Designing an environmental tax on carbon emissions to meet EU targets: a proposal for the Spanish economy

L. Dary Beltran[a*]
ldbeltran@uloyola.es

Manuel Alejandro Cardenete[a]
macardenete@uloyola.es

Ferran Sancho[b]
ferran.sancho@uab.cat

[a]Department of Economics, Universidad Loyola Andalucía. Av. de las Universidades, s/n, 41704-Dos Hermanas, Seville, Spain.

[b]Department of Economics, Universitat Autònoma de Barcelona. 08193-Bellaterra, Catalonia, Spain

[*]Corresponding author

Designing an environmental tax on carbon emissions to meet EU targets: a proposal for the Spanish economy

Abstract: In response to increased awareness of climate change, environmental sustainability has become a policy objective in Europe. Despite a decrease in greenhouse gas emissions, the European Commission deems current progress insufficient. Discussions on implementing environmental policies persist, with environmental taxation emerging as one of the most controversial yet potentially effective economic instruments for reducing emissions. However, the extent of its impact on the economy remains under debate, as improvements in welfare and environmental quality hinge on various economic, political, and public preference factors. Therefore, we analyse the economic impact of introducing an environmental tax to achieve emission reduction targets in Spain, while also testing two systems for recycling tax revenues. This allows us to assess the potential for a second dividend. We select Spain as the unit of analysis due to its minimal utilisation of environmental taxes, as it ranks among the European countries that are least active in combating climate change using taxation.

Keywords: Environmental taxation; Emissions mitigation; Tax recycling.

JEL Classification: D57, E16, H21, H23

1. Introduction

Increasing industrialisation, urbanisation, globalisation, and population growth have defined significant social, environmental, cultural, and economic challenges that countries now prioritise in their policy agendas. In the last three decades, in particular, environmental problems have attracted attention worldwide, leading to the development of policies centred around them and resulting in the emergence of the economic concept called environmental sustainability. This concept implies adopting environmentally friendly production measures, which necessitates the design of fiscal and economic policies to achieve environmental sustainability (Toprak, 2018). In Europe, environmental sustainability has become a policy objective in response to the awareness of climate change. However, the debate on the definition of environmental policy instruments is still ongoing due to the difficulty of their evaluation (Ciaschini et al., 2010) and the associated economic and social consequences.

In this context, the European Climate Change Act entered into force on 29 July 2021[1], setting a legally binding target of zero net greenhouse gas emissions by 2050 and a 55 per cent reduction by 2030 compared to 1990. The legislation requires EU Member

[1] By Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021. Retrieved from https://eur-lex.europa.eu/eli/reg/2021/1119/oj.

States to take the necessary national and EU-level measures to reach these targets. This is expected to be achieved mainly by reducing emissions, investing in green technologies, and protecting the natural environment. Although greenhouse gas emissions continue to fall, the European Commission (2023) considers the current progress towards climate neutrality insufficient. Therefore, after assessing the progress made, it encourages Member States to take further measures to adapt to climate change and thus to update the National Energy and Climate Plans (PNIEC).

In line with European energy and climate policy, Spain continues to develop the Strategic Energy and Climate Framework, which includes various strategic and legislative elements that define the main lines of action to achieve climate neutrality. One of the main elements of this framework is the PNIEC, in which Spain, through Law 7/2021 of 20 May, translates its international commitments into legislation, including the objective of achieving climate neutrality by 2050. In response to the European Commission's proposals, the Spanish government has updated the PNIEC 2023-2030[2], setting a 32 per cent reduction in greenhouse gas emissions compared to 1990, among many other objectives that are more consistent with the emission reductions adopted at the European level (MITECO, 2023). This update includes 46 new measures to achieve the objectives linked to the proposed modification of European regulations in the "Objective 55" and REPowerEU packages, among other reforms of the previous plan, but green taxation remains a pending task.

Although adapting the tax system to the 21st-century economy and generating a new green tax system seems to be a clear political objective, Spain currently ranks among the European countries with the lowest utilisation of green taxes to combat climate change and environmental degradation. Therefore, our research will focus on analysing the Spanish case and examining possible tax policies that could contribute to overcoming this low level of policy intervention.

One of the main difficulties in implementing an environmental policy lies in the methodological differences in its evaluation and effectiveness in terms of competitiveness (Parry, 2004; Bovenberg & Goulder, 2002). One of the most controversial issues is environmental taxation. It clearly is a compelling economic instrument to incentivise cleaner production and consumption habits (Freire-Gonzalez, 2017). It is also associated with the assessment of a double dividend, in other words, if

[2] The PNIEC 2023-2030 update is a draft under consultation at the time of writing.

the policy improves environmental quality (pollution control) and at the same time improves economic efficiency. The latter is through the collection of revenues aimed at influencing variables that allow the internalisation of negative externalities (Pigou, 1920[3]; Tullock, 1967; Baumol & Oates, 1988). However, the extent of the impact on the economy remains a matter of debate, as it ultimately depends on various factors, including economic, political and consumer choices that are affected by prices (Ciaschini et al., 2010).

Various theories and methods have been devised to assess the impact of this dilemma, including macroeconometric models (Abdullah & Morley, 2014), input-output modelling (Gemechu et al., 2014; Sancho, 2021) and applied general equilibrium models (André et al., 2005), which are among the most widely used assessment methods. The latter two are particularly relevant due to their ability to incorporate the interdependencies explicitly and consistently between the different constituent parts of the economic system, by way of capturing the feedback between variables (Pyatt & Round, 1976; Thorbecke, 1985). This economy-wide view allows for a better understanding of the impact of policies on production and welfare as well as their redistributive effects.

These considerations motivate our research, aiming to contribute to the scientific debate with a more up-to-date approach. Above all, we aim to provide an ex-ante empirical analysis of a proposal for green fiscal measures that may contribute to the achievement of climate objectives by systematically promoting a low-carbon economy, focusing on the main economic activities that generate greenhouse gas emissions, as proposed in measure 1.37 of the PNIEC 2023-2030.

