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Taxing electricity consumption in Spain: evidence to design the post-Kyoto world

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ABSTRACT
Due to the relevance of fossil fuels in the electricity matrix in Spain, the electrical sector plays a crucial role in mitigation policies such as carbon taxes. Increased prices of electricity can act as an incentive to enhance energy efficiency contributing to CO_2 abatement. This paper evaluates a tax on electricity consumption (ECT). Focusing on energy efficiency commitments for Spain as established by EU Authorities for Horizon 2020 (H2020), a pricing model was created to assess economic impacts and its effectiveness in meeting this commitment. The analysis was performed by considering two scenarios, without (Scenario 1) and with (Scenario 2) tax recycling between the new tax and employer-paid social security benefits or contributing to price stability. In Scenario 2, the tax reform is achieved with tax recycling, offsetting the introduction of the ECT by reducing employer-paid social security payments. Two alternative restrictions on the tax reform were considered for the simulation of Scenario 2. In the first case, a restriction was imposed to ensure revenue neutrality (2-I). In the second case, the restriction ought to maintain price stability (2-II). Results from different scenarios offer an important range of possibilities for policy decisions. The results show that with a tax rate equal to 1%, there is a remarkable reduction of CO_2 emissions from the electricity sector, and the same happens with other sectors that the literature identifies as drivers of such emissions.

KEYWORDS
governance; market-based mechanisms; mitigation measures; air pollutant emissions; GHG management

Introduction

In February of 2014, a group of experts commissioned by the government of Spain presented its final report with measures that could inspire an in-depth tax reform [101]. This report included the use of taxes to contribute to the battle against climate change and to reduce other taxes such as social security payments.

The report was presented the year prior to the Climate Summit in Paris (COP21), which debated the legal instrument that will substitute the Kyoto Protocol. No doubt, some of the debate will focus on the instruments that countries must use to reach the established objectives. For the critics of the emission trade schemes (ETS) as a useful tool, taxing carbon represents the most effective instrument for pricing carbon, so the proposal made by Spain's committee of experts should be studied in depth as its results could help design a better international agreement.

In any case, independently of the final agreement reached by the United Nations Climate Change Conference in Paris [see text of agreement in 102], as one of the European Union (EU) Member States, Spain's authorities face staunch commitments derived from what is known as the H2020 strategy, which is the more ambitious EU package to fight against global warning. It includes a specific target of 20% for energy efficiency improvement. In terms of energy efficiency, the Spanish commitment for the named H2020 implies that there must be a cumulative reduction in energy consumption of 15,979 ktoe for 2014–2020 [1, 103]. This target is directly linked with electrical utilities as the major provider of energy in Spain.

However, and until now, taxes have not been a policy instrument included in Spain's recent programs to enhance energy efficiency [2,104]. This might very well be due to fears about their possible damage on economic competitiveness in particular on industries like electrical utility and automotive. So, it is relevant to know and assess the economic impacts of tax measures oriented toward energy efficiency improvements before taking a policy decision.

When energy prices increase, for example as a consequence of a new tax, utilities and other companies may respond in different ways: they could change their product mix toward less energy-intensive products; they could invest in new technology that is less energy

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intensive; they could switch their energy input for a relatively cheaper fuel; or they may prefer to cut back production levels.

The implementation of economic instruments like carbon taxes leading to the internalization of the CO_2 externality and an increase in energy prices could be expected to encourage manufacturing firms and households to adopt energy-saving technologies and practices. If an effective energy efficiency policy is to be pursued, then economic instruments providing a price signal to reduce energy demand should be applied [3]. When energy prices fail to reflect the real cost of energy, consumers, utilities and other companies under-invest in energy-efficient equipment.

In this paper, a tax reform is proposed based on the establishment of an environmental Pigouvian tax. An environmental tax, following the double dividend approach [4], would not only produce an improvement in the environment through enhancing energy efficiency, but could also generate other positive economic impacts associated with tax recycling [5, 6]. Thus, the revenues generated by this tax might be used to reduce other existing taxes, such as social contributions [7,8,9]. This approach is in accordance with the fiscal devaluation policy recommended by institutions like Bank of Spain [10], International Monetary Fund (IMF) [105] or OECD [11], among others.

Based on the recommendations presented by the aforementioned committee of experts, this article proposes an environmental tax levied on electricity consumption at the same level as the tax applied on the products consumed by the economic sectors. This tax would differ from Spain's current electricity consumption tax, the essential aim of which is to collect revenue.[1] It is actually inspired by the British Climate Change Levy (CCL), which strives to promote the reduction of GHG emissions and where the tax burden is offset by a reduction of social contributions.

Spain's energy sector is a high-energy-intensity one and is responsible for most of the GHG emissions released into the atmosphere by Spain. The energy-processing sector accounted for 77% of the total GHG emissions in Spain with the energy and transport industries producing the highest emission volumes [12].

The introduction of this new tax on energy into the Spanish economy would presumably modify prices, electricity consumption, GHG emissions, tax revenues, private spending and other macroeconomic variables. To reach the right decision, it is essential to calculate its impacts on variables mentioned. This is the main contribution of this paper as it seeks to evaluate the impact that a tax reform based on the introduction of an environmental tax of the aforementioned characteristics would have, mainly on electricity consumption but also on the rest of the variables. The evaluation was performed by considering two scenarios, without (Scenario 1) and with (Scenario 2) tax recycling between the new tax and employer-paid social security benefits or with tax using a price stability tool. In Scenario 2, the tax reform is subject to two alternative restrictions. First, a restriction would be imposed to ensure revenue neutrality (2-I). Second, another restriction would require that the tax reform guarantees price stability (2-II). Scenario 2-II does not properly imply a tax recycling process. It is focused on price stability as another political target that could be in the policy-maker agenda.

