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Aiming for carbon neutrality: which environmental taxes does Spain need by 2030?

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Abstract

The Green Deal is a new European strategic plan aiming to achieve carbon neutrality in 2050 with a 55%-reduction in emissions by 2030 as an intermediate target. In the next three decades European policymakers will use a wide set of policy levers to achieve these targets, including taxes on fossil fuels and carbon prices. In this context, this study uses a competitive general equilibrium model for a small open economy to identify the optimal tax-mix for oil, natural gas and coal in Spain for a given target of carbon emissions from energy use. The ambitious environmental target for 2030 requires a tax increase of around 50 percentage points in the case of oil, 200 percentage points in the case of natural gas, and 700 percentage points in the case of coal. Alternatively, Spain could replace those taxes on fossil fuels by a carbon tax of 150 €/tCO2, being this level a reference on the carbon price needed to achieve the new European target. This study shows that an optimal mix of taxes or a carbon tax lead to approximately the same welfare loss in the long run, although welfare losses during the transition are slightly higher in the case of the carbon tax when the emissions target is very ambitious. A useful policy insight from this paper is that the current tax rates on fossil fuels are inconsistent with the new European target and, therefore, significant increases are needed, or a considerable higher carbon price is required.

Keywords: CO2 emissions, environmental policy, fossil fuels, optimal tax mix, carbon tax.

JEL Classification: C61, C63, F41, H21, H23, Q43

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1. Introduction

December 2019 marks the presentation of the Green Deal, the European Commission's strategic plan for achieving climate-neutrality by 2050. This plan aims to transform the European Union into a "modern, resource-efficient and competitive economy with no net emissions of greenhouse gases by 2050, in which economic growth is decoupled from resource use and no person or place is left behind"[1]. As part of this strategy and as an intermediate target, the Commission aims to reduce greenhouse gas emissions in at least 55% with respect to 1990 levels by 2030. This target is more ambitious than the previous 40% target for 2030[2]. Within this context, Spain seeks to pass a new climate law to cut its emissions to net zero by 2050. The current Spanish Strategy for a Long-term Decarbonization[3] sets a 23% reduction in greenhouse emissions by 2030. Figure 1 shows annual combusted fossil fuel carbon emissions in Spain from 1965 to 2019[4] and the different targets for 2030.

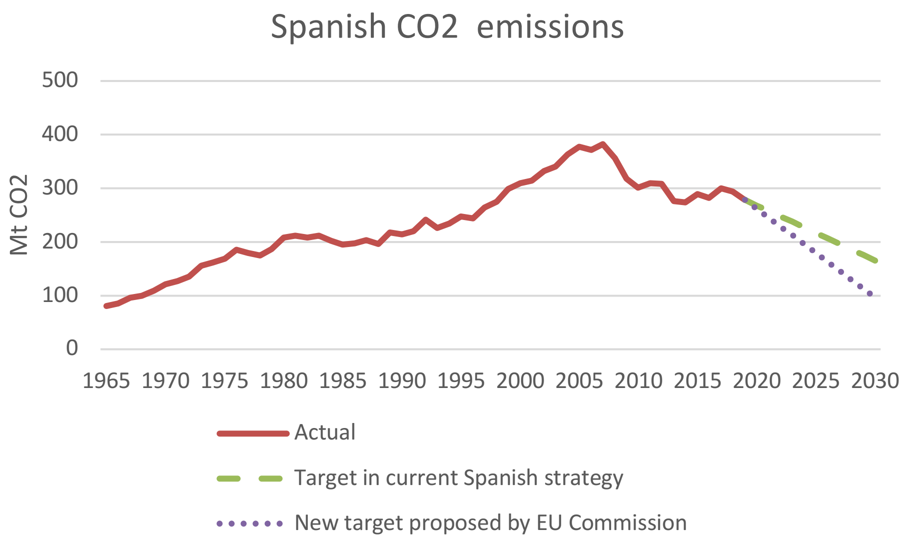

FIGURE 1

[1] European Commission web page: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en, accessed on September 29th, 2020.
[2] 2030 Climate Target Plan. https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en#:~:text=The%20Commission%27s%20proposal%20to%20cut,becoming%20climate%20neutral%20by%202050%20, accessed on September 29th, 2020.
[3] https://energia.gob.es/en-us/Participacion/Paginas/DetalleParticipacionPublica.aspx?k=336, accessed on September 29th, 2020.
[4] BP Statistical Review of the World Energy June 2020.

