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Research article

Economic, ecological and social benefits through redistributing revenues from increased mineral oil taxation in Austria: A triple dividend

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Abstract: To meet the future energy and climate targets in 2030 and 2050 in Austria, it is absolutely necessary to apply extensive measures to reduce the use of fossil fuels. By then, Austria will have to realize a 36% decrease (from 2005 levels) for emission sources outside the European Emission Trading System. The transport sector is a key driver of recently increasing greenhouse gas emissions in Austria. Hence, we examine the macroeconomic and ecologic impacts of an environmental tax reform in Austria from 2020 to 2030. We implement a revenue-neutral tax reform that raises revenues via an increase of the mineral oil tax on diesel and petrol consumption and redistributes these fiscal revenues to the industry and households. In addition, increased fossil fuel taxing would enhance revenues for green investments in e-mobility and thermal refurbishment that stimulate the Austrian economy. The simulation analyses focus on central macroeconomic variables as gross domestic product, employment, investment and private consumption and carbon dioxide emissions. We find that the proposed environmental tax reform generates a triple dividend, leading simultaneously to economic growth and the reduction of greenhouse gas emissions while low-income households can be fully compensated.

Keywords: environmental tax reform; mineral oil tax; transport sector; green investment; macroeconomic simulation

JEL Codes: Q43, Q52, E62

Abbreviations: CO_2: carbon dioxide; CO_2eq: carbon dioxide equivalent; ETR: environmental tax reform; EU: European Union; GDP: gross domestic product; GHG: greenhouse gas emissions; MOT: mineral oil tax; VAT: value added tax

1. Introduction

Austria is committed to international climate targets and a proactive policy with regard to climate change and energy. Via the current Austrian Climate and Energy Strategy “Mission2030” (Federal Ministry of Austria for Sustainability and Tourism and Federal Ministry of Austria for Transport, Innovation and Technology, 2018), the Federal Government has set itself the objective to reduce domestic greenhouse gas (GHG) emissions by 36% by 2030 compared to the 2005 level of 92.6 million tons CO_2eq. This implies to develop further all renewable energy systems, the infrastructure, storage facilities and investments in energy efficiency. Following “Mission2030”, the focus in coming years will need to shift to the transport and space heating sectors, so as to maximize the results from the resources invested. These two sectors have the greatest potential for reductions in GHG emissions (Federal Ministry of Austria for Sustainability and Tourism and Federal Ministry of Austria for Transport, Innovation and Technology, 2018).

Realizing those ambitions involves overcoming numerous technological, economic and social challenges. Only limited resources to finance climate initiatives are available on the national and global level (Yeo, 2019). One way to raise tax revenues, and also spur businesses and consumers to find cost-effective ways to reduce emissions, is to put a price on carbon. Considering the increase of emissions in the transport sector and the enormous contribution from transport to Austria’s total emissions, a focus on this sector for fossil fuel taxation is justified.

The transport sector plays a key role in climate protection. As outlined in the chapter on transport in the Fifth IPCC Assessment Report (Sims et al., 2014), the transport sector globally produced 7.0 Gigatons CO_2eq of direct GHG emissions (including non-CO_2 gases) in 2010 and hence was responsible for approximately 23% of total energy-related carbon dioxide emissions (6.7 Gigatons CO_2eq). The growth in GHG emissions due to an almost exclusively use of fossil fuels has continued in spite of more efficient vehicles (road, rail, water craft, and aircraft) and policies being implemented. Without aggressive and persistent mitigation policies being applied, transport GHG emissions could increase at a faster rate than emissions from the other energy end-use sectors and reach around 12 Gigatons CO_2eq per year by 2050 (Sims et al., 2014). At the EU-28 level, comparable developments are taking place. GHG emissions from the transport sector (including international aviation but excluding international shipping) have been growing since 2014. Compared to 2015, GHG emissions in 2016 had increased by ca. 3%, mainly on account of higher emissions from road transport and contributed 27% of total GHG emissions in the EU-28 (EEA, 2018).