For this analysis, the Social Accounting Matrix (SAM) at purchase prices for Spain in 2006 (SAMESP06) developed by Cansino *et al.* [13] is used. This is the latest available SAM for the economy of Spain. The matrix was constructed with the data from the origin and destination tables of the input–output (IO) framework and from accounting tables published by the National Statistics Institute [106,107]. The SAM serves as the database for a pricing model that includes the new tax.

The pricing model is an IO methodology model introduced by Leontief [108] to study the relationship between wages, profits and prices in the US economy of 1939. This methodology has been widely developed in relation to Spain's economy [14–16, and more recently 3]. This model is an analytical method that is complementary to both the econometric approach [17,18,19] and the general equilibrium models developed in the field of environmental taxation by Bovenberg and Goulder [20], Böhringer [21], Kumbaroğlu [22] and O'Ryan *et al.* [23], and at the international level by Gómez & Kverndokk [24], André *et al.* [25], Manresa & Sancho [5], De Miguel *et al.* [26] and Labandeira *et al.* [27], for the case of Spain.[2]

The paper is structured as follows. Following the introduction, the second section describes both the methodology and the tax on electricity consumption. The third section shows the results obtained from the two scenarios. The fourth section presents the conclusions and implications.

Methodology

The basic model

The empirical basis upon which the model stands is found in each of the columns of the SAMESP06 at purchase prices that correspond to the 26 productive sectors considered. Each column represents the intermediate consumption of each of the activity areas or productive sectors, while the other offers the primary factors used for the production of a single good.[3] The combination of various productive factors and intermediate consumptions, in fixed proportions and under the assumption of constant returns, results in each of the goods produced by each of the sectors indicated. This procedure isolates the price effects that are derived from the substitution effects, so that only partial information is available but allows one to see the effect that the current structure has in the technology. This is a methodology for identifying price effects without any interference from the substitution effects, which require a different methodology, such as computable general equilibrium (CGE). A CGE cannot distinguish these two elements (prices and substitution effects, because they are linked) while the linear model can, and that is the reason why it is used in this work.

In each column of the primary factors matrix of the SAM at purchase prices, trade and transport margins are also shown, as well as the indirect taxes net of subsidies paid by the economic agents when demanding the goods and services required by the companies that produce said goods/services (final demand). Hence, when combining the different components used to define the prices in the model, it is necessary to take into account the existence of two price types: one is the production price for each productive sector and the other is the purchase price or final price for each good produced.

A series of intermediate consumptions reflected in the intermediate consumption matrix of the SAMESP06 have been used to define a standard product. Along with them, a series of production, labor and capital factors have also been employed, to which imports must be added as another productive factor [28]. The labor factor is represented by the gross wages and salaries paid by businesses, and the capital factor by the gross operating surplus and the gross mixed income. These three production factors are included in the primary factors matrix under the SAMESP06 headings labor (sector 27), capital (sector 28) and imports (sector 42). When calculating the production price, both indirect taxes net of subsidies on products (sector 36) and production (sector 37) and employer-paid social security contributions (sector 34) must be added to these intermediate consumption and productive factors. From these data, the cost per unit of each good produced by each industry can be estimated [8]. Following this scheme, the production price[4] of the good produced by sector j, p_j, is contained in the following expression:

$$p_j = (1+t_j)\left[\sum_{i=1}^{26} a_{ij}\cdot p_j + (1+ss_j)\cdot w\cdot l_j + r\cdot k_j + p_m\cdot m_j + ipr_j\right] \tag{1}$$

where t_j, ipr_j and ss_j are the tax rates of net indirect taxes on products, production and employer-paid social contributions, respectively; a_{ij}, l_j, k_j and m_j represent, respectively, the technical coefficients of intermediate consumption, the labor factor, the capital factor and the imported goods; w and r are the unitary remuneration for labor (wage rate) and capital, respectively; and p_m is a price index for the imported goods. Thus, the last four summands on the right of Equation (1) represent the contribution of each of the inputs required for the production of one good by each industry. Social contributions represent a portion of the remuneration for wage earners, and indirect taxes represent a part of the production price.

The value of each parameter representing the technical coefficients was obtained from the SAMESP06. In the case of the technical coefficients referring to the intermediate consumption for each area of activity, it has been calculated from the following expression:

$$a_{ij} = \frac{A_{ij}}{XIP_j} \tag{2}$$

where A_{ij} is the element taken from the intermediate consumption matrix (i.e., the input consumption that sector j makes from sector i), and XIP_j is the total output of sector j.[5] In the case of the productive factor, l_j, its calculation is based on the following expression:

$$l_j = \frac{L_j + CSS_j}{XIP_j} \tag{3}$$

where L_j represents the salaries and wages of sector j and CSS_j, the employer-paid social contributions. For productive factor k_j, the following expression has been used:

$$k_j = \frac{K_j}{XIP_j} \tag{4}$$

where K_j is the gross operating surplus of sector j. Finally, parameter m_j is calculated as follows:

$$m_j = \frac{M_j}{X_{IPj}} \tag{5}$$

where M_j stands for the imports made by sector j.

