-durables	-0.784*	-0.489	0.246**	0.135*	0.216	-1.969***	0.944***	-0.176*	-0.058	0.307*	-1.013***	1.468***	-0.375
7. Health	-1.998***	-0.102	0.405***	0.068	-2.356***	1.255***	-0.524***	1.320***	0.253	-1.200***	0.026	-0.252	1.203*
8. Vehicle fuels	-0.925***	-0.109	-0.012	-0.136***	0.021	-0.073	0.569***	-0.159***	-0.032	-0.145*	-0.232*	0.272	-0.011
9. Transport	-0.854***	0.141	0.084	0.046	0.092	-0.022	0.180**	-0.045	-1.090***	0.210**	0.480***	-0.191	0.016
10. Communications	0.522***	0.085	0.197***	-0.015	-0.047	0.277*	-0.651***	-0.176***	0.222**	-0.189***	0.046	-0.334**	-0.530***
11. Leisure and culture	0.746***	0.366	0.041	0.249***	0.025	-0.816***	0.03	-0.375***	0.461***	0.004	-2.253***	1.196***	-1.095***
12. Hotels and restaurants	-1.069***	-0.076	-0.131**	-0.302***	-0.458***	0.496***	-0.047	0.132**	-0.103	-0.187**	0.494***	-0.974***	0.823***
13. Other non-durables	-1.594***	-0.125	-0.257***	0.105**	0.486***	-0.277	0.713***	-0.034	0.002	-0.563***	-1.036***	1.929***	-0.572*

* p<0.05, **p<0.01, ***p<0.001
SOURCE: BdE VAT Microsimulation Model.

3.2.4 THE OUTPUT OF THE MODEL

The model simulates the tax paid by each household (including both VAT and excise duties) depending on its choice of consumption basket. Then, it computes and aggregates certain variables either by income decile or by age group in order to perform some comparisons. The variables of interest analysed are similar to those analysed in the case of the microsimulator of direct taxation: total revenue, average tax rates, winners and losers, and several inequality measures such as the distribution of after-tax income, Lorenz curve, Gini coefficient and some percentile ratios.

Since the microsimulator of indirect taxation allows for the behavioural responses of households, the output of the model also includes a measure of the welfare impact of the reform, calculated as the compensating variation for each household, that is to say the monetary amount that a household should receive or pay to maintain its pre-reform utility in annual terms.[16] The utility function assumed is based on Banks, Blundell, and Lewbel (1997).

Section 3.3 shows this output for two simulation exercises: first, for a change in the VAT rate and second, for a change in excise duties.

3.2.5 THE ACCURACY OF THE MODEL

The total household expenditure on taxable goods (that is, excluding goods without price such as narcotics or imputed rents, and goods exempt of VAT such as financial products) represented in our dataset amounts to €350,762 million, while the AEAT reports a household expenditure on taxable goods of €331,361 million. Our current model predicts €59,062 million of household VAT revenues and excise duties for 2015, while the revenues reported by the AEAT amount to €71,175 million. This difference (17.02%) could arise from the following factors. First, expenditure measurement and reporting errors (under-reporting in the case of tobacco; infrequency of purchase of leisure goods, for example; and individuals not represented in the survey like those in prison, hospital, etc.). Second, and in the opposite direction, tax evasion, which could affect expenditure on some services, maintenance, etc. And third, minor errors incurred during the aggregation of goods into 119 groups using available price data.

The results could be adjusted to improve the prediction of total aggregated revenue. However, since we are also interested in the distributional effects of the reform we chose not to make these adjustments.[17]

3.2.6 BASELINE RESULTS: INDIRECT TAX REVENUES AND THE DISTRIBUTION OF TAX LIABILITIES UNDER THE 2015 LEGISLATION

Figure 7 shows the revenue that the microsimulator predicts under the existing VAT and excise duty legislation, disaggregated by income deciles.[18] The total revenue amounts to €59,062 million.