In this study, we analyse the potential economic impact of introducing an environmental tax on productive activities that depends on the pollution intensity of each productive sector. The objective of the tax would be to achieve the targets for Spain defined in the PNIEC 2023-2030. We complement the results by simulating different systems to recycle the generated tax revenues that would compensate for the new tax. This allows us to assess the possible existence of a second dividend in Spain. We have chosen Spain for the analysis because, as already mentioned, its green taxes have had an almost negligible environmental impact. It is, in fact, one of the European

[3] Pigou (1920) was a pioneer in the internalisation of negative externalities and proposed a carbon tax as an effective instrument for the reduction of CO2 emissions.

countries that uses them the least to combat climate change. Therefore, it has great potential as a candidate for new initiatives in this area.

For the analysis, we use the novel input-output methodology recently developed by Cardenete et al. (2024), a methodology that offers several advantages. On the one hand, it maintains the traditional operational simplicity of input-output analysis while addressing its main limitation, namely the independent and isolated determination of quantities and prices. In real-world market economies, however, prices and quantities are to a high degree interdependent. Hence, considering their interconnections is essential for a fair assessment of policy effects that are more rooted in reality. On the other hand, another advantage, instrumental in this case, is that the necessary data are usually available, either directly from the input-output framework and national accounts data or from a Social Accounting Matrix (SAM). The latter is the option that we chose in this study.

The document is structured as follows: In Section 2, we present the current state of affairs regarding the question at hand, describing the environmental problems, the situation of Spanish environmental taxation, and providing a brief literature review. Section 3 outlines the nature of the price-quantity model we employ, along with its implementation from the database, and includes the definition of the scenarios. In Section 4, we present the main results and discuss them. Finally, the main conclusions and policy implications are reported in Section 5.

2. The state of the matter

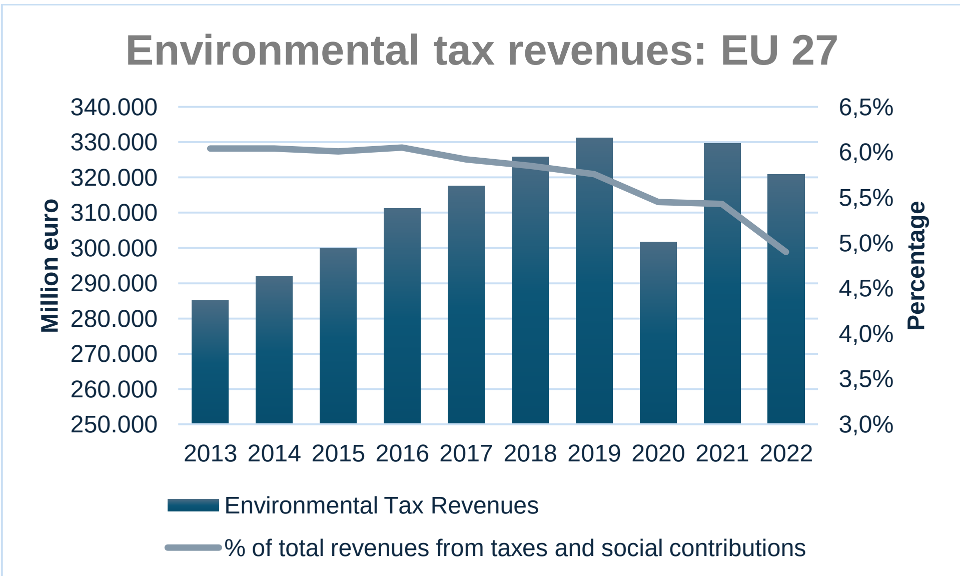
The global average temperature has risen by 1.1°C since pre-industrial times, and the Paris Agreement's goal of keeping the increase below 2°C, with efforts to limit it to 1.5°C, remains unmet, fostering a sense of uncertainty due to potentially catastrophic consequences. Climate change is a paramount global objective, representing the most significant environmental threat. This urgency motivates governments and international organisations to collaborate to reduce greenhouse gas emissions worldwide. In this context, environmental taxes emerge as a potent tool against climate change, serving as the most effective market-based instrument for reducing CO_2 emissions and promoting sustainability (Wei et al., 2015).

The European Commission (2019) aims to adapt the European Union's climate, energy, transport, and fiscal policies to reduce net greenhouse gas emissions by at least

55 per cent by 2030 (European Green Deal). The International Monetary Fund has suggested that countries that produce the most greenhouse gases should introduce a tax on CO_2 emissions. One way to achieve this is through environmental taxation targeting activities according to their polluting damage. This would work as a tool for decarbonising the economy and promoting sustainable development. However, the use of environmental taxes as an environmental policy instrument has declined rather than increased in the EU.

Environmental tax revenues come from four types of taxes: energy taxes, contributing about three-quarters of the total tax revenues; transport taxes, contributing nearly one-fifth; and pollution and resource taxes, contributing about 4 per cent (Eurostat, 2024; Statistics Finland, 2017). In 2022, about 320 thousand million Euros were raised from environmental taxes in the EU-27. The share of environmental tax revenues in total tax revenues for the same year is 4.9 per cent (see Figure 1), while the environmental tax burden is 2.02 per cent.

Figure 1. Environmental tax revenues for 2013-2022 in EU-27 countries. Millions of Euros and percentage.



Source: Authors' calculations based on Eurostat (2024).

In Spain, indirect taxes, broadly identified as environmental taxes, reached 20,529 million Euros in 2022[4], representing 6.2 per cent of the total taxes, which is 3.2 per cent less than in 2021. Of this total, households were the main payers, accounting for 49.9 per cent (INE, 2023). However, there is currently no environmentally oriented taxation system in place that could contribute to reducing polluting emissions by 32 per cent by 2030 compared to 1990 levels. The above data indicate the almost negligible environmental impact of green taxation in Spain, positioning it as one of the European countries that least utilise it to combat climate change. In short, while environmental sustainability is an objective for the Spanish government, taxation is not being utilized as an effective environmental policy instrument, as its orientation towards a decarbonised economy remains unclear. Therefore, a tax reform focused on environmental sustainability, also capable of generating an additional dividend, is imperative in Spain.