Consequently, European policymakers should select a set of policy instruments to significantly curb emissions over the coming years. To this end, carbon taxes are emerging as the right policy tool to reduce greenhouse emissions. As many as 27 Nobel Laureate economists endorsed a proposal published in January 2019 to tax carbon emissions in the United States[5] and return the tax revenues to citizens in the form of dividends. On the other hand, developed countries already use a variety of taxes on fossil fuels for fiscal and environmental proposes.[6]

Identifying the interaction among taxes, international fossil fuel prices, economic activity and carbon emissions is no easy task. Governments tax fossil fuels to different ends such as diversifying energy sources, increasing fiscal revenues, favoring the development of certain industries as well as for environmental reasons (International Energy Agency, 2013). Taxes change the relative price of fossil fuels, which impacts energy consumption, the composition of the energy mix, level of economic activity, societal welfare and thereby ultimately affects carbon emissions.

The aim of this study is to find the tax rate on fossil fuels and carbon consistent with targets for 2030 fixed by the current Spanish strategy (23% below 1990 levels) and the EU commission (55% below 1990 levels). Given the carbon targets indicated by the European Commission, the level of these taxes might prove useful as a benchmark for policymakers.

This study uses a general equilibrium model for the Spanish economy. Focusing on long-run impacts, the government taxes the consumption of oil, coal and natural gas to achieve its environmental target. We identify the optimal mix of taxes on fossil fuels under a competitive equilibrium solution to achieve a specific carbon emissions reduction target. We compare the optimal tax-mix to a standard carbon tax in terms of the welfare cost for each alternative. Previous

[5] https://clcouncil.org/economists-statement/

[6] OECD (2019), Taxing Energy Use 2019: Using Taxes for Climate Action, OECD Publishing, Paris, https://doi.org/10.1787/058ca239-en.

studies focus on the optimal tax on a specific fossil fuel. However, to the best of our knowledge, a gap is present concerning optimal taxes on oil, natural gas and coal simultaneously.

The rest of the paper is organized as follows. Section 2 briefly describes existing literature on this topic. Section 3 features a brief summary of our model assessment. Section 4 presents and discusses quantitative and qualitative results. Finally, section 5 concludes and presents policy implications.

2. Literature review

The final impact of a specific policy on emissions will ultimately depend on the structure of the economy, household preferences, technological conditions, international energy prices and the potential flexibility for switching among different fuels. Aldy and Stavins (2012) study the advantages and disadvantages of different environmental policy tools such as carbon taxes, cap-and-trade, emission reduction credits, clean energy standards and fossil fuel subsidy reductions. This study additionally provides policymakers with the choice to either adapt or live with the consequences of climate change. Precisely, the Paris Agreement suggests that a combination of mitigation and adaptation policies provides the most cost-effective policy response at a national level for each country in function of their distinct social-economic circumstance, state of development and resource endowment. Nordhaus (2007) analyses the advantage of price-type approaches like carbon and fossil fuel taxes, over quantity-oriented control instruments. He concludes that price-type approaches present some relevant advantages in reducing greenhouse emissions. Hassler et al (2016) reach a similar conclusion. Marron and Toder (2014) signal that implementing carbon taxes at a global level poses significant challenges, and the potential benefits of a carbon tax will depend on the practical implementation of said tax.

This paper is based on the model by Blazquez et al. (2017), which uses a Dynamic Stochastic General Equilibrium (DSGE) model to explore the relationship between the international price of these three primary fossil fuels and carbon emissions in the short term. They find that international prices directly affect carbon emissions by way of their impact on the fossil fuel mix, while doing so indirectly by way of their impact on economic growth. A similar approach has been used by Pereira and Pereira (2014) for the case of Portugal and Tumen et al. (2016) for Turkey. Golosov et al. (2014) use a global approach to analyse long-run optimal environmental taxation. They find that the optimal carbon tax is generally higher than the well-known estimates by Nordhaus and Boyer (2000), but it is well below the levels needed to achieve the required Paris Agreement target reductions in carbon emissions. Golosov et al. (2014) also states that coal is the main threat to climate change due to its abundant reserves. A computable general equilibrium model (CGE) is the methodological approach used by Barker et al. (2007) to explore carbon leakage in six European countries. Kumbaroğlu (2003), using the same methodology for a small emerging open economy, suggests that the government should use taxes to incentive coal consumption and disincentive oil and natural gas to accelerate economic growth in the short term in Turkey. Solaymani (2017) explores the impact of fossil fuel taxes on carbon emissions in a small open economy using a CGE model. This study states that carbon taxes are more efficient than energy taxes in reducing CO_2 emissions in Malaysia. Parry and Williams (1999) compare a set of eight policy instruments in the US economy under different scenarios. They find that quotas tend to generate higher welfare losses than do taxes and emission permits.