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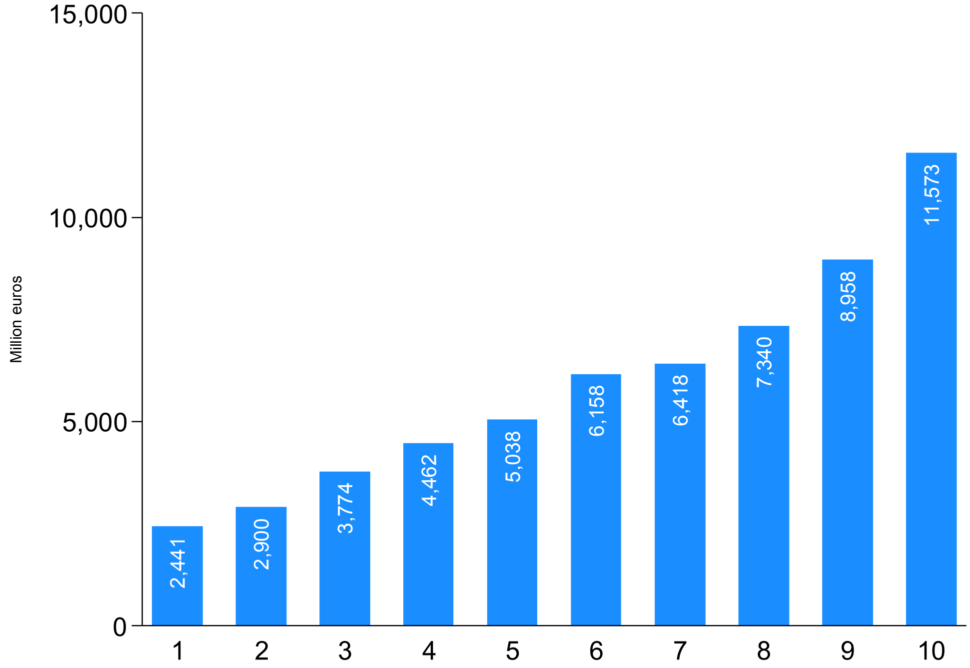
16 Note that, under this definition, a reform that increases a household's welfare leads to a negative compensating variation (the amount this household should pay back to return to its initial utility level). The output produced by the model, however, shows the welfare gain, and therefore such a reform leads to a positive value (an increase in welfare).

17 Sources of adjustment that could be used include: Data on total consumption of vehicle fuels (except in the case of tax evasion) provided by the *Comisión Nacional de Mercados y Competencia*. Data from the *Comisionado de Tabacos* for tobacco, and from the *Asociación de Fabricantes de Bebidas Espirituosas*, *Cerveceros de España* and the *Federación Española del Vino* for spirits, beer and wine, respectively.

18 We show the output of the microsimulator in terms joint VAT and excise duties given that each tax depends from one another (c.f. formulae in Sectiorn 2.2.2). A microsimulator of VAT alone causes a downward bias in the estimated baseline revenue because this amount is calculated simulating the elimination of all excise duties, and such a reform also impacts VAT revenue downwards. Nonetheless, we have computed the total revenues and the average effective tax rate without excise duties as a robustness check. Total revenues amounts to €45,707 million, which is an 88.93% of the VAT revenue reported by the AEAT, and average tax rate is 11.88%, close to the one reported by Laborda et al (2016) and Laborda et al (2017).

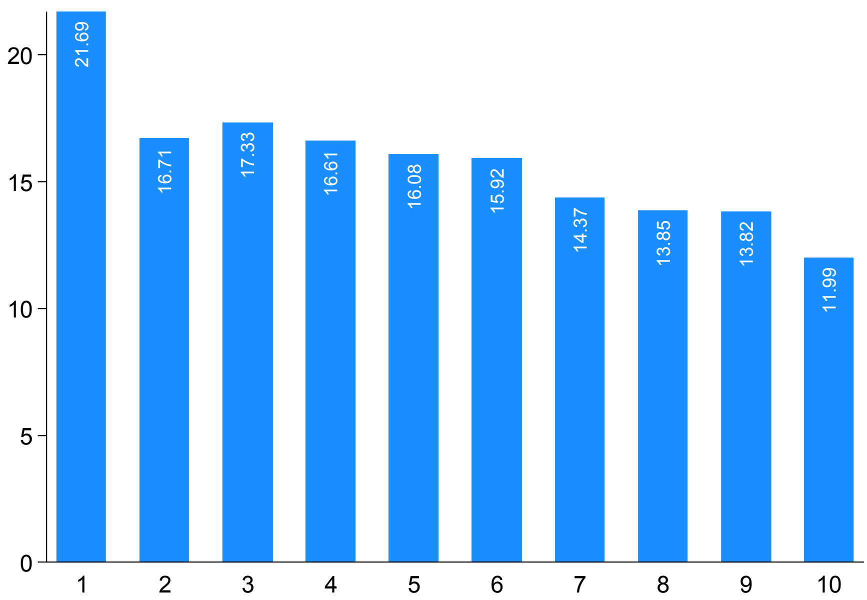
REVENUE FROM VAT AND EXCISE DUTIES BY INCOME DECILE IN 2015 FIGURE 7



SOURCE: BdE VAT Microsimulation Model.

Figure 8 presents the average tax rate faced by each income decile calculated as a percentage of income. That is, the total tax payments as a percentage of income. The tax rates in this case decrease over the income deciles, showing that the VAT-excise duties tax is regressive.