A European precedent is the case of Finland, which was the first country to utilize carbon taxes as a tool to mitigate climate change. Initially, these taxes were based on the carbon content of fossil fuels and later expanded to include an energy component (Khastar et al., 2020). Even before the Paris Agreement, discussions on environmental fiscal measures were underway, with notable examples including the Nordic carbon tax (Aslani et al., 2013), measures implemented by Switzerland, Australia, and Japan in 2008, as well as those enacted in South Africa, Mexico, Chile, and India around 2010 (Khastar et al., 2020).

However, research analysing the effectiveness and impact of such instruments is diverse in terms of the specific measures studied and the methodologies used to assess their impact in various contexts. Studies on the subject range from the examination of the effects of energy price increases on reducing environmental damage, such as in the case of Mexico (Uri & Boyd, 1997), to considerations of the potential for environmental taxes to inadvertently accelerate global warming, a concept known as the "green paradox" (analysed by Edenhofer and Kalkuhl, 2011). It has been realised that the design, analysis, and anticipated outcomes of environmental fiscal measures depend heavily on country-specific structural factors, such as income levels (Wesseh et al.,

---

[4] According to the Environmental Accounts published by the Spanish National Statistics Institute (INE, 2023), three types of indirect taxes are classified as environmental. These are taxes on energy, transport and pollution and resources. From an economic accounting point of view, they are excise taxes and are not usually defined with an environmental objective, but with a fiscal objective.

2017). Consequently, they warrant country-specific analysis to evaluate their environmental effectiveness and welfare impacts accurately.

Our research proposes a new environmental tax in the form of a carbon dioxide emissions tax, aimed at discouraging the consumption of polluting goods, thus generating a first dividend. By recycling the revenue of this new tax, the possibility of an additional economic divided emerges. One policy option is reducing another tax—in our case, the labour tax—to maintain the aggregate level of public revenue (Grubb et al., 1993). Another policy option would be to return the tax collected by way of financing additional public expenditure, therefore maintaining the same public deficit. Under both possible return policies, we can examine whether or not the economy could achieve a double, or even triple, beneficial dividend[5]. On the one hand, such a tax contributes to reducing negative environmental impacts, while on the other hand, it may work to minimise the adverse impact on the economy. This is because a tax reform not only addresses environmental concerns but also addresses inefficiencies within the tax system itself.

We will consider three scenarios: in the first, we calculate the ecotax that would reduce total greenhouse gas emissions by 32 per cent in 2030 compared to 1990. Since in 1990, emissions amounted to 288.4 million tons of CO_2, to achieve the reduction target, Spain would have to reduce its emissions by 41.93 per cent between 2016 and 2030. In other words, over 14 years, it would have to set an annual reduction target of around 3 per cent. In the second scenario, the ecotax's revenue is recycled to reduce taxes on labour, while keeping total government tax revenue constant. In the third scenario, the ecotax is recycled by stimulating the economy in a Keynesian manner, i.e., the revenue collected from the new tax is returned by stimulating public consumption demand while keeping the public deficit constant. The second and third scenarios aim to compensate, in real terms, for the contraction of the economy that the ecotax would cause.

3. Methodology and Scenarios

Environmental taxes must be carefully designed to internalise external costs and ensure that prices reflect all social costs of production, including environmental costs (Pigou,

[5] The double dividend hypothesis, which can be interpreted in different ways depending on the variant considered (Mooij, 2002), was first proposed by Pearce (1991) and later extended to include a third dividend.

1920). They serve as an incentive-based policy instrument to potentially address the consequences of climate change. Nonetheless, part of the discussion revolves around the appropriate methodology for assessing the environmental and economic effectiveness of this policy tool.

Several studies have demonstrated the feasibility of a double dividend, generating arguments for or against it (Bovenberg, 2002; Goulder, 1995), finding empirical results suggesting the occurrence of a double dividend in some of the scenarios, including a third dividend (Bovenberg & Goulder, 2002; Ciaschini et al., 2012; Maxim, 2020) or, opposite, claiming that these tax reforms do not improve the environment or generate cost reductions (Babinker et al., 2003; Bovenberg & de Mooij, 1994; Li & Lin, 2013).

Focusing on the Spanish case, previous studies have empirically analysed the effects of an ecotax. Among them is Sancho (2020), who analysed the effectiveness of an ecotax using an inter-industry model that links consumption demand with changes in private income levels resulting from an ecotax for the Spanish economy. The main result was that no double dividend was observed. Others have done so using computable general equilibrium models (Manresa & Sancho, 2005), as this broadens the view by considering the circular flow of income and includes a detailed tax structure. While Labandeira et al. (2004) found a double dividend for a national carbon tax recycled through social security contributions, André et al. (2005) focused on a regional analysis (Andalusia) where the ecotax on emissions was recycled through income taxes or employers' social security contributions, leaving the government deficit unchanged, and found a double dividend as well.

For the present analysis, our analytical tool is based on the extended input-output (I-O) model recently developed by Cardenete et al. (2024). This version of the model improves the explanatory power of the traditional input-output model by linking the price and quantity modules, thus providing feedback between quantities and prices. Since an ecotax will impact prices, it is essential that this price effect is captured by the quantities demanded. At the same time, changes in quantities will affect the demand for factors and their prices, which, in turn, will again affect price formation, and so on. The feedback loop between prices and quantities, which is omitted in the standard I-O model, is appropriately captured in the extended model, providing a better representation of the price-quantity interactions typically observed in the real functioning of markets.

In what follows, we simplify the methodological details of the extended I-O model and focus instead on disclosing the main interdependencies. The model technology is represented by a fixed coefficients nonnegative I-O matrix **A** and fixed labour and capital nonnegative fixed coefficients (row) vectors, **l**' and **k**' respectively. The endogenous variables are the total output vector **x**, the final demand vector **f**, the price vector **p**', total labour use L_u, total capital use K_u, the wage rate w, and the capital services price r.