The tax rates of net indirect taxes on intermediate products, production and employer-paid social contributions and technical coefficients were obtained from the SAMESP06 through the following expressions:

$$t_j = \frac{IP_j}{XIP_j - IP_j} \tag{6}$$

$$ipr_j = \frac{IPR_j}{XIP_j} \tag{7}$$

$$ss_j = \frac{CSS_j}{CSS_j + L_j} \tag{8}$$

where the numerator represents the revenue in each sector and the denominator, its tax base, which in the case of net indirect taxes is the total output minus the indirect tax that falls on the products paid by the sectors (IP_j). The tax base of the taxes on production is the total output for each sector. In the case of employer-paid social contributions, the tax base is the sum of wages and salaries plus contributions. The tax rates obtained are not the nominal rates established by the existing regulations, but effective rates calculated from the SAM.

The purchase price is the result of adding trade and transport margins (39), together with the indirect taxes[6] levied on finished products (38) and to the production price. The expression used to calculate the purchase price, q_j, is as follows:

$$q_j = \left(1 + idf_j\right) \cdot \left[p_j + mg_j\right] \tag{9}$$

where idf_j is the net tax rate levied on finished products and applied as a percentage of the production price, and mg_j represents the trade and transport margins. Taxes are calculated as the quotient between the revenue and its tax base according to the SAMESP06, through the following expression:

$$idf_j = \frac{IDF_j}{DF_j - IDF_j} \tag{10}$$

where DF_j is the final demand. The parameter that represents the vector for trade and transport margins, mg_j, is obtained as follows:

$$mg_j = \frac{MG_j}{DF_j} \tag{11}$$

The production price, the purchase price and the wage rate are endogenously obtained within the model. This is not the case with the unitary remuneration of capital and the price of imported goods, which are considered exogenous in the model. With regard to the latter, since foreign prices are the outcome of the interaction of supply and demand in foreign markets, they fall outside the pricing model considered. For the remuneration of capital services, there is no benchmark index equivalent to what the consumer price index (CPI) represents as a reference for salaries. This is the reason why, following Cardenete and Sancho [8], this price is also considered exogenous in the model.

Regarding the wage rate, it adjusts itself to the evolution of consumer prices through the CPI.[7] Thus, to calculate the wage rate, which, in turn, behaves as a final price variation index, the following expression is used:[8]

$$w = \sum_{j=1}^{26} q_j \alpha_j \tag{12}$$

where the wage rate, w, is a weighted average purchase price for the various goods produced by the productive sectors. α_j is the weight used, which represents the proportion of goods consumption j in relation to total private consumption.

Taking into account the aforementioned references – where the data provided by the SAMESP06 are reproduced – the model sets the initial prices for both the products and the productive factors to unity. The model and the various simulations have been solved with the help of the GAMS[9] (General Algebraic Modeling System) software developed by Brook *et al*. [29] for the World Bank.

Electricity consumption tax and indirect revenue

Following a scheme similar to that of Cansino *et al.* [30], an electricity consumption tax (ECT) has been introduced into the above-described model. The effective tax rate of the ECT has been set, merely as a theoretical exercise, at 1%, without modifying the rest of the model. A 1% tax rate would be imposed on the supply of electricity ("taxable commodity") as fuels (that is lighting, heating, cooling and power) by business consumers. Electrical utilities become a crucial piece of the fiscal mechanism. This tax would then be passed on to the final prices. The tax rate considered is charged at a specific rate per unit of electricity. This rate seeks to change business and household behavior in Spain to reduce electricity consumption. Companies are considered taxpayers if they supply fossil fuels or electricity generated from fossil fuels, for commercial consumption. As such, they should register as suppliers. Utilities may be held liable and pay a penalty if they are required to register as taxpayers and fail to do so. This tax would be applicable to goods produced by the electricity sector [7] while other sectors in the model remain unchanged. This new tax is incorporated into the model at the same level as the net tax on products, as reflected in its calculation using the following expression:

$$p_j = \left(1 + t_j + ect_j\right) \cdot \left[\sum_{i=1}^{26} a_{ij} \cdot p_j + \left(1 + ss_j\right) \cdot w \cdot l_j + r \cdot k_j + p_m \cdot m_j + ipr_j\right] \tag{13}$$

The private spending index

Changes in purchase prices as a result of a tax modification give rise to variations in household purchasing power and spending level. The gain or loss of consumers can be measured, following Cardenete and Sancho [8], through the so-called private spending index (PSI), which calculates the variation in consumer expenditures, as required to purchase the original basket of goods and services at new prices. With this, Y can be defined as the income used to purchase the original basket of goods and services and Y' as the income used to purchase the same basket of goods and services after the tax is introduced; the difference between the two will measure the variation in household expenditure between the initial and final situations.

$$PSI = Y - Y' = \sum_{j=1}^{26} q_j \cdot C_j - \sum_{j=1}^{26} q'_j \cdot C_j = \sum_{j=1}^{26} \left(q_j - q'_j\right) \cdot C_j \qquad (14)$$

where q_j and q'_j are, respectively, the initial and final purchase price of the basket of goods and services, and C_j is the basket of goods and services or consumption of the representative household. The PSI is the difference between Y and Y'; that is, the variation of consumer income after the tax has been introduced. A positive (negative) difference indicates that the final situation is better (worse) than the initial one; that is, consumers will need a lower (higher) income to buy the same basket of goods and services, resulting in a higher (lower) level of household income. Although this measure includes neither the adaptation nor the modification of consumer habits in the face of the new prices, it helps to approach the improvement or worsening of private spending.