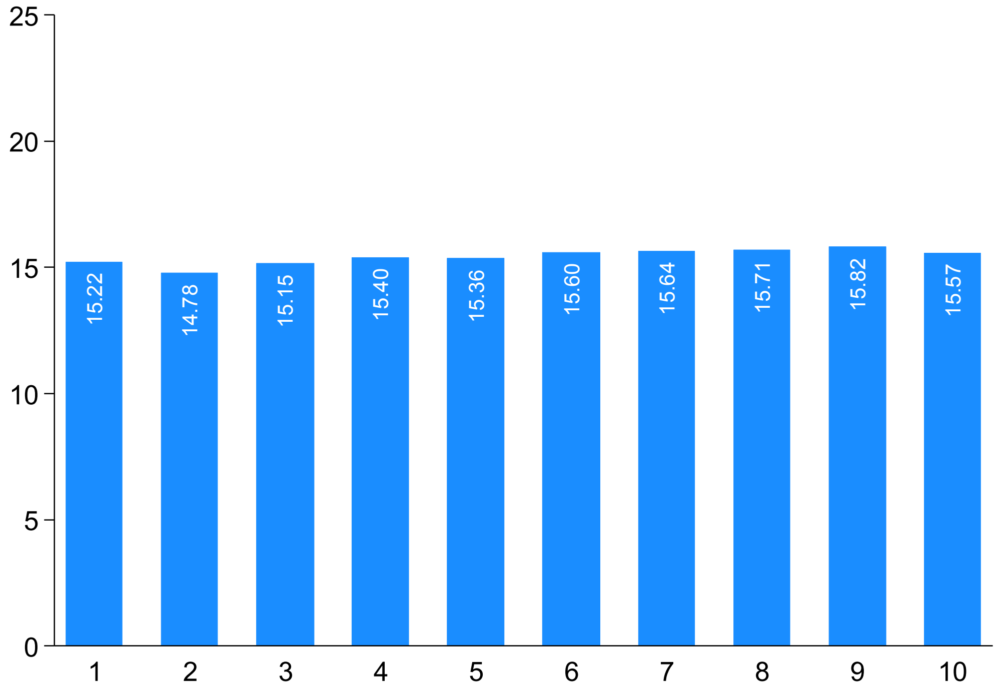
MEAN OF AVERAGE EFFECTIVE TAX RATE (AS % OF INCOME) BY INCOME DECILE FIGURE 8



SOURCE: BdE VAT Microsimulation Model.

However, Figure 9 presents the average tax rate faced by each income decile calculated as a percentage of consumption.[19] That is, the total tax payments as a percentage of consumption. In this case, the tax rates are mildly flat.

MEAN OF AVERAGE EFFECTIVE TAX RATE (AS % OF CONSUMPTION) BY INCOME DECILE IN 2015 **FIGURE 9**



SOURCE: BdE VAT Microsimulation Model.

The disparity in the results when the effective tax rate is computed relative to income and relative to consumption is not new in the literature. When looking at VAT payments as a percentage of total expenditure (as opposed to disposable income), Figari and Paulus (2012) conclude that for five European countries (Belgium, Greece, Ireland, Hungary and the UK), the VAT system does not seem to be regressive. Indeed, households in the richest disposable income decile pay a higher fraction of their total expenditure on VAT than households in the lowest income decile because they spend a higher proportion of their expenditure on goods and services that are taxed at higher rates.[20]

Given that the European Directive (2006/112/EC) of 28 November 2006 defines VAT as "a general tax on consumption proportional to the price of the goods and services" the tax base is the individual expenditure instead of individual income as in the PIT Microsimulation model. Therefore, from now on, we provide average tax rates computed as a percentage of consumption instead of income.[21]

19 Notice that the denominator includes consumption on goods exempt from VAT or excise duties as is usual in the literature.

20 From a theoretical point of view, redistributing income through income tax is less costly in efficiency terms, because it does not distort individual consumption (Atkinson and Stiglitz, 1976; Mankiw et al., 2009). That is, if the policy objective is to tax individuals on the basis of their income, it is preferable to tax income directly, unless consumption choices reveal something about income that cannot be captured by personal income tax (e.g. there is significant tax evasion and under-reporting that hinders the efficient collection of income tax, and consumption tax is less prone to evasion).

21 The IFS report for the European Commission also reports the average tax rates as a percentage of consumption when evaluating reforms. (Adam et al., 2011).

3.3 Simulation examples

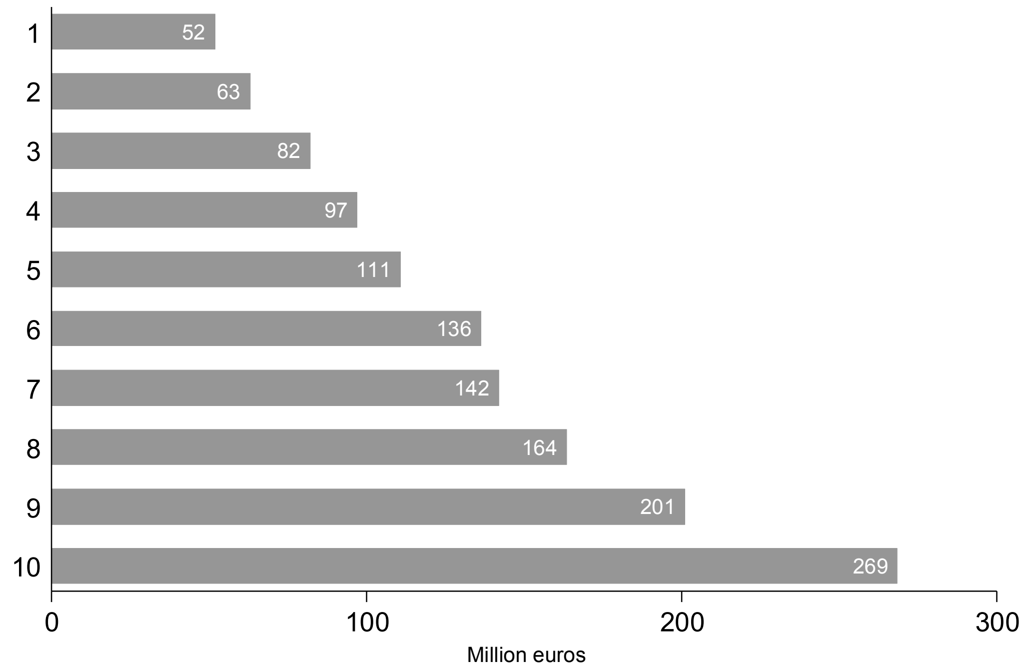
In what follows we present two hypothetical reforms to illustrate the possibilities of the BdE VAT Microsimulation Tool. These examples should not be understood in any way as reform proposals of the Banco de España.