The quantity equation of the model is represented by:

$$\mathbf{x} = \mathbf{A} \cdot \mathbf{x} + \mathbf{f}(m(w, r, L_u, L_k), \mathbf{p}') \tag{1}$$

In expression (1), final demand **f** depends on private income m and prices **p**'. Private income m, in turn, depends on factor prices and total factors use. The price formation equation follows the price equal average cost rule and takes the form:

$$\mathbf{p}' = \mathbf{p}' \cdot \mathbf{A} + w(L_u, \mathbf{p}') \cdot \mathbf{l}' + r(L_k, \mathbf{p}') \cdot \mathbf{k}' \tag{2}$$

Factor prices depend on demand and supply factors. On the demand side, the level of factors L_u and K_u needed to fulfill production **x** will rise factors prices up if they are above their initial levels. On the supply side, the evolution of commodity prices **p**' will determine the cost of delivering additional units of labor and capital via marginal cost imputations.

Finally, total factors use for labour and capital will depend on the level of total output **x** eventually delivered in the economy:

$$\begin{aligned} L_u &= \mathbf{l}' \cdot \mathbf{x} \\ K_u &= \mathbf{k}' \cdot \mathbf{x} \end{aligned} \tag{3}$$

Expressions (1) to (3) capture the interdependency essentials of the extended I-O model that incorporate feedback between quantities and prices. Also notice that unlike in the standard I-O model, equations (1) and (2) cannot be independently solved by matrix inversion since the usual exogenous variables of the standard model (i.e., final demand and factor prices) now turn out to be endogenous. In other words, the quantity and price equations are no longer independent, and they influence each other, giving overall a higher degree of plausibility to the analysis.

The introduction of an ecotax will directly affect the structure of the price equation (2), creating a ripple effect throughout the system and readjusting all endogenous variables in equations (1) through (3) to the new policy-induced equilibrium state. By comparing the initial values to the counterfactual ones, we can evaluate the role played by the policy and assess its degrees of success in promoting reductions in carbon emissions as well as in possible additional economic dividends.

We implement the extended I-O model using a SAM for Spain in 2016. The SAM builds upon the structure of the I-O Table and comprises a classification of 30 productive activities, two primary factors (labour and capital), two institutional sectors (households and public administration), a savings/investment account, and the foreign sector. In addition, the SAM presents an important tax disaggregation, including a personal income tax, employer and employee social security contributions, net indirect taxes on products and output, other net taxes on production and a value added tax (VAT) distinguishing VAT imputed on consumption, investment, and public administration purchases.

We introduce CO_2 emissions using fixed coefficients that indicate the volume of emissions (in thousands of tonnes) per unit of production and we assume that there is a technological link between the level of economic activity and the level of emissions. This allows any change in the tax structure to affect the allocation of resources to output generation and, hence, to emissions. We have obtained the information on sectoral CO_2 discharges from the air emissions accounts for industries and households from the Instituto Nacional de Estadística of Spain (INE, 2023). All pollutants of CO_2, methane (CH_4), nitrous oxide (N_2O), and household emissions were converted to CO_2 equivalents. This means that we have both production and consumption emissions in our model.

3.1 Scenarios

According to the mitigation report of the sixth assessment cycle of the Intergovernmental Panel on Climate Change (IPCC, 2022), measures taken in Europe to cope with the pandemic and the energy crisis triggered by the invasion of Ukraine led to projections of a global average temperature increase of 3.2°C by 2100. This increases the pressure to prioritise early action on climate change and prompts an update of the PNIEC.

Our research proposes introducing a new environmental tax to achieve one of the PNIEC 2023-2030 objectives. Therefore, we consider three simulations as exogenous shocks to the Spanish tax system, and we correspondingly modify the tax parameters present in the model described above.

Scenario 1: A new homogeneous environmental tax rate of 2.8 per cent per year for 14 years is introduced in the cost function for the production of the required material inputs, which makes it possible to achieve the emission reduction target of the PNIEC 2023-2030 of 32 per cent by 2030 compared to 1990. That is, at an annual rate of 3 per cent, considering that emissions in 2016 were 335,100 thousand tonnes of CO_2, while the PNIEC update sets a target of 194,590 thousand tonnes of CO_2 equivalent by 2030.

In this simulation, the environmental tax is initially incorporated as an *ad-valorem* charge in the price equation (2). The consequent adjustment of equilibrium magnitudes, prices **p'** and quantities **x**, will also adjust total tax collections since all the tax bases depend on prices and quantities. The new environmental tax will add revenue to the taxes already present in the fiscal system[6]. If we label the initial tax revenue as R^0, the new tax revenue will be $R^1>R^0$.

Scenario 2: The same environmental tax rate is introduced while we keep aggregate tax revenue constant in real terms at the initial level R^0. We do this by adequately reducing employers' contributions to Social Security. In other words, we reduce labour taxes by a factor λ to compensate for the presence of the new environmental tax in such a way that total tax collections remain unaltered.

Scenario 3: The ecotax is levied as in scenario 1, but now the extra tax revenue is fully used to finance additional government spending to stimulate the economy in a Keynesian way. The restriction is to keep government deficit constant. If G denotes aggregate government spending, the simulation examines the new equilibrium state where R^1-G^1= R^0-G^0. Since tax revenue increases, sectoral government expenditures are scaled up by a factor μ that respects the policy preference expressed in the initial expenditure vector.

[6] The different taxes in the model include: personal income taxes, indirect taxes on production, value-added taxes, employers' contribution to Social Security, and employees' contributions to Social Security.

The three scenarios focus on promoting the reduction of CO_2 emissions via taxation to achieve the first dividend, i.e., the environmental dividend. Additionally, considering the intersectoral relationships in the economy and the circular flow of income, we also assess the impact of these measures regarding he possibility of a second or third dividend, i.e., the impact of fiscal policies on employment, income, and welfare. To facilitate a better understanding of the results, it is worth clarifying the mechanism of the chain reaction generated by the introduction of the ecotax in our model. First, it affects price formation, which subsequently influences the consumer price index, the cost of using primary factors, the adjustment of wages and transfers via indexation, the welfare of private agents, consumers' demand, and the level of total output. Once all these effects have been generated, it is possible to determine the changes in CO_2 emissions, income, labour, and welfare.

4. Results and discussion

Tables 1, 2, 3 and 4 summarise the results obtained. Each table includes a comparison between the initial equilibrium and the results after the application of each of the three scenarios. Table 1 also shows the results for tax revenue in the six categories considered, including the new ecotax.