Other studies look at the impact of environmental taxes on the economy and emissions. Franks et al. (2015) suggest that fiscal objectives can be as relevant as environmental targets. They find that carbon taxes in fossil-fuel importing countries may capture part of the revenue of fossil fuel producers. Also using a CGE model, Fraser and Waschik (2013) find that environmental taxes on different types of energy resources, including fossil fuels, lead to a double dividend in the case of Australia. Finally, Ferran (2010) employs a similar methodology for Spain to assert the critical role of elasticities of substitution among inputs in achieving a double dividend.

Basing our work on the described results of the aforementioned literature, we implement environmental policy by changing fossil fuel tax rates. This policy is easy to implement, and it impacts positively on emissions (Nordhaus (2007), Hassler et al (2016), Marron and Toder (2014), Parry and Williams (1999) among others). Finally, we compare the efficiency of this policy with that of carbon tax because it is the instrument currently proposed by governments and international institutions.

3. The model

We adapted the neoclassical growth model for Spain proposed by Blazquez et al. (2017) to include the government. Our model consists of a decentralized small open economy with a representative household, competitive firms, government and external sector that interact actively by trading final goods, foreign bonds and three primary energy inputs[7]: oil, natural gas and coal. This model focuses on carbon emissions from energy use; it ignores emissions arising from land use, agriculture, or industrial processes like cement or steel production.

The representative household obtains utility from the consumption of final goods and leisure.[8] This household maximizes its expected utility defined over the sequences of consumption and labor subject to a budget constraint. The total income consists of four components: labor income, the return on real capital stock, the real return on debt holdings and a lump-sum transfer from government. On the other hand, current income and financial wealth can be used for consumption, investment in physical capital, and portfolio changes.

[7] From a methodological point of view, one limitation of our study is that no renewables technology is taken into consideration. Renewables make it possible to keep the consumption of energy constant while reducing the use of fossil fuels. In other words, the deployment of renewable sources would help curb the consumption of fossil fuels. However, from a technical point of view, renewable sources can only replace fossil fuels to a certain point. The electricity sector can partially shift from the use of coal or natural gas to renewable sources. Yet fossil fuel powered generation plants will remain critical given the limitations of current renewable technologies. Future technological developments such as cost-effective large-scale batteries may provide a solution to the problem of intermittency. These developments could undermine the importance of taxes on fossil fuels or carbon emissions. At any rate, fossil fuels represent 82% of the primary energy throughout the sample under study.

[8] It would be interesting to include the consumption of final energy in the utility function because the consumption of numerous goods and services requires energy. This could potentially increase the welfare cost of a tax reform. However, one of our objectives is to compare the effectiveness of taxing energy inputs versus a carbon tax. The omission of final energy in the utility function therefore has no impact on the result of this comparison.

Crude oil, natural gas and coal are the only three primary sources of energy of this economy; all of them are inputs in the production function for final goods and services. Firms also use labor and capital as inputs. The production function for final goods F is a Cobb-Douglas technology function nested with two Constant Elasticity of Substitution (CES) functions G and H that model the technical relationship between fossil fuels. The use of a Cobb-Douglas function combining labor, capital and energy to model the production of the final good is standard practice in macroeconomic literature given its consistency with stable shares of factor payments on national income, as shown by the data (see Golosov et al, 2014)[9]. However, we propose the CES function, a more general structure for the energy part of the model because the estimated values for the parameters of the CES function reflect different degrees of complementarity or substitution between these intermediate inputs. This is a key point in the paper. Eq (1) describes the production function.

$$Good_t = F\left(capital_t, labor_t, G\left(oil_t, H(gas_t, coal_t)\right)\right) \quad (1)$$

where $Good_t$ is the final good, and F, G and H are functions that model the combination of the labor, the stock of capital, oil, natural gas and coal as inputs to produce the final good.

The firm producing the final goods and services is perfectly competitive and maximizes profits subject to the technological constraint described in Eq. (1), which requires energy inputs to produce the final good, i.e. the producer of the final good is constrained by energy costs and the energy production process.

[9] It could be convenient to generalize the production function of the final good to consider lower substitution elasticities between energy and the composite capital-labor, as supported by some empirical results with microdata (see Koetse, De Groot and Florax, 2008). However, these authors among others (Hassler et al. 2012 for the US economy) find that substitution between inputs is lower in the short-term and higher in the long-term. A Cobb-Douglas production technology seems to be a reasonable assumption given that the long-term effects of the environmental policy are the object of our study. Please note that the available data for Spain are annual; input substitution is easier in an annual period than it is in quarterly or monthly periods.