3.3.1 A CHANGE IN VAT: A ONE POINT INCREASE IN THE STANDARD VAT RATE

In the first illustrative example of the BdE VAT Microsimulation Tool we simulate a one point increase in the VAT rate for goods taxed under the standard rate, from 21% to 22%.

Figure 10 shows the revenue change as a result of the reform, disaggregated by income decile. The total revenue increases by €1,317 million. Revenue increases more in the top deciles given that the richest households consume more goods and services than the poorest one.

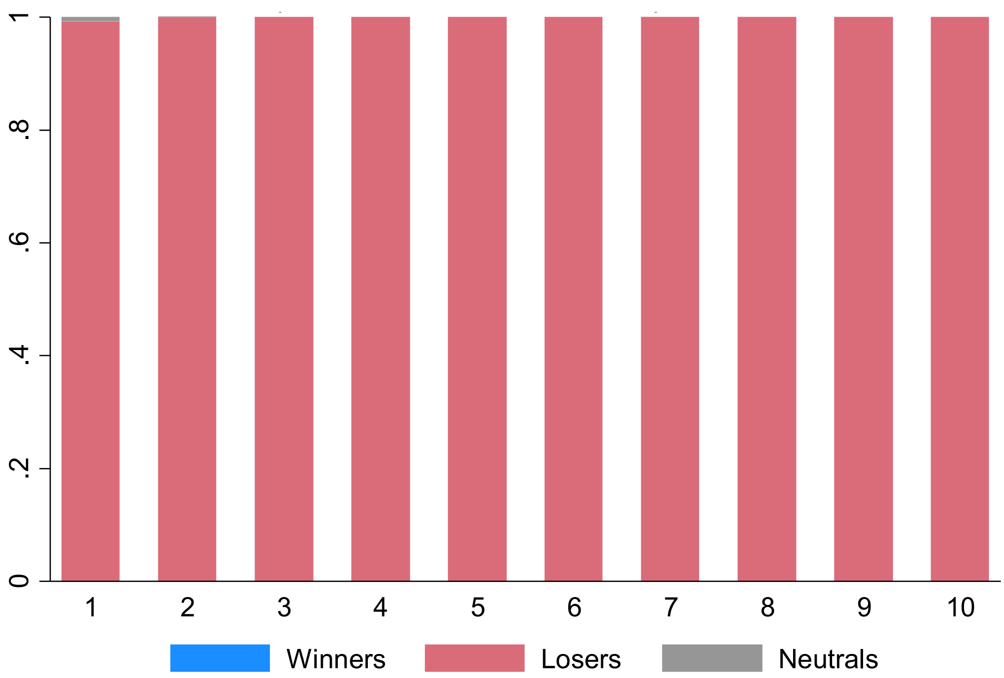
REVENUE CHANGE BY INCOME DECILE **FIGURE 10**



SOURCE: BdE VAT Microsimulation Model.

Figure 11 shows the winners and losers of the reform, as measured by their tax payments. Since almost every household consumes goods taxed at the standard VAT rate, every household loses.

WINNERS AND LOSERS **FIGURE 11**



SOURCE: BdE VAT Microsimulation Model

Table 11 shows the amounts behind Figure 11. For example, we can see that, among all losers, the average loss is €72.0. Losers belonging to the bottom percentile lose €28.8 on average, while losers belonging to the top percentile lose €147.9 on average.