Table 1. Main tax indicators in millions of Euros.

		Scenario 1		Scenario 2		Scenario 3	
Tax categories	**Initial**	**After shock**	**% Variation**	**After shock**	**% Variation**	**After shock**	**% Variation**
Indirect tax	31.909	30.104	-5,65	30.251	-5,20	29.884	-6,34
Environmental tax		59.863		61.302		59.573	
Value added tax	82.388	77.944	-5,39	81.562	-1,00	77.502	-5,93
Corporate labour tax	109.834	102.713	-6,48	52.587	-52,12	101.956	-7,17
Personal labour tax	37.143	34.722	-6,52	36.629	-1,38	34.465	-7,21
Income tax	83.644	78.998	-5,55	82.587	-1,26	78.562	-6,08
Total collections	344.918	384.318	11,42	344.918	0,00	381.943	10,73

Source: own elaboration

As mentioned above, the initial revenue from the ecotax is zero. Therefore, an average variation of 60.246 million euros would be expected after its implementation on total production. However, although the collection of taxes increases in scenarios 1 and 3 due to the new tax (11.42 per cent and 10.73 per cent, respectively), the collection of the remaining five categories decreases, with the collection of labour taxes by the employer and the employee being particularly affected (by 6.48 per cent and 6.52 per cent respectively in scenario 1; by 7.17 per cent and 7.21 per cent respectively in scenario 2). In Scenario 2, the employer's contribution is reduced by 52.12 per cent, avoiding the drastic reduction in VAT, employee contribution and income tax, which barely exceeds 1 per cent of the variation.

Table 2 presents the main income and labour indicators. As shown, the introduction of an ecotax is reflected in the economy as an increase in prices, which is more pronounced in scenarios 1 and 3, with price increases of 12.1 per cent and 11.3 per cent, respectively. It is noteworthy that in scenario 2, where the green tax is offset by a reduction in the employer's contribution, prices increase by only 2 per cent. The wage share increases by 7.8 per cent and 7.9 per cent in scenarios 1 and 3, respectively, while it increases by 1.2 per cent in scenario 2. However, the contribution of demand and supply influences on the change in the wage rate shows that most of the change in the wage rate originates on the supply side (reflecting the impact of marginal costs), which is more pronounced in scenarios 1 and 3, and to a lesser extent in scenario 2. On the other hand, the impact of demand on the wage rate is negative, so its increase is weighted differently.

Table 2. Main labour and income indicators

		Scenario 1	Scenario 2	Scenario 3
Labour and income Indicators	**Benchmark**	**After shock**	**After shock**	**After shock**
CPI	1	1,121	1,020	1,113
Wage rate	1	1,078	1,012	1,069
Capital price	1	1,095	1,013	1,085
Employment (% change)		-2,74	-0,63	3,35
Demand influence on wage rate		-0,012	-0,003	-0,015
Supply influence on wage rate		0,091	0,015	0,085
Labour income (% change)		-6,52	-1,38	-7,21
Non-labour income (% change)		-5,05	-1,20	-5,49
Lambda for tax compensation			0,5145	

Source: own elaboration

Table 2 also indicates that scenarios 1 and 2 are less detrimental to non-labour income, as they experience smaller declines in real terms compared to labour income. The decline in labour income affects purchasing power due to the adjustment of the CPI. However, the reduction in employer contributions in scenario 2 reduces the CPI and prevents a further decline in labour income. Regarding the level of employment, the three scenarios yield different results. Introducing an ecotax leads to a decrease in employment of 2.74 per cent in scenario 1, which could be mitigated by recycling it through the employer's contribution in scenario 2, resulting in a much smaller decrease in employment of 0.63 per cent. Scenario 3, on the other hand, presents the opposite outcome, as recycling ecotax revenues through public spending would imply an increase in employment of 3.35 per cent. Nonetheless, labour income in this scenario experiences the most significant decrease.

Table 3 presents the results for the main welfare indicators. As shown, disposable income decreases in all three scenarios, but this decline is less pronounced when the ecotax is recycled through a reduction in the labour share (-1.30 per cent). Similarly, real GDP declines by 3.23 per cent and 3.78 per cent in the first and third scenarios, respectively, while it remains nearly unchanged in the second scenario (-0.74 per cent). Regarding the output index, it decreases by 3.11 per cent in the first scenario and only slightly in the second scenario (-0.71 per cent). However, the most interesting result is found in the third scenario, where an increase in public spending while keeping the public deficit constant implies an increase in production, leading to higher prices. Surprisingly, this results in a reduction in purchases of goods and services. In other words, the price effect offsets the increase in income, similar to the crowding-out effect. This is reflected in the equivalent and compensating variations changes over real GDP. For the third scenario, the level of additional income in terms of real GDP needed to compensate for the estimated welfare loss would be 0.87 per cent. In contrast, scenarios 1 and 3 would be 3.88 per cent and 4.28 per cent, respectively. Once again, the second simulation shows better results in terms of welfare. In terms of the Konus cost-of-living index, there is a decrease in relative welfare in all three scenarios, with scenario 2 experiencing a lesser decrease as expected.

Table 3. Main welfare indicators

Welfare indicators	Benchmark	After shock	After shock	After shock
Disposable income (% change)		-5,67	-1,30	-6,22
Real GDP (% change)		-3,23	-0,74	-3,78
Output index (% change)		-3,11	-0,71	3,59
Equivalent variation (% over real GDP)		-3,88	-0,87	-4,28
Compensating variation (% over real GDP)		-4,35	-0,88	-4,77
Konus Index (cost of living)	1	1,12	1,02	1,11

Source: own elaboration

Finally, Table 4 shows the results in terms of emission reductions. Although Scenario 2 produces better results in economic and welfare terms, this is not the case in terms of emission reductions, as it would only achieve an annual reduction of 0.71 per cent. On the other hand, scenarios 1 and 2 would provide a compelling incentive to reduce emissions, allowing them to decrease at an annual rate that would meet the target set by the PNIEC.