Similarly, Austria emitted 82.3 million tons CO_2eq in 2017, with the transport sector being one of the main sources of GHG emissions, as in previous years. As displayed in Figure 1, the transport sector has seen an increase in GHG emissions of around 74% since 1990. In 2017, GHG emissions from transport increased by about 3.2% or 0.8 million tons CO_2eq compared to 2016. With 24.3 million tons of CO_2eq, the transport sector was the largest source of GHG emissions outside the European emissions trading scheme in 2016. Since 1990, the transport sector displays the highest growth of all sectors in the period 1990–2016, with an increase in emissions of 67%, mainly due to the increase in car mileage (Austrian Federal Environmental Agency, 2019).

The weak economy is mainly responsible for the decrease in emissions from 2007 to 2009. GHG emissions from the transport sector rose again in 2010, mainly due to increased demand for freight transport services as a result of the slight economic recovery. The decline in emissions from 2011 to 2012 is due to lower fuel sales due to rising fuel prices. The significant increase in emissions in 2013 can be explained by the sharp rise in fuel sales, especially fuel exports. The reasons for the decline in 2014 are lower fossil fuel sales and the decline in fuel exports this year, coupled with an increase in sales of biofuels (Austrian Federal Environmental Agency, 2019). However, low fuel prices, especially for diesel, are causing sales and emissions to rise for the second year in succession.

Hence, against the background of progressive climate change and energy security, an extensive conversion of the mobility system including a strong usage of alternative drive systems such as hybrid and electric motors is necessary.

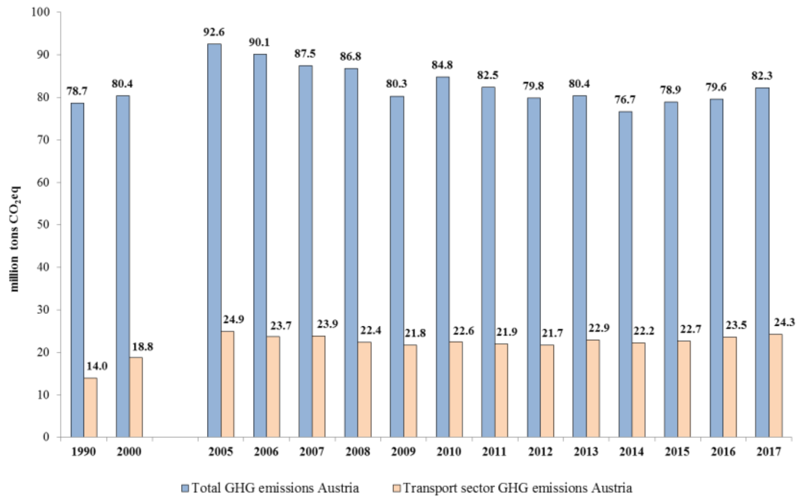

Figure 1. Total and transport sector GHG emissions in Austria.

Based on data from Statistik Austria (2019a), revenues from environmental taxes amounted to approximately €9.5 billion in 2017. More than 58% of the total environmental tax revenue were accounted for by energy taxes (with a share of 82% from mineral oil taxes which amount to €4.5 billion), 34% by transport taxes, approximately 7% by resource taxes and approximately 1% by pollution taxes. Figure 2 offers an overview about historical environmental tax revenues in Austria.

The mineral oil tax is an excise duty that is usually levied per liter of diesel or petrol. For a liter of diesel, the Austrian mineral oil tax is €0.397 and for a liter of petrol €0.482. This results in an implicit CO_2eq tax on petrol of €225 per ton of CO_2eq and on diesel of €163 per ton of CO_2eq. The fuel prices for the end consumer consist of the net price, which in turn covers the costs for crude oil, production, distribution as well as a profit surcharge, and the value added tax (VAT). The tax share, i.e. the share of the mineral oil tax including VAT, averages 55% for petrol and around 50% for diesel. Table 1 indicates that since 2014, the increase in consumption of diesel and petrol has again led to an increase in mineral oil tax revenues.