Results

Because there is no possibility of substitution between inputs in a model price such as the one carried out in this paper, middle/long-term analysis is not recommended. Only short-term results are shown. The results obtained are associated with two reference scenarios. In the first, the tax reform does not entail the tax recycling of the new tax, the ECT. In the second scenario, the reform does include tax recycling or price stability as a target, which consists of counterbalancing the introduction of the ECT with a reduction of the employer-paid social security contributions. In the second scenario, the tax reform is subject to two types of alternative restrictions, one that requires the total tax revenue to remain constant (revenue neutrality) and the other that requires prices to remain constant (price stability) after the tax reform.

Scenario 1

The effective ECT tax rate has been set, merely as a theoretical exercise, at 1%, without modifying the rest of the model. These results would allow a revised tax rate to be set to meet Spain's H2020 target. Table 1 shows the effects that the introduction of this tax would have on the price of the goods produced by the various areas of activity, as well as the average effect on the whole. The second column reflects the increase in production prices, while the third shows the increase in purchase or consumption prices.

As expected, the introduction of the ECT gives rise to an increase in prices, and this tax falls on the production prices which would later impact on acquisition prices.

However, the magnitude varies from one sector to another. The price of electricity shows the greatest increase. As expected, the electrical industry receives the higher impact. In terms of purchase prices, the

Table 1. Changes in prices and energy consumption.

	Changes in prices after introduction of the ECT (%)		Variation of primary energy consumption (ktoe)
Productive sector	Production price	Purchase price	2014
1. Agriculture, livestock and forestry	0.01	0.01	− 0.1
2. Fisheries	0.02	0.02	0.0
3. Coal	0.02	0.00	0.0
4. Oil and natural gas	0.00	0.00	0.0
5. Non-energy extractive industries	0.01	0.01	0.0
6. Oil refineries	0.00	0.00	− 4.4
7. Electricity	3.01	3.58	− 367.1
8. Gas	0.01	0.01	0.0
9. Water	0.05	0.05	0.0
10. Food and stimulants	0.03	0.02	− 0.3
11. Textile and leather	0.02	0.01	− 0.1
12. Timber products	0.03	0.02	− 0.6
13. Chemical industry	0.01	0.01	− 0.4
14. Building materials	0.04	0.03	− 1.0
15. Metallurgy	0.01	0.01	− 0.2
16. Metal products	0.04	0.04	− 0.1
17. Machinery	0.01	0.01	0.0
18. Vehicles	0.01	0.01	0.0
19. Other transport elements	0.02	0.02	0.0
20. Other manufactured products	0.03	0.03	− 0.1
21. Construction	0.05	0.05	− 0.1
22. Retail and catering	0.04	0.13	− 0.3
23. Transport and communications	0.03	0.03	− 0.2
24. Other services	0.04	0.05	0.0
25. Market services	0.03	0.03	− 0.4
26. Non-market services	0.07	0.07	− 1.1
Overall variation	**0.12**	**0.09**	**− 376.6**

Source: Authors' own elaboration based on SAMESP06.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

increase in this sector is 3.58%. Other goods experiencing an elevated increase, though small in relation to that of the aforementioned sector, are those produced by retail and catering (22), non-market services (26), water (9) and construction (21) sectors, among others. These are goods for which energy consumption has a relatively higher weight as an input than it does for other products.

The reason behind this increase in the electricity sector can be found in their input demand. Electricity appears in the IO matrix as significant intermediate inputs for themselves [31]. The fact that an important portion is self-consumption is due to the structure of the sector. Within the IO framework, this activity area includes the production and distribution of electricity. In Spain, production, distribution and marketing are all activities that are undertaken by independent companies. Therefore, an important amount of the inputs is transactions among firms within the same area of activity.

In terms of production prices, the increment is similar, reaching 3.01% for electricity. As for the remaining sectors, the price increase is most visible in the non-market services sector (26) with a 0.07% rise, and construction (21) and water (9), with increments of around 0.05%.

A rise in the price of electricity generates an increase of production prices for all sectors, which is higher as the input increases. This rise in production prices affects the increase of the final price for all goods and services. Furthermore, the increment of the final prices causes wage growth, which in turn – because wages are indexed to purchase prices through the CPI – becomes one of the factors contributing to the increase of prices. Nevertheless, the increase in the final price is mild, reaching only 0.09%. Results in terms of price changes are in line with Buñuel [17] who also found little inflationary impact caused by a carbon tax levying various energy sectors. Labandeira and Labeaga [18] also carried out an IO exercise to assess some economic impacts of another carbon tax for the Spanish economy, but not one mainly foucused on sectoral price changes.

The change in sectoral prices caused by the introduction of the ECT provoked a change in the pattern of household consumption, as shown in Table 1. From data offered by the Household Budget Survey [109] the changes in household spending (in constant terms) of each sector associated with changes in sectoral prices have been calculated. The changes in sectoral prices have been calculated from the CPI sector offered by the National Institute of Statistics. This allows the more precise estimation of the reaction of household consumption of each sector as a result of the changes in prices caused by the introduction of the ECT. In the specific case of the electricity sector, the literature provides estimates of the elasticity of consumption. The value of −0.25 offered by Labandeira *et al.* [32] was used, which is very similar to that offered by Romero *et al.* [33].

The changes in the consumption of each sector were used as a proxy for the change in sectoral output. From this, it is possible to calculate the changes in energy consumption caused by the ECT. The sequence is as follows: The introduction of the ECT causes a change in the prices of both production and consumption of every sector. The latter modification causes a shift in the household consumption of the 26 sectors. This consumption change implies a variation in the production sector and causes a change in the energy consumption.