Table 4. Impact of policies on CO_2 emissions (Thousand tonnes CO_2 equivalent)

Emissions	Scenario 1	Scenario 2	Scenario 3
Initial	326.262	326.262	326.262
After shock	316.202	323.957	314.808
Variation in %	-3,08	-0,71	-3,51

Source: own elaboration

The debate on environmental policies often revolves around the possibility of imposing burdens on the economy, such as taxes (Fullerton & Metcalf, 1997), which can have distortionary effects on consumption. The introduction of an environmental tax alters the relative prices of goods and services, potentially influencing the consumption choices of households. However, as a means of generating revenue, the government could utilise it to discourage inefficient behaviour. This revenue could then be used to finance the reduction of distortionary taxes, not only aiding in emissions reduction but also compensating for welfare losses (Bohm, 1997), as we see in our second scenario.

Other studies have demonstrated that the results obtained depend on the structural conditions of the economy, which would allow for the achievement and sustainability of such a double dividend over time. For instance, Babiker et al. (2003) illustrated that a weak double dividend may not occur if an economy is burdened with numerous distortions. As our second scenario has indicated, compared to the first, a budget-neutral tax reform could reduce CO_2 emissions while mitigating the negative economic impact, corroborating the findings of other empirical analyses (Manresa & Sancho, 2005)[7].

However, as observed, the tax burden has been shifted onto primary factors (labour and capital), affecting the employment rate. This contrasts with scenario 3, where maintaining the public deficit constant positively affects the employment rate. In this third scenario, although the economy experiences contraction, there is a slightly more significant reduction in emissions than anticipated to achieve the emission reduction target for 2030, accompanied by an increase in employment of 3.35 per cent, indicating signs of a third dividend (Freire-González, 2018).

The results obtained with the first and second scenarios in terms of emission reductions (-3.08 per cent and -0.71per cent, respectively) are like those obtained by Manresa and Sancho (2005), who simulate through a Computable General Equilibrium Model (CGE) the adoption of taxes on energy use without recycling the revenues, obtaining a level of CO_2 emission reduction of 4 per cent (first scenario). On the other hand, when they consider a neutral reduction in labour taxes, total emissions decrease, but less than in the previous simulation. This allows us to confirm that, although our three scenarios show a contraction in economic activity, they lead to reduced emissions (first dividend). However, the second simulation shows that the economy reacts little to the recycled ecotax by reducing the employer's share. This may further indicate the Spanish economy's ability to respond positively to an effective environmental policy on CO_2 emissions based on low-cost labour tax reductions (second dividend) (Maxim, 2020).

Note that the equivalent change indicator varies less in scenario 2 than in scenarios 1 and 3. However, the third scenario shows a better response in terms of CO_2 emission reduction and employment (third dividend), which could be appropriate for Spain, which is characterised by high unemployment rates. However, this result is contrary to that found by Allan et al. (2014), who, after analysing three scenarios similar to ours, did not find a double dividend for recycling through an increase in public spending, while they did find a double dividend for recycling through a reduction in income tax. Nevertheless, we agree with Maxim (2020), who concludes on the empirical robustness of the double and triple dividends found in the results for European

[7] Manresa and Sancho (2005) found that in addition to the proven impact on CO_2 emissions and the efficiency of the tax system, it also improves employment levels, which could be described as a triple dividend.

countries, as well as on the effectiveness of recycling the ecotax on CO_2 emissions through labour taxes.

It should be noted that the results obtained are closely linked to the formulation of the tax rate and the modelling approach employed. Applying the same rate to all sectors and making certain simplifying assumptions introduces greater distortions, which could be mitigated by refining the proposed simulation. Some studies have demonstrated that altering certain assumptions (Bento & Jacobsen, 2007) or utilising more sophisticated models (Fernández et al., 2011; Fodha et al., 2018) could potentially lead to situations of double and triple dividends.

5. Concluding remarks

Our research analyses the introduction of an ecotax into the Spanish economy to achieve the emission reduction target proposed in the PNIEC 2023-2030 and the potential for a double or triple dividend resulting from it through three scenarios (counterfactuals). To achieve this goal, we adapt the methodology proposed by Cardenete et al. (2024), which is based on input-output analysis but overcomes the limitation presented in terms of independently determining quantities and prices. The model has been calibrated with a SAM constructed for Spain with the base year 2016. This SAM reflects the circular flow of income and captures the economic interdependence between activities and institutional sectors, and establishes a correspondence with the system variables represented in the model.

In summary, we have defined our scenarios with reference to the literature on environmental taxation and have examined their potential to incentivise emissions reductions. Additionally, apart from evaluating its impact on environmental efficiency, the possible capacity of these policies to generate beneficial effects on economic activity and welfare must also be evaluated, allowing us to verify the possible existence of a double or even a triple dividend.

Our main findings suggest that, although all three scenarios confirm the ability of the ecotax to contribute to the reduction of CO_2 emissions (first dividend), scenarios 1 and 3 would make it possible to achieve the target set in the PNIEC 2023-2030, but they would also generate economic costs to a greater or lesser extent. Increasing the costs of polluting industries may have some negative effects that are difficult to measure, thus avoiding verification of the double dividend hypothesis (Oates, 1995).

In Scenario 2, recycling the ecotax through a reduction in employers' contributions leads to a smaller economic contraction and a reduction in CO_2 emissions, although to a lesser extent than in the other two scenarios. This suggests that a double dividend could be achieved, as it was expected that the tax compensation would make the ecotax less effective in reducing emissions.

Scenario 3, on the other hand, shows the most considerable reduction in CO_2 emissions and a significant impact on labor, income, and welfare indicators, but responds positively in terms of employment, showing signs of a third dividend.

Although the results described above are counterfactual, the type of effects we potentially observe highlights the relevance for the proper design of environmental tax policies, especially in discerning the possibility of additional positive dividends, as has been discussed for years by academics and politicians. The model we use, even when it overcomes the traditional price-quantity dichotomy of input-output analysis, makes simplifying assumptions, and does not capture reality in its entirety (McKitrick, 1997). Thus, the usual caveat regarding caution in interpretation applies. What seems certain is that an ecotax would definitely work in reducing CO_2 emissions.