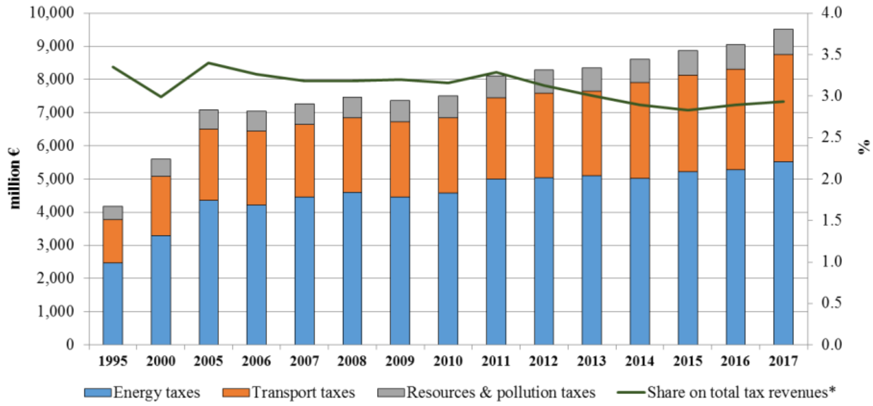

Figure 2. Environmental tax revenues in Austria. Note: *Total revenues from taxes and social contributions after deduction of amounts assessed but unlikely to be collected.

Table 1. Mineral oil tax revenues in Austria, 2020–2030.

Year	Mineral oil tax revenues		
	million €	*Share of total energy taxes revenues*	*Share of total environmental taxes revenues*
2005	3,565	82%	50%
2006	3,553	84%	50%
2007	3,689	83%	51%
2008	3,894	85%	52%
2009	3,800	85%	52%
2010	3,854	84%	51%
2011	4,213	84%	52%
2012	4,181	83%	50%
2013	4,173	82%	50%
2014	4,135	82%	48%
2015	4,218	81%	48%
2016	4,338	82%	48%
2017	4,551	82%	48%

Source: Calculation based on Statistik Austria (2019).

Existing literature on carbon taxing in Austria (Breuss and Steininger, 1995; Kirchner et al., 2019) focuses on effects on central macroeconomic variables, GHG emissions and distributional effects. With regard to the transport sector, Titelbach et al. (2018) evaluate the social effects and direct distributional effects of potential measures on Austrian private households. However, an analysis of the effects on the economy as a whole and an ex-ante analysis are not carried out. The present study fills this gap and draws explicitly attention on Austria's recent transformation process via the planned #mission2030 strategy and offers strategies to tackle rising GHG emissions in the transport sector. To our knowledge and for the first time, this study presents an ambitious attempt to account ex-ante for the implications of more intensive mineral oil taxation in Austria in combination with a revenue-recycling scheme which supports simultaneously economic, ecologic and social targets. We define a revenue-neutral environmental tax reform (ETR) covering increased mineral oil taxes on the revenue-raising side and green finance instruments accounting for investments in e-mobility and thermal renovation and compensation measures for especially low-income private households and industry on the revenue-recycling side. Simulations run by a macro-sectoral model for Austria provide results about economic and ecological variables which indicate a triple dividend.

The remainder of the paper is divided into five sections. In Section 2, we explain the motivation of our research by stating the economic theory of environmental taxation and the double-dividend hypothesis and propose an ETR which aims at mitigating the Austrian transport sector's GHG emissions and simultaneously generates revenues for public green investment and compensation transfers to industry and private households. In Section 3, the model applied for the simulation analysis is briefly presented. Section 4 offers the results of the simulated tax reform. Section 5 concludes.

2. Research design

2.1. Ecological tax reform and the double-dividend theory

In principle, the introduction of environmental taxes should focus on the steering effect or the ecological effectiveness of the instrument. As shown by Baumol (1971) and Baumol and Oates (1972), the main motive for their implementation is the setting of prices for negative externalities via fiscal interventions, which leads to an increase in the costs of environmentally damaging inputs or activities. This is intended to change production and consumption activities in the direction of more sustainable or environmentally friendly structures.