For the initial situation as well as for each of the scenarios considered, the consumption data are shown in Table 7. To calculate the change in the energy consumption data, the sectoral primary energy consumption data for 2014 (launch year for Spain's commitment for 2020) published by the Spanish Institute of Statistics are used. Relevant figures for Scenario I are contained in Table 1. The fourth column in Table 1 shows the variation in primary energy consumption for the year in which ECT is applied (2014). The impact on the electric utility industry is clear and expected.

Table 2 shows the effects that the introduction of the ECT has on the collection of the various indirect taxes. The 0.28% increase in total revenue due to the introduction of ECT is not solely due to the new tax itself, but rather to an increment of the revenue from remaining indirect taxes, with the exception of the production tax, which remains unaffected. The reason for this cascade effect associated with the introduction of the ECT is that this measure originates an increase in prices, resulting in a higher tax base for the rest of the taxes. With regard to employer-paid social contributions, their tax base also increases because wages rise

Table 2. Effects on the tax revenues and relative weight of the taxes.

	Effects on the tax revenues of the introduction of the ECT (millions of Euros)			Relative weight of the taxes on the total revenue	
Type of tax	Initial situation	With ECT	Variation (%)	Initial situation	With ECT
Net taxes on products (industries)	22,164.6	22,171.1	0.03	10.38	10.35
Net taxes on production	1915.0	1915.0	0.00	0.90	0.89
Employer-paid social contributions	104,148.0	104,237.6	0.09	48.78	48.68
Net taxes on finished products	85,293.4	85,416.9	0.14	39.95	39.89
ECT	0.0	385.2	–	0.00	0.18
Total revenue	**213,521.0**	**214,125.8**	**0.28**	100.00	100.00

Source: Authors' own elaboration based on SAMESP06.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

Table 3. Social contributions and effects on final prices.

Productive sector	Employer-paid social contributions simulated to reach the set targets			Effects on final prices of the introduction of the ECT and changes in the effective rates of employer-paid social contributions (%)	
	Initial social contributions	(2-I)	(2-II)	(2-I)	(2-II)
1. Agriculture, livestock and forestry	0.1254	0.1248	0.1245	− 0.0033	− 0.0111
2. Fisheries	0.1434	0.1427	0.1423	− 0.0061	− 0.0182
3. Coal	0.2825	0.2812	0.2805	− 0.0041	− 0.0085
4. Oil and natural gas	0.2041	0.2031	0.2026	− 0.0001	− 0.0003
5. Non-energy extractive industries	0.2388	0.2377	0.2371	− 0.0110	− 0.0240
6. Oil refineries	0.2801	0.2788	0.2780	− 0.0038	− 0.0079
7. Electricity	0.2595	0.2583	0.2576	3.5526	3.5343
8. Gas	0.2718	0.2706	0.2699	− 0.0105	− 0.0219
9. Water	0.2574	0.2562	0.2555	− 0.0499	− 0.1060
10. Food and stimulants	0.2337	0.2326	0.2320	− 0.0198	− 0.0436
11. Textile and leather	0.2229	0.2219	0.2213	− 0.0108	− 0.0244
12. Timber products	0.2262	0.2252	0.2246	− 0.0188	− 0.0420
13. Chemical industry	0.2387	0.2376	0.2370	− 0.0102	− 0.0222
14. Building materials	0.2390	0.2379	0.2372	− 0.0296	− 0.0645
15. Metallurgy	0.2522	0.2510	0.2503	− 0.0108	− 0.0231
16. Metal products	0.2263	0.2253	0.2247	− 0.0298	− 0.0666
17. Machinery	0.2333	0.2322	0.2316	− 0.0105	− 0.0232
18. Vehicles	0.2601	0.2589	0.2582	− 0.0105	− 0.0222
19. Other transport elements	0.2409	0.2398	0.2391	− 0.0168	− 0.0365
20. Other manufactured products	0.2245	0.2235	0.2229	− 0.0221	− 0.0495
21. Construction	0.2406	0.2395	0.2388	− 0.0454	− 0.0988
22. Retail and catering	0.2196	0.2185	0.2180	− 0.1018	− 0.2302
23. Transport and communications	0.2237	0.2227	0.2221	− 0.0248	− 0.0556
24. Other services	0.2238	0.2228	0.2222	− 0.0390	− 0.0875
25. Market services	0.1908	0.1899	0.1894	− 0.0171	− 0.0414
26. Non-market services	0.2290	0.2280	0.2274	− 0.0612	− 0.1358
Overall variation	**0.2238**	**0.2227**	**0.2222**	**0.0311**	**0.0000**

Source: Authors' own elaboration based on SAMESP06.
(2-I): Where the objective is to maintain the revenue.
(2-II): Where the objective is to maintain price stability.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

due to their being indexed to the CPI, as previously stated.

The increase in revenue, higher in some taxes than others, together with new revenue from the ECT, slightly modifies the weight of taxes in relation to the total revenues. The results presented in Table 2 show that the introduction of the ECT reduces the relative weight of all taxes, more specifically by 0.03 percentage points (pp) in the case of the net tax on intermediate products; 0.01 pp in net tax on production; 0.1 pp for the employer-paid social security contributions, and 0.06 pp for the tax on finished products. The relative weight of the ECT is thus 0.18% of the total.

Scenario 2

In this second scenario, the tax reform involves, in addition to the introduction of the ECT, a reduction of the employer-paid social security benefits. The reform is also subject to a first restriction of revenue neutrality and to a second restriction of price stability.