The government taxes fossil fuels and transfers a lump-sum of the corresponding revenues to the representative household. This mechanism minimizes the impact of taxes on household disposable income and the government runs a balanced fiscal budget.

It is important to stress that Spanish CO_2 emissions make no impact on household welfare or economic activity through global warming. In this model, the level of carbon emissions is irrelevant to the household and the firm. They only pay attention to economic variables such as private consumption, investment or profits. The government sets a carbon emissions target according to an exogenous environmental criterion, i.e. it follows the carbon target set by the European Commission. We think this is a reasonable assumption given the size of Spanish carbon emissions (0.9% of global emissions).

In order to achieve target carbon emissions in a decentralized economy, the government must solve a second-best problem in the steady state[10]. The government must choose a combination of tax rates on fossil fuels that maximizes household welfare in steady state while simultaneously achieving a specific level of carbon emissions.

We would like to highlight that other policy tools such as carbon cap-and-trade, clean energy standards, carbon regulation, or subsidies to alternative energies are not taken into account. An optimal policy in the real world could consist in combining different instruments; the optimal tax mix of the model should therefore be understood as a stylized theoretical benchmark.

4 Empirical results and discussion

4.1 Discussion of the results from a theoretical perspective

[10] We focus on the long-term analysis so that the welfare cost analysis can be interpreted as the comparison between two economies with different levels of carbon emissions once their respective steady states have been reached. The resolution of the model implies a log-linearized approximation around the steady-state. When the emission reduction target is low, the numerical solution for the transition of variables is accurate. However, the numerical solution could yield imprecise transitions for the variables when the target is very large (80% emissions reduction).

This section analyses optimal taxes on oil, natural gas and coal to reduce carbon emissions in a small, decentralized and competitive Spanish economy. We want to make it clear that this optimal tax mix is second best[11]. We define optimal tax-mix as a combination of tax rates on fossil fuels that minimizes negative impact on household welfare in the steady state while concurrently achieving a specific target of CO_2 emissions. According to standard practice, we define welfare loss as the decrease in private consumption units (by the household) in steady-state corresponding to the optimal tax mix and lower emissions relative to the consumption in the initial steady-state equilibrium of the economy. Additionally, we compare the optimal tax mix on fossil fuels to a carbon tax.

We initially characterize the steady state for the Spanish economy as having no taxes for which to obtain the baseline level of carbon emissions. We use the Bayesian estimation of the structural parameters[12] of the model in Blazquez et al. (2017) to characterize this benchmark scenario. Subsequently, we define an environmental objective. That is, we set a new level of carbon emissions as a percentage ω of the initial level with $0\% < \omega < 100\%$. The government sets the optimal tax-mix as a function of ω to achieve the environmental target.

The optimal tax-mix is commonly obtained numerically in this type of model. However, we find that the optimal tax-mix satisfies the following two conditions represented in Eq. (2):

$$\frac{P_o(1+\tau_o^*)}{P_c(1+\tau_c^*)} = \frac{\xi_o}{\xi_c} \quad and \quad \frac{P_g(1+\tau_g^*)}{P_c(1+\tau_c^*)} = \frac{\xi_g}{\xi_c} \qquad (2),$$

Where P_o, P_c, P_g are the respective prices of oil, coal and gas, $\tau_o^*, \tau_c^*, \tau_g^*$ are the optimal tax rates on oil, coal and gas, and ξ_o, ξ_c, ξ_g are carbon emissions per calorific unit of oil, coal and gas.

[11] This paper finds the optimal tax mix, keeping the conditions of the competitive equilibrium and subject to the accomplishment of an exogenous target for carbon emissions. This approach is different form the first best provided by a central planner. The central planner computes the optimal goods allocations, including the optimal energy mix, in the absence taxes and domestic goods prices, with the only constraints given by the domestic aggregate resources' constraint, which includes the external balance of goods and energies imported valued at international prices, and the target on emissions.

[12] See Table 1 in Technical Appendix for more details.

This means that the higher the level of CO_2 embodied in the fuel for a given set of international prices of fossil fuels, the larger the optimal tax rate.

Given the level of emissions of each type of fuel and the long-term international prices, the optimal tax-mix satisfies that the *ad valorem tax* on coal should be the highest because it is the fossil fuel with the highest level of emissions and the lowest international prices. However, an interesting result of the study is that the lowest tax rate should always be on oil, given its higher price, even though natural gas is the cleanest fossil fuel. Noteworthy is the fact that this is a general conclusion for any economy because international relative prices and the relative level fossil fuel emissions are similar for all the economies. Figure 2 shows the optimal tax-mix for a maximum 80% ($0\% < \omega < 80\%$) emission reduction.