Environmental taxes or eco-taxes are based on a uniform concept which defines environmental taxes as taxes whose base has a destructive effect on the environment. Thus, e.g. processes or products that damage the environment or consume non-renewable resources are covered. The tax base can be selected according to various criteria, depending on the type of externality that is to be reduced. Environmental taxes aim on the one hand at climate protection; on the other hand, the consumption of non-renewable energy sources should be reduced. Moreover, environmental taxes should influence the current consumption of certain substances by setting a price for external effects. The most important example in this context is taxes on fossil fuels. If environmental pollution is caused by all economic sectors, a cross-sectoral, uniform environmental tax should be chosen, such as the mineral oil tax in Austria.

Alternatively, instead of a quantity tax on the energy fuel consumed, the emissions caused could also be used as a basis, which would correspond to the climate policy objective and would require the differentiation of tax rates according to climate relevance. On the other hand, taxes can also be used to influence investment and purchase decisions, as these subsequently determine the current consumption of energy and thus also the resulting emissions. Such fiscal interventions occur primarily in the area of motorized private transport in the form of registration taxes, which are often differentiated according to environmentally relevant criteria such as type of vehicle, engine power, consumption or emissions.

The concept of an ETR, i.e. the shift of the tax burden from labor to resource and environmental consumption, has been discussed in the economic literature and economic policy for more than three decades. In addition to the reduction of environmental pollution, the potential for a double dividend, i.e. positive economic effects that can result from the shift in the tax system

(Pearce, 1991; Goulder, 1995; Goulder et al., 1997), is mentioned as one central outcome of an ETR. A revenue-neutral ETR can generate positive employment effects (second dividend) in addition to achieving a certain environmental objective (first dividend, e.g. reduction of GHG emissions from the use of fossil fuels). The redistribution of tax revenues is central to the realization of this effect. This can be achieved by reducing distorting fiscal interventions—e.g. wage-related taxes and levies—or by financing environmentally relevant investments (e.g. public transport, renewable energies, environmentally relevant R&D) by the public sector or as investment promotion for the private sector. This can trigger an innovation boost for environmentally friendly technologies and accelerate structural change in the economy. In addition, the demand impulses triggered by consumption or investment improve economic performance.

2.2. Design of an environmental tax reform with revenue-raising via a mineral oil tax increase

On the revenue-raising side, the considered ETR comprises a dynamic increase in the mineral oil tax on petrol and diesel consisting of a one-off increase of €0.15 per liter (excl. VAT) in 2020 and a gradual increase of €0.03 per liter (excl. VAT) per year in the period 2021 to 2030. This implies additional costs of €0.45 per liter (excl. VAT) in 2030. Figure 3 displays the path of the analyzed mineral oil tax increase.

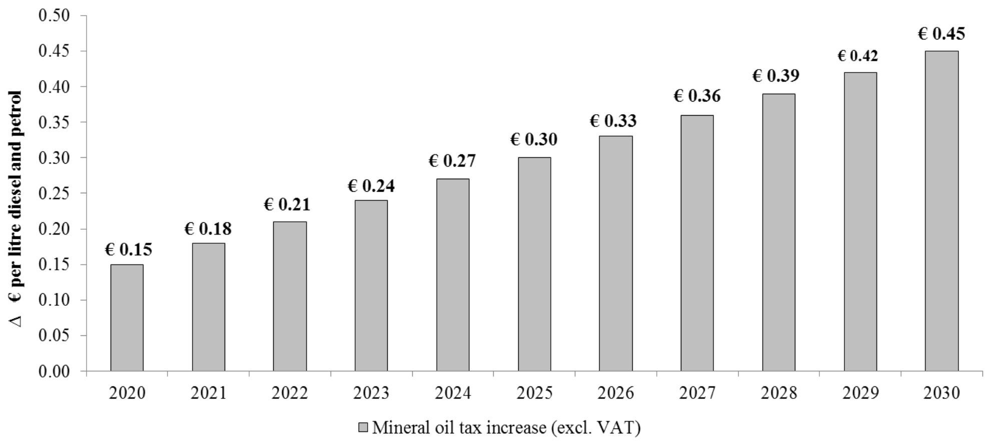

Figure 3. Analyzed mineral oil tax increase.