This second scenario draws inspiration from Cardenete and Sancho [8] and the British CCL,[10] where the introduction of the rate is compensated by a 0.3% reduction of the employer-paid social contributions. In the present model, the offset of employer-paid social contributions required to ensure that the tax reform is financially neutral, in terms of both revenue (scenario 2-I) and prices (scenario 2-II), has been calculated.

Table 3 shows the results regarding the tax rates that affect each of the 26 sectors. The second column presents the effective rate of the initial employer-paid social contributions – that is, before the introduction of the ECT and the offset through their reduction. The third and fourth columns reflect the decrease in the effective rates of the contributions in order to satisfy the required restrictions: in the first case, maintaining revenue neutrality.

In both simulations, the calculated average rate of employer-paid social security benefits is lower than considered in the first scenario, which is the data recorded in the second column (22.38%). However, the reduction of the average rate is moderate. In the first case, the weighted average of the effective rate of the social contributions drops to 22.27%, representing a reduction of only 0.49%. In the second simulation, where reaching price stability is the objective, the reduction is 0.7%.

The effects on revenue and prices are shown in Table 4. In the first case, where a 0.49% reduction of the average rate of the employer-paid social security contributions is required to maintain a constant revenue, there is a slight price increase of 0.031%. In the second case, the average effective rate of the employer-paid social security contributions must be reduced by 0.7% to maintain stable prices; the total revenue experiences a 0.16% decrease.

If the revenue of the various taxes is analyzed, one observes that, in both simulations, net taxes on

Table 4. Effects on the tax revenues and the prices of a decrease in social contributions (millions of Euros).

Type of tax	(1)	(2-I)	(2-II)
Net taxes on products (industries)	22,164.6	22,153.9	22,144.1
Net taxes on production	1915.0	1915.0	1915.0
Employer-paid social contributions	104,148.0	103,700.6	103,396.6
Net taxes on finished products	85,293.4	85,366.5	85,337.9
ECT	0.0	385.1	385.0
Total revenue	**213,521.0**	**213,521.0**	**213,178.6**
Price index	1.0000	1.00031	1.0000
Scale factor of social contributions		0.995	0.993

Source: Authors' own elaboration based on SAMESP06.
Initial situation.
(2-I) Simulation 1: Rate reduction of the employer-paid social security contributions keeping the total revenue unchanged.
(2-II) Simulation 2: Rate reduction of the employer-paid social security contributions keeping the prices unchanged.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

Table 5. Variation of primary energy consumption (Ktoe), scenarios 2-I and 2-II.

Productive sector	2-I	2-II
1. Agriculture, livestock and forestry	0.0	0.1
2. Fisheries	0.0	0.0
3. Coal	0.0	0.0
4. Oil and natural gas	0.0	0.0
5. Non-energy extractive industries	0.0	0.0
6. Oil refineries	5.0	10.2
7. Electricity	− 363.8	− 361.9
8. Gas	0.0	0.0
9. Water	0.0	0.0
10. Food and stimulants	0.2	0.5
11. Textile and leather	0.1	0.2
12. Timber products	0.5	1.1
13. Chemical industry	0.4	0.8
14. Building materials	0.9	1.9
15. Metallurgy	0.2	0.5
16. Metal products	0.1	0.2
17. Machinery	0.0	0.0
18. Vehicles	0.0	0.0
19. Other transport elements	0.0	0.0
20. Other manufactured products	0.1	0.2
21. Construction	0.1	0.1
22. Retail and catering	0.3	0.6
23. Transport and communications	0.2	0.5
24. Other services	0.0	0.1
25. Market services	0.2	0.6
26. Non-market services	1.0	2.2
Overall variation	− 354.4	− 341.9

Source: Authors' own elaboration based on SAMESP06.
Note: SAMESP06, social accounting matrix for Spain 2006.

production remain constant and, as expected, both net taxes on products paid by the various areas of activity and social contributions decrease. However, in the case of net taxes on finished goods, the revenue slightly increases. The reason for this increment is the effect that the two simulations have on the final prices. In Table 3, the fifth and sixth columns, respectively, reflect the final prices in simulations 2-I and 2-II. Changes of the final prices modify, in turn, the tax base for the tax on finished goods. The tax base increases in the electricity sector but decreases in the other areas of activity; this translates into higher revenue in the first case and lower revenue in the rest. Nevertheless, the lower revenue cannot compensate for the increase in the electricity sector, causing the total revenue from this tax to be higher.

Table 6. Private spending index (PWI) following the introduction of the ECT and its offset by a reduction of social contributions (millions of Euros).

	PWI
Initial situation	0.0
Introduction of the ECT	− 375.5
Introduction of the ECT and offset by a reduction of the contributions; objective: to maintain the revenue	176.6
Introduction of the ECT and offset by a reduction of the contributions; objective: to maintain the prices	489.2

Source: Authors' own elaboration based on SAMESP06.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

Similar to Table 1, and using the data from Table 7, Table 5 shows the variation in energy consumption for each sector in scenarios 2-I and 2-II. Once again, the electrical utility industry directly receives the impact of the tax reform showing a decrease of 363.8 ktoe for scenario 2-I and for the year 2014, and of 361.9 for scenario 2-II.

Table 6 shows how the rise in the final prices following the introduction of the ECT causes an increase of household spending that is associated with increased expenditure on the purchase of the original basket of goods and services. In Scenario 1, the increment of the final prices reduces the households' purchasing power that could be quantified in − 375.5 million Euros. In the simulation for Scenario 2-I, the price reduction following the decrease of the average effective rates for the employer-paid social contributions softens the decline of the PSI to 176.6 million Euros.