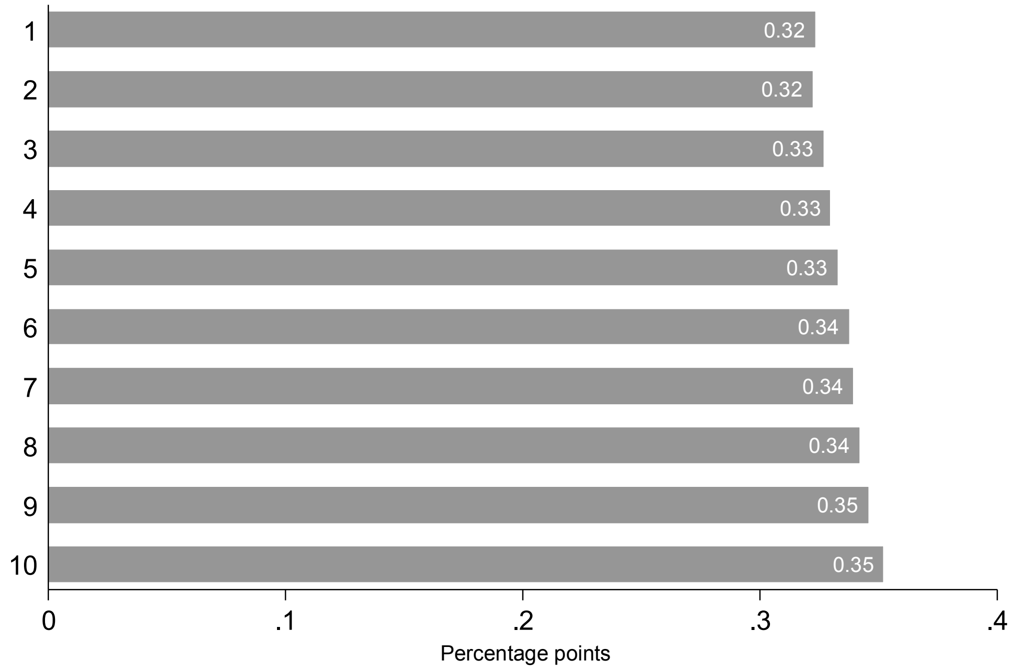
WINNERS AND LOSERS **TABLE 11**

Deciles	Total			Winners			Losers			Neutral	
	Population	Gain (+) or loss (-)	Avg. gain or loss	Number	%	Avg. gain	Number	%	Avg loss	Number	%
	millions	million €	€	millions		€	millions		€	millions	
1	1.8	-52	-28.5	0.0	0.0	0.0	1.8	99.0	28.8	0.0	1.0
2	1.8	-63	-34.3	0.0	0.0	0.0	1.8	100.0	34.3	0.0	0.0
3	1.8	-82	-45.1	0.0	0.0	0.0	1.8	100.0	45.1	0.0	0.0
4	1.8	-97	-53.2	0.0	0.0	0.0	1.8	100.0	53.2	0.0	0.0
5	1.8	-111	-60.6	0.0	0.0	0.0	1.8	100.0	60.6	0.0	0.0
6	1.9	-136	-73.1	0.0	0.0	0.0	1.9	100.0	73.1	0.0	0.0
7	1.8	-142	-79.0	0.0	0.0	0.0	1.8	100.0	79.0	0.0	0.0
8	1.8	-164	-89.1	0.0	0.0	0.0	1.8	100.0	89.1	0.0	0.0
9	1.8	-201	-109.4	0.0	0.0	0.0	1.8	100.0	109.4	0.0	0.0
10	1.8	-269	-147.9	0.0	0.0	0.0	1.8	100.0	147.9	0.0	0.0
Total	18.3	-1,317	-72.0	0.0	0.0	0.0	18.3	99.9	72.0	0.0	0.1

SOURCE: BdE VAT Microsimulation Model.

Figure 12 shows that the average tax rate (as a percentage of consumption) of the upper deciles increases most, as is to be expected from the fact that richer households spend a larger share of their total expenditure on goods taxed at the standard rate than poorer ones.