The average consumer price for diesel in 2018 was €1.22 per liter, while one liter of petrol cost an average of €1.26 (Austrian Automobile, Motorcycle and Touring Club, 2018). Assuming a constant net price (€0.61 per liter diesel and €0.57 per liter petrol), the increase of the mineral oil tax in 2030 analyzed here would result in a petrol price of €1.76 per liter and a diesel price of €1.79 per liter. These price levels are shown in Table 2.

The price elasticity of fuel demand is negative; a fuel price increase thus causes a reduction in fuel demand. Moreover, it is not constant over time: certain possible responses to a rise in fuel prices, such as the purchase of lower-consumption vehicles or changes in residential locations, are only implemented with a certain time lag. For this reason, the reaction to a rise in fuel prices is more pronounced in the long term than in the short term. Because of that, we focus on strict increasing mineral oil taxation between 2020 and 2030 in order to stimulate significant reductions in fuel demand. There are various empirical findings on the level of price elasticity. In the short-term perspective, they fluctuate between −0.055 and −0.3. This means that if fuel prices double, the fall in demand will be between 5.5 and 30 percent (Brons et al., 2008; Hymel et al., 2010).

Table 2. Effects of the mineral oil tax increase on diesel and petrol prices in Austria, 2020–2030.

	Petrol *[€per liter]*				Diesel *[€per liter]*			
Year	Net Price	MOT	VAT	Total	Net Price	MOT	VAT	Total
BAU	0.61	0.40	0.21	1.22	0.57	0.48	0.21	1.26
2020	0.61	0.55	0.23	1.40	0.57	0.63	0.24	1.43
2021	0.61	0.58	0.24	1.43	0.57	0.66	0.25	1.47
2022	0.61	0.61	0.24	1.47	0.57	0.69	0.25	1.51
2023	0.61	0.64	0.25	1.50	0.57	0.72	0.26	1.54
2024	0.61	0.67	0.26	1.54	0.57	0.75	0.26	1.58
2025	0.61	0.70	0.26	1.58	0.57	0.78	0.27	1.61
2026	0.61	0.73	0.27	1.61	0.57	0.81	0.28	1.65
2027	0.61	0.76	0.27	1.65	0.57	0.84	0.28	1.69
2028	0.61	0.79	0.28	1.68	0.57	0.87	0.29	1.72
2029	0.61	0.82	0.29	1.72	0.57	0.90	0.29	1.76
2030	0.61	0.85	0.29	1.76	0.57	0.93	0.30	1.79

Notes: MOT = Mineral oil tax. The business-as-usual (BAU) values of the net fuel prices are drawn from Austrian Automobile, Motorcycle and Touring Club (2018).

In order not to weaken the overall economic growth, the revenues as a result of the increase in the mineral oil tax, are recycled so that those, who use energy sources efficiently and ecologically effectively, have an economic advantage. This recycling of tax revenues can maintain purchasing power and create growth impulses for the economy. An important trigger of green investments within the studied ETR is the implementation of public investment measures which are intended to initiate targeted increases in renewable energies and energy efficiency. As a result of their investment character, positive economic multi-round effects can result.

In order to achieve GHG emission reduction in the Austrian transport sector by further strengthening the development of e-mobility, the studied ETR comprises revenue recycling via public investment in electric vehicles and the electricity charging infrastructure. Accounting for the share of approximately 70% of renewable energies in the electrical power mix, Austria is well positioned to introduce e-mobility. With its motivated development plans defined in the "Ökostromgesetz" (Green Electricity Act), Austria is willing to continue to raise the share of renewable energy sources for the production of electricity. By doing so, the supply of e-mobility with cost-efficient renewable energy can be possible.

Further, the thermal renovation of buildings is a key task mentioned in the Austrian Climate and Energy Strategy "Mission2030" (Federal Ministry of Austria for Sustainability and Tourism and Federal Ministry of Austria for Transport, Innovation and Technology, 2018). Currently, space and water heating in residential and commercial buildings generate around 16% of Austrian CO_2eq emissions in sectors outside the European Emissions Trading Scheme. As a response to this challenge, revenues are also located to thermal refurbishment investments in Austria.