In terms of the possibility of obtaining a double dividend, our results seem to indicate that its occurrence in Spain following the implementation of an ecotax would be likely, aligning with the findings of various studies at the European level. Freire-González (2018) analysed 40 studies on the double dividend hypothesis of environmental taxation using CGE modelling between 1993 and 2016 and found that 55.1 per cent of the simulations achieved a double dividend through recycling environmental taxes to reduce other taxes or through compensatory lump-sum transfers, with the former being the most effective method. Maxim (2020) obtained similar results, concluding from his analysis that European countries tend to achieve the best outcomes in obtaining second and third dividends.

To improve the design of our approach, one possibility would be to fine-tune the ecotax rates based on CO_2 emissions content or intensity ranges. As a first approximation, we have defined a policy that is easier to apply by omitting the implementation and regulation costs associated with ecotax rates adapted to the specific level of sectoral emissions. The analysis of policies more correlated to the damage caused by emissions would be an extension of this study since the studies carried out to date show that the design and modulation of the fiscal measure is essential to achieve the expected impacts in the environmental, economic, and social areas. It would also be important to analyse what would happen if the tax rates were reduced in line with the reduction in polluting emissions, which is the expected result, especially if the tax depends on the amount of CO_2 emitted. The effectiveness of the measure is likely to change, especially when the first dividend is achieved.

Funding

The first and second author thank the support of the Climamodel-SEJ511 project funded by PAIDI, Junta de Andalucía. The third author thanks the support of Research Projects PID2020-116771GB-100 from the Ministry of Science of Spain and SGR-2021-00194 from the Department of Universities and Research of Catalonia.

Statements and declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abdullah, S., & Morley, B. (2014). Environmental taxes and economic growth: Evidence from panel causality tests. *Energy Economics*, *42*, 27-33. http://dx.doi.org/10.1016/j.eneco.2013.11.013

Allan, G., Lecca, P., McGregor, P., & Swales, K. (2014). The economic and environmental impact of a carbon tax for Scotland: A computable general equilibrium analysis. *Ecological Economics*, *100*, 40-50. https://doi.org/10.1016/j.ecolecon.2014.01.012

André, F. J., Cardenete, M. A., & Velázquez, E. (2005). Performing an environmental tax reform in a regional economy. A computable general equilibrium approach. *The Annals of Regional Science*, *39*, 375-392. https://doi.org/10.1007/s00168-005-0231-3

Aslani, A., Naaranoja, M., & Wong, K. F. V. (2013). Strategic analysis of diffusion of renewable energy in the Nordic countries. *Renewable and Sustainable Energy Reviews*, *22*, 497-505. https://doi.org/10.1016/j.rser.2013.01.060

Babiker, M. H., Metcalf, G. E., & Reilly, J. (2003). Tax distortions and global climate policy. *Journal of Environmental Economics and Management*, *46*(2), 269-287. https://doi.org/10.1016/S0095-0696(02)00039-6

Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy*. Cambridge University Press.

Bento, A. M., & Jacobsen, M. (2007). Ricardian rents, environmental policy and the 'double-dividend' hypothesis. *Journal of Environmental Economics and Management*, *53*(1), 17-31. https://doi.org/10.1016/j.jeem.2006.03.006

Bohm, P. (1997). *Environmental taxation and the double dividend: fact or fallacy*. In T. O'Riordan (Ed.), *Ecotaxation* (106-124). Earthscan, London. https://10.4324/9781315070674-10

Bovenberg, A. L. (2002). Green tax reforms and the double dividend: an updated reader's guide. In *Environmental Policy Making in Economies with Prior Tax Distortions* (pp. 73-96). Edward Elgar Publishing. https://doi.org/10.4337/9781035304639.00010

Bovenberg, A. L., & de Mooij, R. A. (1994). Environmental policy in a small open economy with distortionary labor taxes: a general equilibrium analysis. In *International environmental economics: Theories, models and applications to climate change, international trade and acidification* (pp. 213-254). Elsevier.

Bovenberg, A. L., & Goulder, L. H. (2002). Environmental taxation and regulation. In *Handbook of public economics* (Vol. 3, pp. 1471-1545). Elsevier.

Cardenete, A., Lima, MC. & Sancho, F. (2024). A methodology to study price-quantity interactions in input-output modeling: an application to NextGenerationEU funds. *Economic Systems Research*, https://doi.org/10.1080/09535314.2024.2337375

Ciaschini, M., Pretaroli, R., Severini, F., & Socci, C. (2010). Environmental tax reform and double dividend evidence. *WP Economic Developmment Department-University of Macerata*.

Ciaschini, M., Pretaroli, R., Severini, F., & Socci, C. (2012). Regional double dividend from environmental tax reform: An application for the Italian economy. *Research in Economics*, *66*(3), 273-283. https://doi.org/10.1016/j.rie.2012.04.002

de Mooij, R. A. (2002). The double dividend of an environmental tax reform. *Handbook of Environmental and Resource Economics*, 293-306.

Edenhofer, O., & Kalkuhl, M. (2011). When do increasing carbon taxes accelerate global warming? A note on the green paradox. *Energy Policy*, *39*(4), 2208-2212. https://doi.org/10.1016/j.enpol.2011.01.020

European Commission (2019). The European Green Deal. Retrieved from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

European Commission (2023). Progress made in cutting emissions. Energy, Climate change, Environment. Retrieved from https://climate.ec.europa.eu/eu-action/climate-strategies-targets/progress-made-cutting-emissions_en

European Parliament (2021). Official Journal of the European Union. Regulation (EU) 2021/1119 of The European Parliament and of the Council of 30 June 2021. European Climate Law. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119

Eurostat (2024). Database. Environmental tax revenues. Retrieved from https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax__custom_10336101/default/table?lang=en

Fernández, E., Pérez, R., & Ruiz, J. (2011). Optimal green tax reforms yielding double dividend. *Energy Policy*, *39*(7), 4253-4263. https://doi.org/10.1016/j.enpol.2011.04.041

Fodha, M., Seegmuller, T., & Yamagami, H. (2018). Environmental tax reform under debt constraint. *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, (129), 33-52. https://doi.org/10.15609/annaeconstat2009.129.0033

Freire-González, J. (2018). Environmental taxation and the double dividend hypothesis in CGE modelling literature: A critical review. *Journal of Policy Modeling*, *40*(1), 194-223. https://doi.org/10.1016/j.jpolmod.2017.11.002

Fullerton, D., & Metcalf, G. E. (1997). Environmental taxes and the double-dividend hypothesis: did you really expect something for nothing?. National Bureau of Economic Research (No. w6199).