In the simulation for Scenario 2-II, the objective of maintaining price stability leads to a larger price reduction and, consequently, to a reduction in the private spending that amounts to 489.2 million Euros.

Finally, considering the changes in primary energy requirements, Table 8 contains total CO_2 emissions avoided due to ECT. The original data came from the Spanish National Statistics Institute [110]. However, the data source used required the grouping of some of the 26 sectors considered in the analysis to 20. These data refer to CO_2 emissions from the combustion of fossil fuels. The results displayed in Table 8 are logical. The sector that most reduces the CO_2 emissions is the electricity sector, where the impact of ECT on prices, output and power consumption is higher. It should be taken into consideration that despite the presence of nuclear energy in the Spanish electricity grid and the increasing involvement of the Renewable Energy Sources, a significant proportion of electricity generation in Spain comes from the use of fossil fuels [111]. The relevant impact on this sector goes in line with the role it plays as a driver of CO_2 emissions in Spain [34,35].

The second sector showing a further reduction of CO_2 emissions is the material building sector. This is because the lime and cement industries are important drivers of CO_2 emissions. Also relevant is the impact on the transport and communications sector. It should be borne in mind that the penetration of alternative vehicles to engines is very limited in road transport in Spain.

Finally, the emission reductions in the retail and catering sector should be highlighted. This result is

Table 7. Effect on consumption following the introduction of the ECT by sector (millions of Euros).

Productive sector	(1)	(Scenario 1)	%	(2-I)	%	(2-II)	%
1. Agriculture, livestock and forestry	16,976.3	− 2.0	− 0.01	0.6	0.00	2.1	0.01
2. Fisheries	5603.6	− 0.9	− 0.02	0.4	0.01	1.1	0.02
3. Coal	59.3	0.0	− 0.01	0.0	0.01	0.0	0.01
4. Oil and natural gas	63.1	0.0	0.00	0.0	0.00	0.0	0.00
5. Non− energy extractive industries	128.4	0.0	− 0.02	0.0	0.02	0.1	0.04
6. Oil refineries	21,504.0	− 1.3	− 0.01	1.4	0.01	3.0	0.01
7. Electricity	7859.3	− 70.4	− 0.90	− 69.8	− 0.89	− 69.4	− 0.88
8. Gas	1793.8	− 0.3	− 0.02	0.3	0.02	0.7	0.04
9. Water	2420.5	− 2.1	− 0.09	2.1	0.09	4.5	0.19
10. Food and stimulants	74,606.0	− 18.3	− 0.02	16.3	0.02	35.8	0.05
11. Textile and leather	34,873.2	− 11.0	− 0.03	9.2	0.03	20.6	0.06
12. Timber products	3293.4	− 0.7	− 0.02	0.6	0.02	1.4	0.04
13. Chemical industry	13,740.4	− 1.5	− 0.01	1.4	0.01	3.1	0.02
14. Building materials	1140.5	− 0.4	− 0.03	0.3	0.03	0.7	0.06
15. Metallurgy	177.6	0.0	− 0.01	0.0	0.01	0.0	0.02
16. Metal products	2100.5	− 0.7	− 0.04	0.6	0.03	1.4	0.07
17. Machinery	16,302.9	− 1.9	− 0.01	1.7	0.01	3.8	0.02
18. Vehicles	22,688.4	− 0.4	0.00	0.4	0.00	0.9	0.00
19. Other transport elements	2504.7	− 0.1	0.00	0.1	0.00	0.2	0.01
20. Other manufactured products	23,054.8	− 6.1	− 0.03	5.1	0.02	11.4	0.05
21. Construction	9530.1	− 4.7	− 0.05	4.3	0.05	9.4	0.10
22. Retail and catering	127,989.9	− 176.0	− 0.14	143.3	0.11	324.1	0.25
23. Transport and communications	34,567.0	− 13.3	− 0.04	11.1	0.03	24.9	0.07
24. Other services	32,554.9	− 16.7	− 0.05	14.0	0.04	31.3	0.10
25. Market services	124,616.1	− 35.4	− 0.03	23.4	0.02	56.7	0.05
26. Non-market services	14,369.4	− 11.2	− 0.08	9.7	0.07	21.5	0.15
Total variation	**594,518.0**	**− 375.5**	**− 0.06**	**176.6**	**0.03**	**489.2**	**0.08**

Source: Authors' own elaboration based on SAMESP06.
Initial consumption.
(2-I) Changes in consumption following the introduction of the ECT and its offset with a decrease of social contributions. Objective: to maintain the revenue.
(2-II) Changes in consumption following the introduction of the ECT and its offset with a decrease of social contributions. Objective: to maintain price stability.
Note: ECT, electricity consumption tax; SAMESP06, social accounting matrix for Spain 2006.

Table 8. CO_2 emissions avoided up to 2014 (ktoe).

Productive sector	(1)	(2-I)	(2-II)
Agriculture, livestock, forestry and fisheries	− 1	0	1
Energy extractive industries	0	0	0
Non-energy extractive industries	0	0	0
Oil refineries	− 1	1	3
Electricity, gas and water	− 904	− 895	− 891
Food and stimulants	− 1	1	3
Textile and leather	− 1	1	1
Timber products	0	0	0
Chemical industry	− 1	1	2
Building materials	− 17	15	33
Metallurgy and metal products	− 2	2	4
Machinery	0	0	0
Transport elements	0	0	0
Other manufactured products	− 1	1	2
Construction	− 3	3	5
Retail and catering	− 9	8	17
Transport and communications	− 14	12	26
Other services	0	0	1
Market services	− 1	1	2
Non-market services	0	0	1
Total variation	**− 958**	**− 849**	**− 787**

Source: Authors' own elaboration based on SAMESP06.
Note: SAMESP06, social accounting matrix for Spain 2006.

consistent with those obtained by Alcántara *et al.* [31], noting that the retail sector is a driver of electricity consumption.