Carbon pricing policies and environmental taxes, respectively, tend to have most impacts on the lowest income households, as basic goods, such as energy and food have a high GHG intensity (Druckman and Jackson, 2008; Shammin and Bullard, 2009). This implies that innovative income transfer policies for households would be necessary as well. As outlined in Ottelin et al. (2018), carbon pricing leads to the increase of the price of energy and food for all household types, but the low-income households could cover the growing costs with the new income transfer which means that their carbon footprints would not automatically diminish. The central share of GHG emission reductions would stem from the deviations in the consumption behavior of middle- and high-income households.

Similar to Goers and Schneider (2019), the key elements of the reimbursement in the amount of the additional annual mineral oil tax revenues comprise the reduction of non-wage labor costs for companies (30% of the additional mineral oil tax revenues incl. VAT per year), compensation transfers to private households (30% of the additional mineral oil tax revenues incl. VAT per year) and investment in key technologies such as vehicle propulsion using electricity (20% of the additional mineral oil tax revenues incl. VAT per year) and thermal renovation (20% of the additional mineral oil tax revenues incl. VAT per year).

3. Methodology

In order to evaluate the potential impacts of the proposed ETR, the study relies on a suitable framework: the MOVE2 model which is a comprehensive time-series macroeconomic model of economy-energy-environment relations within Austria (Goers et al., 2015). All endogenous variables are explained by stochastic equations, and the economic relationships are generated through the estimation of time series. For the purposes of modeling variations in fuel consumption and GHG emissions as a result of relative price changes and feed-back effects in the economy, the model has a high resolution for aspects of the national energy market and their interdependence with the economy, featuring 13 economic sectors (including private households) and 24 different energy carriers. MOVE2 and its predecessor model MOVE (Tichler, 2009) are empirically oriented and data-rich models, which do not use assumptions about a general equilibrium in the long-term economy. Hence, their strength is in analyzing trends in the short and medium term.

A hybrid version between a simultaneous estimate and the linking of individual equations was chosen for the MOVE models (Tichler, 2009) where certain model segments are implemented in a simultaneous equation system. The Seemingly Unrelated Regression is best suited to cope with equations with relatively few data points. Main aggregates as investments, gross value added, energy consumption, employment, and wages are derived via the sectoral level. Thus, systems of 12 different equations are carried out for each aggregate in the model. The individual equations are differently specified due to the structural characteristics of the different economic sectors. The connection of different modules of the model (e.g. economy and energy) is fulfilled by linking stochastic equations and identities.

General inputs to the model are historical data with regard to sectoral energy demand and supply, investments costs in the economic sectors, energy-related and non-energy-related consumption behaviors of private households, and a number of energy price levels that are set exogenously. Outputs are macroeconomic variables such as GDP, employment, investment and consumption, CO_2eq emissions, and import/export activities. For the present analysis, the following input has been considered: diesel and petrol prices, green investments in e-mobility and thermal renovation, lump-sum transfers as a compensation for private households, and the reduction of non-wage labor costs for companies.

In order to display the explicit effects of policy measures and investment decisions, two scenarios are set up in the MOVE2 model for simulations. First, a baseline scenario of developments in the Austrian economy is calibrated by historical data. This baseline scenario is based on key assumptions on economic growth, population growth and energy prices made by the Austrian Federal Environmental Agency for the discussion of Austria's climate policy, which are scenarios for the energy sector development and GHG emissions up to 2030 and 2050 (Austrian Federal Environmental Agency, 2019). Second, a scenario was modeled, which basically involved a projection of what will be because of the in Section 3 proposed mineral oil tax increase as part of an ETR. By subtracting the simulation results of the 'what if ETR takes place' scenario from the baseline case it becomes possible to identify and characterize the exact macroeconomic impacts of the increased mineral oil taxes introduced under the ETR. In summary, the simulations via MOVE2 illustrate the difference between what will happen if everything stays constant and what will happen in case of the implementation of an ETR. As any modelling exercise it is a "best guess", but the model is well suited to the purpose as already shown in former macroeconomic analyses for Austria (Goers and Schneider, 2019; Moser et al., 2018; Bointner et al., 2013).