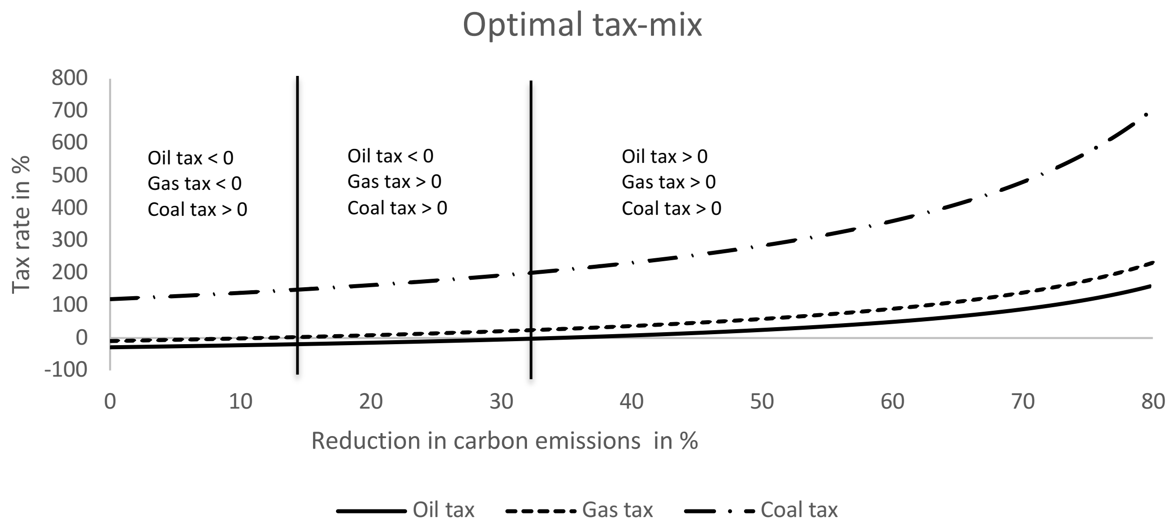

FIGURE 2

Figure 2 suggests that subsidizing oil and natural gas could be part of an optimal strategy to reduce CO_2 emissions. Despite this shocking result, the idea presents no novelty. For example, Van der Ploeg and Withagen (2012) suggest that policymakers should disincentivize coal consumption in favor of oil. This counterintuitive result is only relevant from a purely academic perspective. The optimal strategy is to tax coal heavily, subsidize oil and, to a lesser extent, natural gas for reductions below 11% ($\omega < 11\%$). As the CO_2 target becomes more ambitious, the scope to subsidize oil and natural gas disappears. The optimal strategy for a CO_2 target above 11% and below 34% is to subsidize oil and tax natural gas and coal. The economic intuition behind this result is that governments can take advantage of the gap in emissions as well as the gap in prices among fossil fuels. Taxing coal heavily reduces carbon emissions and provides revenues that can be used to encourage the consumption of more productive and less polluting fossil fuels, i.e., oil and natural gas.

An interesting finding is that the optimal tax-mix keeps the fossil fuel energy mix constant for any given rate of emissions, as shown in Figure 3. In other words, given the economic structure of the Spanish economy, an optimal energy mix is present regardless of the environmental emissions target. This energy mix is constant; the shares are around 50% for oil, 31% for natural gas, and 19% for coal. We underscore that the optimal energy mix is identical to that of a central planner. This implies that the "second best" energy mix resulting from the optimal tax-mix is identical to the "first best" energy mix.