Conclusions

As an alternative of the ETS, carbon taxes might have an important opportunity in international agreements in a post-Kyoto Protocol world.

Electrical utilities are so important in the development of political measures against climate change due to the share of fossil fuels in the matrix. Many of these political measures are market-oriented carbon-pricing tools and several market-oriented instruments are also linked with countries' commitments in improving energy efficiency. This is the case for carbon taxes as a market-oriented tool, and this is also the case for Spain looking through energy efficiency commitments in H2020.

In this work, a linear general equilibrium model was applied to analyze the impact of a tax reform based on the introduction of a new tax on electricity consumption with a theoretical tax rate of 1%. The analysis considers two scenarios. These results allow consideration of the economic consequences due to the introduction of a tax. The results could be useful for international agreements in the post-Kyoto world in order to reach national commitments.

The results obtained in this study allow the authors to conclude the following:

First, the introduction of an electricity consumption tax (ECT) without tax recycling has an inflationary impact, and causes an important increase of household spending (greater than the increase in revenue generated by the new tax) and an increase in the total tax revenue of 0.28%.

Second, the introduction of the new tax (ECT) with tax recycling and tax neutrality requires a small reduction in employer-paid social security contributions and generates only a slight increase in consumer prices, and an increase of household spending less than the revenue generated by the new tax.

Third, the introduction of the new tax (ECT) with price stability leads to a decline in employer-paid social security contributions. This is higher than in the previous case, resulting in a 0.16% reduction in revenues and a significant decrease of household spending.

Last but not least, the electrical utility sector acts as a key driver to achieve the Spanish commitment by greatly reducing its energy primary consumption. The CO_2 emissions avoided by this sector are remarkable. The same happens with other sectors that the literature identifies as CO_2 emissions drivers.

In summary, in the current context of economic and financial crisis, in which both price stability and tax neutrality seem essential requirements for all energy policy designs, the authors believe that the introduction of the new tax (ECT) with tax recycling and neutrality will contribute to enhance Spanish energy efficiency at the cost of slightly increasing inflation and moderately increasing the private spending index. Although this paper considers only a single tax rate for all of the utilities concerned, further analysis could enhance the tax design to a new one with different tax rates which consider how clean/green electricity is for every utility considered as the key taxpayer.

It should be noted that the model used is a linear general equilibrium model. Although this kind of model is perfectly valid when analyzing the effect on prices and revenues, it is more limited than an applied general equilibrium model, which allows the establishment of a comprehensive and complex network of relationships between the different economic agents, as well as the consideration of a greater number of macroeconomic variables. The authors recommend caution with results obtained because of the limits of the analysis in the middle/long term. However, as an approximation to this network of interactions, the linear general equilibrium model provides enough insight into the effects that may result from a tax reform, and can be later expanded with the application of an applied general equilibrium model. These results are of interest to energy policy-makers and designers fighting against climate change.

Finally, a pricing policy such as the ECT might be complemented with other instruments that include information for consumers and financial support for the purchase of energy-efficient appliances. Energy efficiency standards such as building energy codes and those for electrical appliances would be also considered. Energy consumers may be informed of the negative impact of their energy demand on the global warming problem.

Notes

1. The electricity tax was implemented by Law 66/1997 of December 30, 1997, on Fiscal, Administrative and Social Order Measures, and had the basic objective of obtaining revenue to counterbalance the removal of an electricity billing surcharge that was meant to provide support to the coal industry.
2. The latter work integrates a micro-econometric model and a general equilibrium model.
3. In IO analysis, each area of activity considered produces a single good, employing the same production technology.
4. Each area of activity purchases the intermediate goods that it requires at their purchase prices, taxes included. However, the burden of indirect taxes falls not on the producer but rather on the final consumer. Therefore, the price that must be taken into account is the production price.
5. The total output of sector j does not correspond with the total number of uses or resources of the SAM, since it does not include the net indirect taxes (38) levied on the products making up the final demand or the trade and transport margins (39) on those same products.
6. Indirect taxes on products include the value added tax (VAT), taxes and duties on imports, excises, etc. The ideal would be to have these taxes expressed in a disaggregated form, especially in the case of VAT. However, the unavailability of disaggregated data of this tax by area of activity has made the consideration of all indirect taxes as a whole necessary.
7. The reason lies in that for wage negotiations in the private sector and the establishment of the remuneration for public officials, the CPI is taken as the benchmark indicator. There are other possible assumptions, like using the total weight of salaries and wages in the sector in relation to the total wage bill, but the results obtained are very similar to those of CPI usage.
8. In applied general equilibrium (AGE) modeling, this assumption is very common [27]. The explanation is based on the fact that households take their decision on base to real wages. This assumption is too suitable to include a labor market in the full non-linear AGE, taking into account the relation between the real wages and the ratio between real unemployment and unemployment after the simulation.
9. The solution software used by GAMS is MINOS.
10. The British CCL is intended to contribute to the reduction of greenhouse gas emissions. It is a tax on the consumption of products for lighting, heating and electricity of industry, commerce, agriculture and public administration sectors, and for other services. The taxed products are electricity, gas, liquid hydrocarbons and coal. This rate is applied per nominal unit of power and, in the case of electricity, is £0.0043 per kilowatt-hour.

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