The economic, ecological and fiscal effects for Austria for the period 2020 to 2030 are calculated as follows: The first step is to simulate the increase of the mineral oil tax without reinvesting the additional revenue in Section 4.1. In this case, the additional revenues are used purely to cover the national deficit and do not imply any recycling. This step allows for an overview of how high the possible additional revenues from the tax reform are. In a second step, a simulation is carried out in Section 4.2. in which the additional revenues are recycled on the basis of the scheme defined in Section 2.

4. Empirical results

4.1. Increase of mineral oil tax without revenue-recycling

In the scenario of a dynamic increase of the mineral oil tax as mentioned in Section 3 in which the additional tax revenues are used exclusively for national budget consolidation, negative macroeconomic effects will be generated in the period from 2020 to 2030, with lower economic growth and a decline in employment. The higher cost burden on households and companies generated via the mineral oil tax increase has negative effects on consumption and investments compared to the baseline scenario. Positive effects in the period 2020 to 2030 can be observed in the form of a reduction of CO_2eq emissions by an average of 4.9 million tons per year. Accounting for social costs of carbon of €50 per ton CO_2eq, an annual reduction of CO_2 damage costs by €245 million would be achieved. Table 3 presents these results.

Table 3. Simulated effects on macroeconomic, fiscal and ecologic variables of the mineral oil tax increase in Austria, 2020–2030.

Year	GDP *(million €)*	Investments *(million €)*	Private consumption *(million €)*	Employment *(employees)*	MOT revenues *(million €)*	CO_2eq emissions *(million tons)*
2020	−971	−548	−460	−17,900	+1,220	−2.2
2021	−1,010	−629	−405	−16,700	+1,400	−2.8
2022	−992	−690	−350	−19,600	+1,560	−3.5
2023	−990	−755	−294	−22,200	+1,720	−4.0
2024	−975	−809	−239	−24,800	+1,870	−4.6
2025	−952	−855	−184	−27,300	+2,010	−5.1
2026	−933	−890	−129	−29,600	+2,140	−5.7
2027	−901	−913	−74	−31,600	+2,280	−6.1
2028	−914	−938	−62	−33,300	+2,440	−6.5
2029	−929	−962	−53	−34,400	+2,620	−6.8
2030	−946	−988	−45	−35,100	+2,840	−7.0
Ø	−956	−816	−209	−26,600	+2,010	−4.9

Notes: MOT = Mineral oil tax. Additional direct, indirect and induced effects compared to a reference scenario where no MOT increase is applied. Rounded and nominal values. Source: Own calculation based on MOVE2 (Goers et al., 2015).

4.2. Revenue-neutral tax reform: Increase of mineral oil tax with revenue-recycling

Based on the simulation results of a mineral oil tax increase in Section 4.1, the generated revenues are redistributed via the scheme presented in Section 3. The costs for energy savings due to thermal refurbishment are based on the abatement costs from Köppl et al. (2014). Furthermore, we assume that per vehicle and the corresponding charging infrastructure, there will be additional costs of €12,000 per year compared to conventional fossil fuel vehicles (Steinmüller et al., 2017) with an average fuel consumption of 939 liter petrol or diesel per year (Statistik Austria, 2019b). Table 4 presents the yearly amounts recycled for the reduction of non-wage labor costs, compensation transfers to households and green investments in key technologies (thermal renovation, e-mobility).

The simulation displays an initial reduction of GHG emissions in 2020 by 2.2 million tons CO_2eq compared to the reference scenario. In the medium term the reduction amounts to 7.4 million tons CO_2eq in 2030 which corresponds to an average reduction of 5.2 million tons CO_2eq per year for the time 2020 to 2030. This reduction of GHG emissions is achieved through continuous price increases for fossil fuels via the mineral oil tax increase on the one hand, and through public investments in thermal renovation and the use of e-mobility on the other. Even so, the proposed ETR alone cannot guarantee that the targets for the transport sector's reduction of CO_2eq emissions, agreed nationally under the current Austrian climate and energy strategy "Mission2030" that foresees a reduction of 14.3 million tons CO_2eq compared to 2016, are fulfilled.