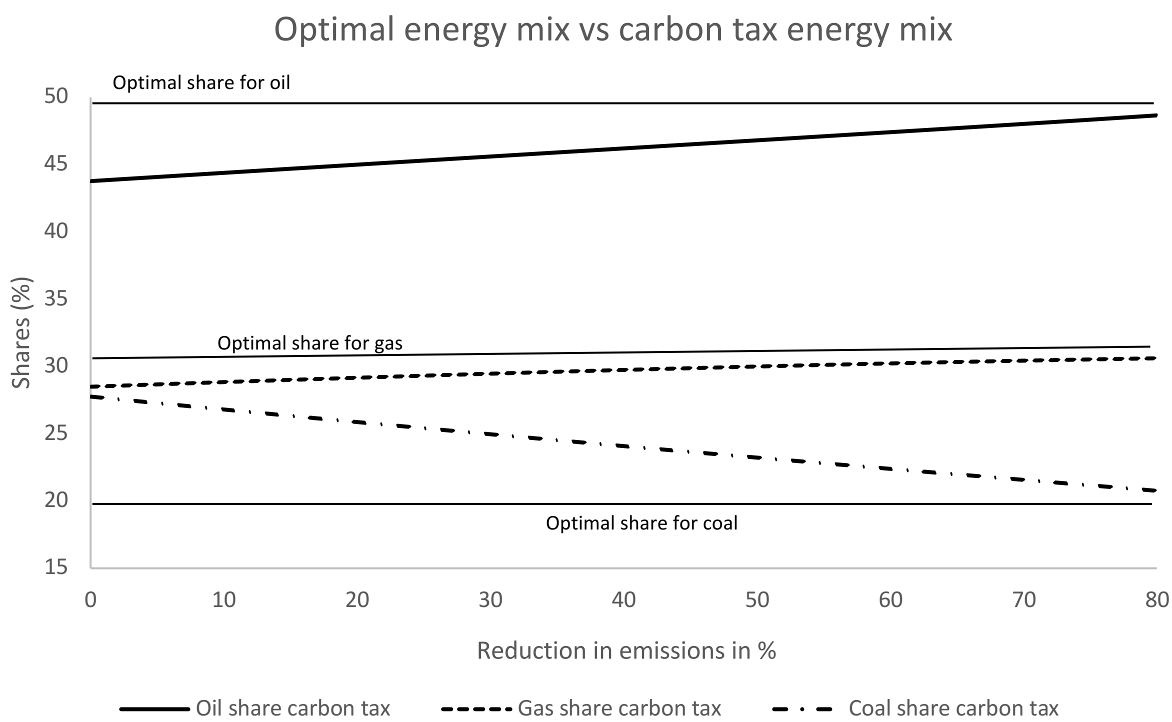

FIGURE 3

How different is this tax structure to a carbon tax? A carbon tax has some advantages over the current tax structure on fossil fuels. First, a carbon tax directly penalizes the negative externality, according to ‘the Polluter Pays’ Principle. This makes carbon taxes attractive from a social point of view. Second, its simplicity makes a carbon tax easy to manage and reduces the need for information. This is why it is relevant to compare the size of the welfare cost linked to carbon tax versus that of an optimal tax-mix. Eq (2) shows that the relative domestic prices (after taxes) of fossil fuels equals the relative ratio of carbon emissions. It is easy to see that the ratio of domestic prices with the carbon tax does not satisfy Eq. (2), as may be seen in expression (3):

$$\frac{P_o + \tau^{CO2}\xi_o}{P_c + \tau^{CO2}\xi_c} \neq \frac{\xi_o}{\xi_c} \quad and \quad \frac{P_g + \tau^{CO2}\xi_g}{P_c + \tau^{CO2}\xi_c} \neq \frac{\xi_g}{\xi_c} \tag{3}$$

Only if $\frac{P_o}{P_c} = \frac{\xi_o}{\xi_c}$ and $\frac{P_c}{P_g} = \frac{\xi_c}{\xi_g}$ then Eq. (3) and Eq. (2) are identical. This implies that the carbon tax is the optimal tax mix in a competitive economy. It is also straightforward to derive that Eq. (3) tends to converge into equation Eq. (2) when the environmental target is ambitious and taxes on fuels and carbon are high.

Figure 4 shows that the welfare losses arising from the carbon tax are slightly larger than the ones coming from the optimal tax-mix. As previously mentioned, both policies tend to converge as the environmental target becomes more and more ambitious. Standardly, welfare losses are nonlinear; they increase as the target becomes increasingly ambitious.