Gemechu, E. D., Butnar, I., Llop, M., & Castells, F. (2014). Economic and environmental effects of CO2 taxation: an input-output analysis for Spain. *Journal of Environmental Planning and Management*, *57*(5), 751-768. https://doi.org/10.1080/09640568.2013.767782

Goulder, L. H. (1995). Environmental taxation and the double dividend: a reader's guide. *International Tax and Public Finance*, *2*, 157-183.

Grubb, M., Edmonds, J., Ten Brink, P., & Morrison, M. (1993). The costs of limiting fossil-fuel CO2 emissions: a survey and analysis. *Annual Review of Energy and the Environment*, *18*(1), 397-478. https://doi.org/10.1146/annurev.eg.18.110193.002145

INE (2023). Cuentas medioambientales. Emisiones a la atmósfera. Serie 2008-2022. Retrieved from https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176941&menu=ultiDatos&idp=1254735976603

INE (2023). Cuentas medioambientales. Impuestos ambientales. Avance 2022 y año 2021. (Last accessed on 15 February 2024). https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176942&menu=ultiDatos&idp=1254735976603#:~:text=Losper cent20impuestosper cent20ambientalesper cent20alcanzaronper cent20los,queper cent20enper cent20elper cent20aper centC3per centB1oper cent20anterior

Intergovernmental Panel on Climate Chante, IPCC (2022).AR6 Synthesis Report: Climate Change 2022. Retrieved from https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

Khastar, M., Aslani, A., & Nejati, M. (2020). How does carbon tax affect social welfare and emission reduction in Finland? *Energy Reports*, 6, 736–744. https://doi.org/10.1016/j.egyr.2020.03.001

Labandeira, X., Labeaga, J. M., & Rodríguez, M. (2004). Green tax reforms in Spain. *European Environment*, *14*(5), 290-299. https://doi.org/10.1002/eet.361

Li, A., & Lin, B. (2013). Comparing climate policies to reduce carbon emissions in China. *Energy Policy*, *60*, 667-674. https://doi.org/10.1016/j.enpol.2013.04.041

Manresa, A., & Sancho, F. (2005). Implementing a double dividend: recycling ecotaxes towards lower labour taxes. *Energy Policy*, *33*(12), 1577-1585. https://doi.org/10.1016/j.enpol.2004.01.014

Maxim, M. R. (2020). Environmental fiscal reform and the possibility of triple dividend in European and non-European countries: Evidence from a meta-regression analysis. *Environmental Economics and Policy Studies*, *22*, 633-656. https://doi.org/10.1007/s10018-020-00273-8

McKitrick, R. (1997). Double dividend environmental taxation and Canadian carbon emissions control. *Canadian Public Policy/Analyse de Politiques*, 417-434. https://doi.org/10.2307/3552072

Ministerio para la Transición Ecológica y el Reto Demográfico MITECO (2023). Borrador de actualización del PNIEC 2023-2030. Retrieved from https://www.miteco.gob.es/es/energia/participacion/2023-y-anteriores/detalle-participacion-publica-k-607.html

Oates, W. E. (1995). Green taxes: Can we protect the environment and improve the tax system at the same time? *Southern Economic Journal*, 915-922. https://doi.org/10.2307/1060731

Parry, I.W., 2004. Are emission permits regressive? *Journal of Environmental Economics and Management* 47, 364–387. https://doi.org/10.1016/j.jeem.2003.07.001

Pearce, D. (1991). The role of carbon taxes in adjusting to global warming. *The Economic Journal*, 101(407), 938-948.

Pigou, A. C. (1920). *The economics of welfare*. London: McMillan & Co.

Pyatt, G., y Thorbecke, E. (1976). *Planning techniques for a better future.* Geneva: International Labour Office.

Sancho, F. (2021). The mitigation potential of eco-taxation on carbon emissions: income effects under downward rigid wages. *Environmental Economics and Policy Studies*, *23*(1), 93-107. https://doi.org/10.1007/s10018-020-00280-9

Shmelev, S. E., & Speck, S. U. (2018). Green fiscal reform in Sweden: econometric assessment of the carbon and energy taxation scheme. *Renewable and Sustainable Energy Reviews*, *90*, 969-981. https://doi.org/10.1016/j.rser.2018.03.032

Statistics Finland (2017). Accrual of environmental taxes was over EUR 6 billion in 2015. Retrieved from https://www.stat.fi/til/yev/2015/yev_2015_2017-09-07_tie_001_en.html

Thorbecke E (1985) *The social accounting matrix and consistency-type planning models.* In: Pyatt, G. and Round, J. (Eds.) Social accounting matrices: a basis or planning. Washington D.C: World Bank.

Toprak, D. (2018). Environmental policies and fiscal Instruments in the context of sustainable development: An analysis of environmental taxes. *Mehmet Akif Ersoy*

Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, *5*(3), 812-838. https://doi.org/10.30798/makuiibf.419655

Tullock, G. (1967). Excess benefit. *Water Resources Research*, *3*(2), 643-644.

Uri, N. D., & Boyd, R. (1997). An evaluation of the economic effects of higher energy prices in Mexico. *Energy Policy*, *25*(2), 205-215. https://doi.org/10.1016/S0301-4215(96)00126-7

Wei, Y. M., Mi, Z. F., & Huang, Z. (2015). Climate policy modeling: an online SCI-E and SSCI based literature review. *Omega*, *57*, 70-84. https://doi.org/10.1016/j.omega.2014.10.011

Wesseh Jr, P. K., Lin, B., & Atsagli, P. (2017). Carbon taxes, industrial production, welfare and the environment. *Energy*, *123*, 305-313. https://doi.org/10.1016/j.energy.2017.01.139