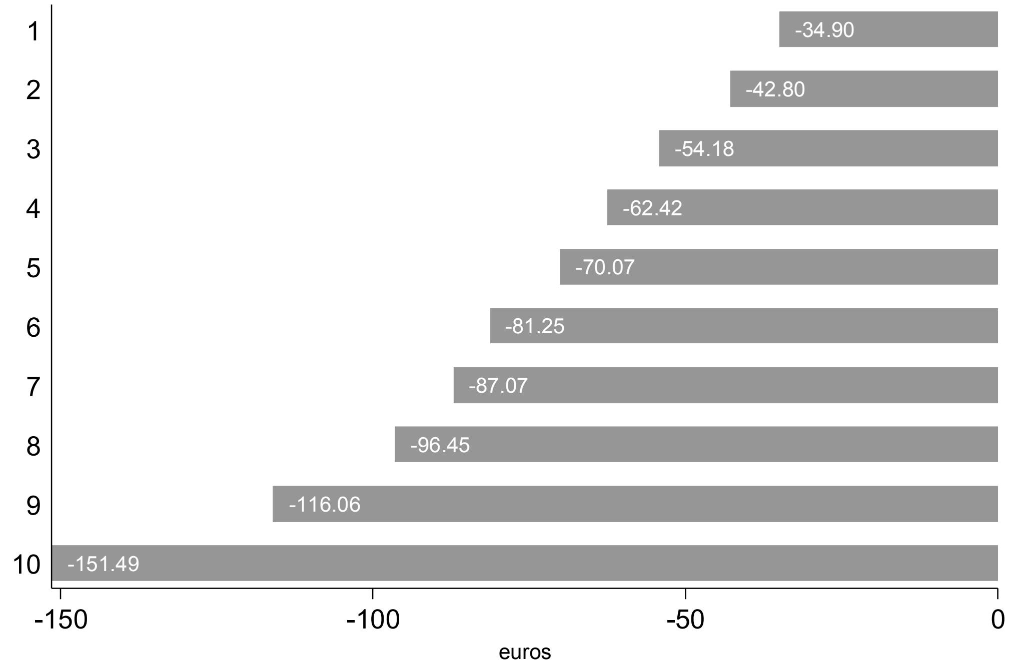
CHANGE IN AVERAGE TAX RATE (AS % OF CONSUMPTION) BY INCOME DECILE **FIGURE 12**



Source: BdE VAT Microsimulation Model

With regard to welfare changes, Figure 13 shows that all deciles of income experience a welfare reduction, which is larger for the top deciles. The welfare change is measured using the compensating variation, as explained in Sections 3.2.3 and 3.2.4. In particular, the annual income of the households in the top decile would need to increase by €151.49 in order to restore their initial utility level.

WELFARE CHANGE **FIGURE 13**



SOURCE: BdE VAT Microsimulation Model.

Table 12 shows the effect of the reform on inequality, which in this case is a very small decrease in the Gini coefficient. Looking at the percentile ratios, we observe a moderate decrease in inequality in all percentile ratios except for 50/25.

INEQUALITY MEASURES: AFTER-TAX CONSUMPTION **TABLE 12**

Indices	Pre-Reform	Post-Reform	Change (pp)
90/10	6.027	6.024	-0.0026
90/50	2.298	2.297	-0.0007
50/10	2.622	2.622	-0.0004
75/25	2.558	2.557	-0.0015
75/50	1.569	1.568	-0.0010
50/25	1.630	1.630	0.0001
Gini	0.363	0.363	-0.00013

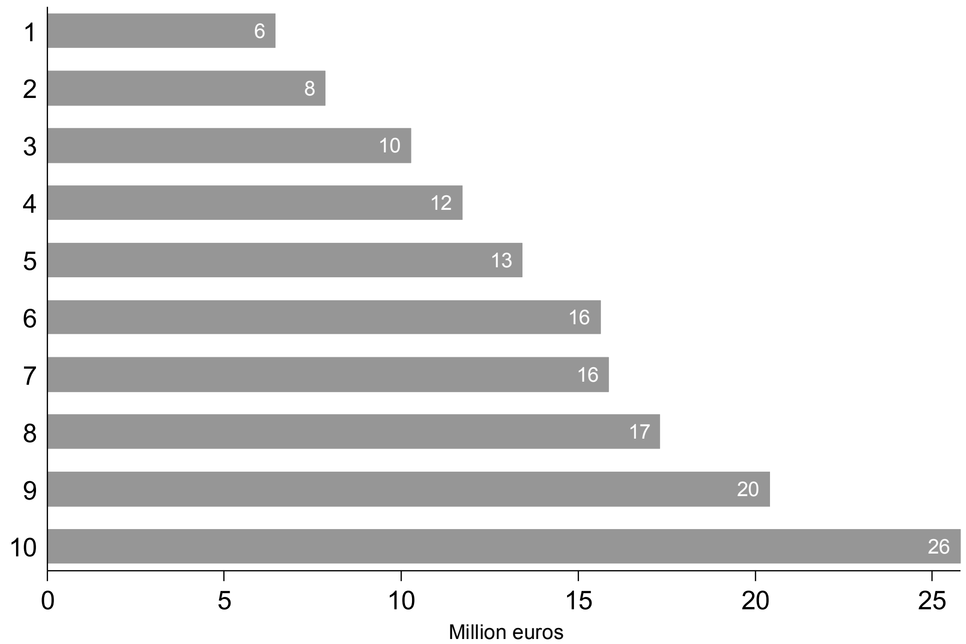
SOURCE: BdE VAT Microsimulation Model.

3.3.2 A CHANGE IN EXCISE DUTIES: AN INCREASE IN THE AD QUANTUM TAX ON SPIRITS

In this second illustrative example we simulate an increase in the ad quantum tax on spirits from €9.13 per litre of pure alcohol to €17.94, which is the average tax rate in the euro area and close to that in France.

Figure 14 shows the effect on tax revenue from each decile, the total increase amounting to €145 million.