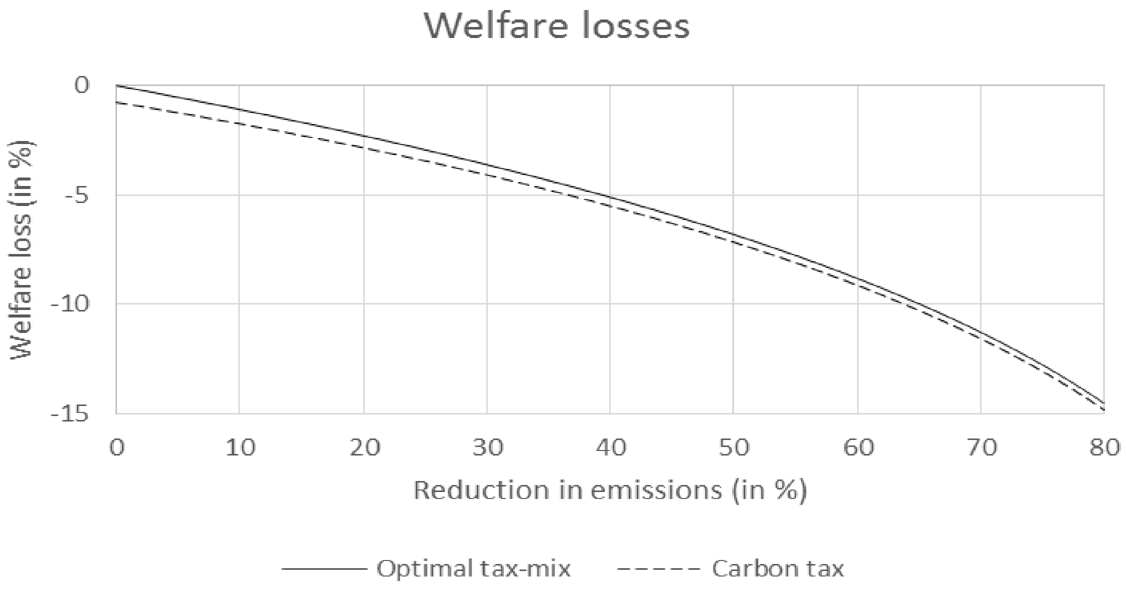

FIGURE 4

In sum, from a theoretical point of view, welfare losses in the optimal tax mix of competitive economy and the carbon tax in the steady state are only slightly different. This difference nearly vanishes for ambitious targets such as that of the European Union member states for 2050. Thus, the optimal tax mix and the carbon tax almost converge. Both policy instruments lead to the same results in terms of welfare losses from a practical perspective.

4.2 Taxes consistent with the Spanish Strategy for a Long-term Decarbonization and the European Commission's plan to reduce greenhouse emissions in 2030.

The aim of this paper is to provide a benchmark for policymakers. To this end, it centers on two carbon targets: the one set by the current "Spanish Strategy for a Long-term Decarbonization" and that of the European Commission plan for 2030. We prefer to focus on 2030 rather than 2050 because the upcoming 30 years of energy technologies and energy markets may be significantly different. This model simulates Spain's energy consumption using historical data and market dynamics to make a reasonable near-term assumption. Energy technologies and consumer behavior evolve slowly. However, as in any other model, this one also proves less useful along an increasingly extensive time horizon.

In Spain, as in other European countries, fossil fuel taxes differ among fuels. Yet in Spain they even vary among the country's different provinces. It is far from straightforward to summarize all the tax rates on coal, natural gas, and oil in a single tax rate. The VAT on energy is 21%; a special 5.1% tax is imposed on electricity generation; hydrocarbons are levied with a special tax ranging between 150 and 551 euros per 1,000 liters of gasoline and gasoil (which varies among regions, economic sectors, and fuels); and the carbon price changes every day (EU Emission Trading System is a market price fluctuating on daily basis). All these taxes and fees impact the final price of fossil fuels paid by consumers. In light of this information and assuming a carbon tax of 20 euros per ton[13], we can roughly estimate a total tax rate of around 130% on oil[14], a 60% tax on natural gas and, a 100% tax on coal.

The current Spanish target and the new European target imply a respective 23 and 55% decline in emissions. Table 1 shows the taxes required to achieve these additional carbon emission reductions. These taxes would replace the current cascade of different taxes. The bottom line here is the need for a substantial increase in fossil fuel tax rates to fulfil the long-term carbon target. Comparing the actual tax mix with the optimal one, we find a clear misalignment for coal and natural gas, but the case of oil is not as evident.

TABLE 1

Optimal tax mix on fossil fuels			
	Estimated effective tax rate	Target 23%	Target 55%
Oil	130%	81%	180%
Natural gas	60%	131%	256%
Coal	100%	460%	761%

[13] The average European Trading Scheme price was around 20 €/tCO2 in 2018-2019.
[14] We assume that around 60% of a barrel of oil is gasoline, and it is gasoil once refined. The special tax is 432 €/1,000 liters of 98 octane gasoline, 401€/1,000 liters of 95 octane gasoline, 307 €/1,000 liters of gasoil A, 79€/1,000 liters of gasoil B and C, and 14€/ton of fuel oil.