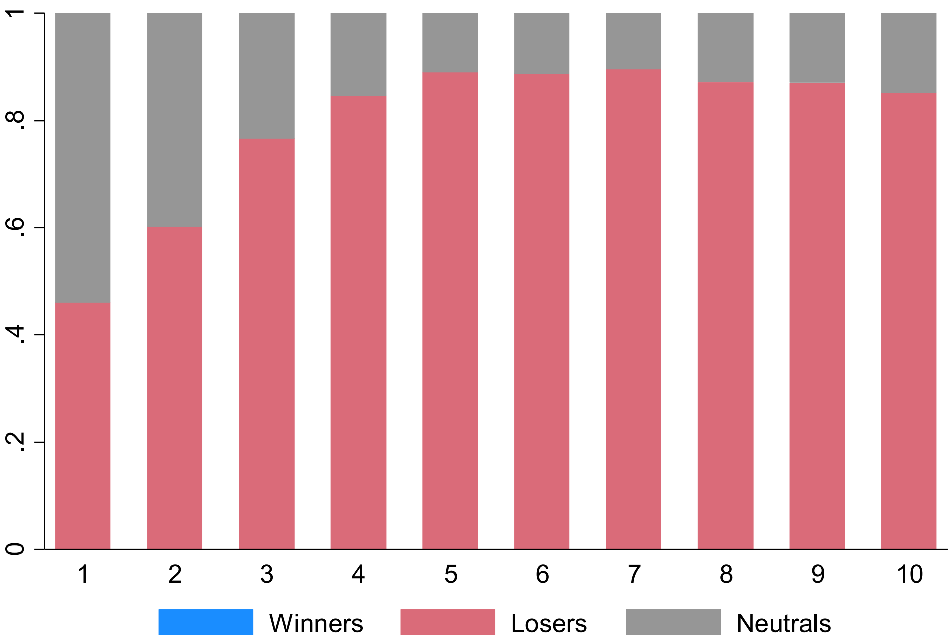
REVENUE CHANGE BY INCOME DECILE **FIGURE 14**



SOURCE: BdE VAT Microsimulation Model.

In Figure 15 we observe that for each decile there is a significant proportion of households that are neutrals with regard to the reform. This result is explained by the high proportion of households with zero spirit expenditure in their budgets (close to 30% on average). The proportion of losers is higher for the middle deciles.

WINNERS AND LOSERS **FIGURE 15**



SOURCE: BdE VAT Microsimulation Model.

Table 13 provides a more detailed view of the effect of the reform. In total, 79.4% of households lose, while the remaining 20.6% are neutrals. The average loss among all losers is €7.9. Bottom decile losers experience an average loss of €3.5 while top decile losers experience an average loss of €14.2.