Welfare losses with transitional dynamics		4.1%	11.0%
Requiered carbon tax			
Carbon tax €/tCO2		38	150
Welfare losses with transitional dynamics		4.5%	12.7%

The carbon tax in 2030 should be around 40 and 150€ per ton of carbon dioxide (€/tCO2) depending on the target. Although this carbon tax is high, it is consistent with other studies. For example, an exercise by top energy modelers organized at Stanford University in 2014 found that a 50% reduction in US emissions by 2050 would require a carbon tax ranging between 85 and 255 €/tCO2 (Metcalf, 2019) [15]. Burke et al.[16] (2019) find that the carbon price needed to achieve net zero in UK[17] is 83 €/tCO2 (within a band range of 66–155 €/tCO2) in 2030. Kaufman et al. (2020)[18] conclude that, for the United States of America, the 2030 carbon price consistent with net zero emissions in 2050 ranges between 66 and 106 €/tCO2[19]. The report of the High Level Commission on Carbon Prices (2017)[20] concludes that the explicit carbon-price level ranging between 43 and 85 €/tCO2[21] is consistent with the Paris temperature target, a less ambitious target than that of the European Commission, as long as a supportive policy environment is in place.

Table 1 also shows the welfare losses when the economy shifts from the current situation to a new long run equilibrium with higher taxes and lower carbon emissions. The welfare loss is calculated as the increase in private consumption needed to keep the household indifferent between the initial situation and the final one. There are two takeaways from Table 1. First, the welfare losses are not linear, and they tend to increase exponentially as the environmental target becomes more ambitious. This finding is not a surprise and it is standard in this literature. Second, the gap between the two policies studied -the optimal tax mix and the carbon tax, is slighter larger

[15] The prices are of this study are in US dollars. The exchange rate applied is 0.85€ per dollar.
[16] https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2019/05/GRI_POLICY-REPORT_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf
[17] The prices of the study are in pounds. The exchange rate used is 1.10 euros per Sterling pound.
[18] https://www.nature.com/articles/s41558-020-0880-3
[19] The prices are of this study are in US dollars. The exchange rate used is 0.85 euros per dollar.
[20] https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices
[21] The prices of this study are in US dollars. The exchange rate used is 0.85 euros per dollar.

when the transition dynamic is taken into consideration. Policymakers face an interesting puzzle. On the one hand, carbon taxes have some administrative and social advantages over a tax-mix on fossil fuels and, in addition, they can be used to tax non-energy carbon emissions, for example, from agriculture or industrial processes. On the other hand, the transition to the new steady state has slighter larger welfare losses.

5. Conclusions and policy implications

The European Commission presented the Green Deal in 2019. This strategic plan aims to achieve carbon neutrality by 2050. Its intermediate target is to reduce greenhouse gas emissions in at least 55% with respect to 1990 levels by 2030. This work focuses on Spain, and it assesses the optimal tax on fossil fuels to curb carbon emissions. Furthermore, it compares this optimal tax mix with a standard carbon tax, the instrument most preferred by economists for a variety of reasons. To this end, it uses a general equilibrium model for a small open economy in a competitive framework. Thus, the optimal tax mix in this scenario is a second-best policy; it is not the central planner's solution.

As expected, this study first finds that optimal efficiency in reducing CO_2 emissions requires a substantial tax on coal, the fossil fuel with the highest carbon emissions. Second, and once again for the sake of optimal efficiency, our analysis reveals that a tax on oil should be lower than a tax on natural gas, even though natural gas has the lowest level of carbon emissions. The reason for this is the gap between the international price of oil and price of natural gas. Third, the analysis shows that taxes on oil, coal, and natural gas in Spain should significantly increase to achieve the 2030 environmental target defined by the European Commission. We estimate that taxes on oil must increase from the current 130% to 180%, taxes on natural gas must increase from 60% to 260%, and taxes on coal must rise from the current 100% to almost 800%. These increases lead to a 55% reduction in carbon emissions from energy.

Carbon tax is emerging as the preferred policy response to cut greenhouse gas emissions around the world. Therefore, we estimate the carbon tax required to reduce carbon emissions by 55%. We find that the required carbon tax is around 150 €/tCO_2. In this case, the welfare loss associated with this tax is almost identical to the optimal tax rate mix. We show that a carbon tax is, from a practical perspective, an optimal policy if the environmental policy is sufficiently ambitious. This level can be used as reference for the carbon price that is consistent with the new Euroepan environmental target. It is important to highlight that no account is taken of other policy tools such as carbon clean energy standards or subsidies to alternative energies. In the real word, policy is a combination of different instruments; the tax mix of the model should therefore only represent a theoretical stylized benchmark.

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