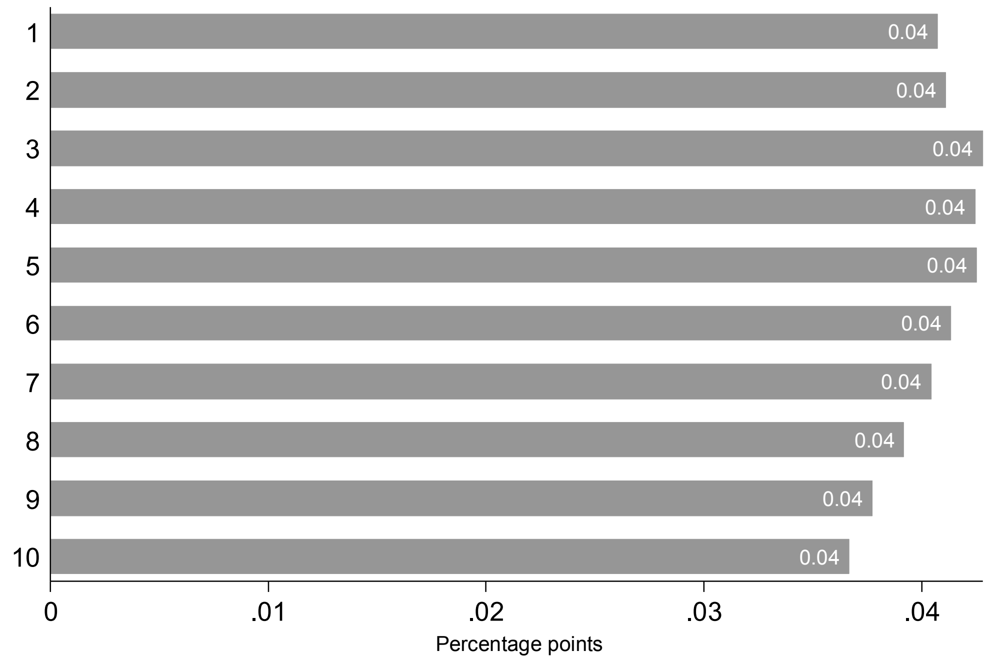
WINNERS AND LOSERS **TABLE 13**

Deciles	Total			Winners			Losers			Neutral	
	Population	Gain (+) or loss (-)	Avg. gain or loss	Number	%	Avg. gain	Number	%	Avg loss	Number	%
	millions	million €	€	millions		€	millions		€	millions	
1	1.8	-6	-3.5	0.0	0.0	0.0	0.8	46.0	5.6	1.0	54.0
2	1.8	-8	-4.3	0.0	0.0	0.0	1.1	60.2	5.7	0.7	39.8
3	1.8	-10	-5.6	0.0	0.0	0.0	1.4	76.6	6.6	0.4	23.4
4	1.8	-12	-6.4	0.0	0.0	0.0	1.5	84.6	7.0	0.3	15.4
5	1.8	-13	-7.3	0.0	0.0	0.0	1.6	89.0	7.8	0.2	11.0
6	1.9	-16	-8.4	0.0	0.0	0.0	1.7	88.7	8.8	0.2	11.3
7	1.8	-16	-8.8	0.0	0.0	0.0	1.6	89.6	9.2	0.2	10.4
8	1.8	-17	-9.4	0.0	0.0	0.0	1.6	87.1	9.9	0.2	12.9
9	1.8	-20	-11.1	0.0	0.0	0.0	1.6	87.0	11.6	0.2	13.0
10	1.8	-26	-14.2	0.0	0.0	0.0	1.5	85.1	15.0	0.3	14.9
Total	18.3	-145	-7.9	0.0	0.0	0.0	14.5	79.4	9.0	3.8	20.6

SOURCE: BdE VAT Microsimulation Model.

Figure 16 shows that the impact of this tax reform on the average tax rate (as a percentage of consumption) is almost identical across deciles of income.

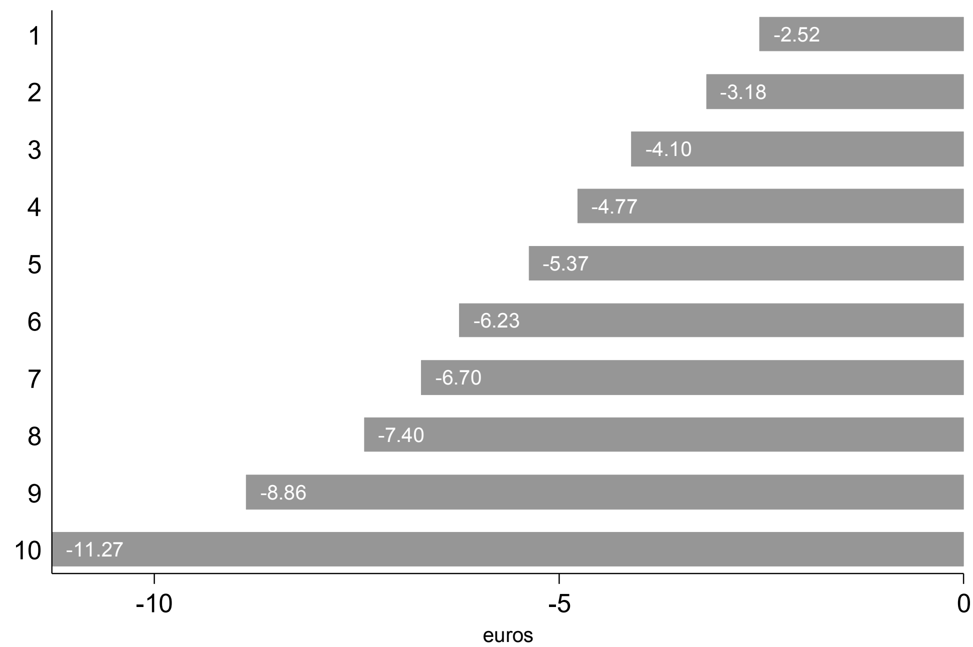
CHANGE IN AVERAGE TAX RATE (AS % OF CONSUMPTION) BY INCOME DECILE **FIGURE 16**



SOURCE: BdE VAT Microsimulation Model.

Figure 17, shows the welfare change by decile, with a higher impact at the top of the distribution.

WELFARE CHANGE **FIGURE 17**



SOURCE: BdE VAT Microsimulation Model.

4 Conclusions

This paper presents the two microsimulation tools developed at the Banco de España to study fiscal reforms. It details the structure of each model and illustrates its capabilities by evaluating simple examples of tax changes. Microsimulation models are a powerful instrument to assess the aggregate and distributional consequences of fiscal policy actions. Therefore, they are widely used as a tool to evaluate fiscal reforms.

The first microsimulation tool simulates the Spanish personal income tax using a stratified random sample of 2013 tax returns. The tool allows more than 1,500 parameters of the tax code to be changed in order to simulate reforms involving tax benefits, tax rates, definitions of taxable income, etc. The model does not account for the behavioural reaction of households, hence it only provides first-round or morning-after effects of reforms.

The second microsimulation tool simulates indirect taxation (VAT and excise duties) using the Spanish Household Expenditure Survey and the Spanish Consumer Price Index. The tool allows changes to be made in the VAT rate on up to 119 goods, and in the different excise duties on tobacco, alcohol, vehicle fuels, and electricity. The tool incorporates a behavioural model, a quadratic almost ideal demand system (QUAIDS) for 13 groups of non-durable goods, plus a fourteenth group of durables that is not incorporated in the behavioural system. This allows households' behavioural reaction to price changes stemming from a tax reform (second-round effects) to be predicted.

Both tools simulate the incidence of tax reforms both in the aggregate and across income and age groups. Therefore, they are useful to inform the policy and public debates on potential fiscal actions.

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