With respect to GDP, an average effect of an additional €984 million per year for 2020–2030 is achieved. These developments are accompanied by employment growth. In absolute terms, the simulation analysis shows that the environmental fiscal reform could lead to the creation of 10,400 additional jobs by 2030. These changes are being driven by growing investments and rising private household consumption. The increased investments of an average of €363 million per year in the period 2020–2030 are the result of the reduction of non-wage labor costs as well as the green investment impulses for the thermal refurbishment and e-mobility. At the level of private households, higher fossil fuel costs are absorbed by the compensation transfer.

For an approximate estimation of the possible distributive impact of diesel and petrol consumption, data from Statistik Austria (Statistik Austria, 2019b) on the number of diesel and petrol passenger cars in private households, their fuel consumption and average annual kilometers of first passenger cars were used. From this, an average annual mileage of approx. 13,800 km per household per first passenger car can be derived. For the first income tertile accounting for low-income households, there are additional costs of €167 million in 2020, which would rise to €502 million by 2030. These will be covered by the compensation payments displayed in Table 4. Further, energy costs savings due to the implementation of thermal refurbishment and an increased income due a higher employment level, and hence higher wage bill, induces positive impacts on private consumption of €841 million per year on average in the period 2020–2030. In connection with the GHG emission reductions, the proposed reform will pay multiple dividends. These results are displayed in Table 5.

The fiscal balance of the government also has positive effects. The proposed ETR is revenue-neutral, so that the sum generated on the revenue side roughly corresponds to the reimbursements to households and the companies. As a result of second-round effects (impulses on the employment level and thus on the wage bill and consumption), additional revenues result from taxes (value added tax, wage tax). Table 6 shows concrete effects on the fiscal balance.

Table 4. Proposed revenue recycling scheme, 2020–2030.

Year	Revenue raising via MOT	Revenue recycling			
	million €	Reduction of non-wage labor costs (*million €*)	Compensation payments for private households (*million €*)	Public investments in thermal renovation (*million €*)	Public investments in e-mobility (*million €*)
2020	1220	370	370	240	240
2021	1400	420	420	280	280
2022	1560	470	470	310	310
2023	1720	520	520	340	340
2024	1870	560	560	370	370
2025	2010	600	600	400	400
2026	2140	640	640	430	430
2027	2280	680	680	460	460
2028	2440	730	730	490	490
2029	2620	790	790	520	520
2030	2840	850	850	570	570
Ø	2010	600	600	400	400

Note: MOT = Mineral oil tax.

Table 5. Simulated effects on macroeconomic and ecologic variables of the proposed environmental tax reform in Austria, 2020–2030.

Year	GDP (*million €*)	Investments (*million €*)	Consumption (*million €*)	Employment (*employees*)	CO_2eq emissions *(million tones)*
2020	−271	+55	+83	−10,200	−2.2
2021	+91	+149	+260	−6,800	−2.9
2022	+389	+214	+423	−3,500	−3.5
2023	+629	+257	+585	−100	−4.1
2024	+848	+301	+735	+1,200	−4.7
2025	+1,054	+343	+877	+2,200	−5.3
2026	+1,246	+392	+1,016	+3,200	−5.9
2027	+1,446	+454	+1,155	+4,300	−6.4
2028	+1,609	+522	+1,256	+5,600	−6.9
2029	+1,789	+602	+1,366	+7,700	−7.2
2030	+1,995	+700	+1,491	+10,400	−7.4
Ø	+984	+363	+841	+1,300	−5.2

Notes: Additional direct, indirect and induced effects compared to a reference scenario where no ETR is applied. Rounded and nominal values. Source: Own calculation based on MOVE2 (Goers et al., 2015).

Table 6. Simulated effects on fiscal variables of the proposed environmental tax reform in Austria, 2020–2030.

Year	Public expenditures due to revenue-recycling (*million €*)	Public revenues due to MOT increase (*million €*)	VAT tax revenues (*million €*)	Income tax revenues (*million €*)	Government balance for covering deficits (*million €*)
2020	1220	1210	−75	−278	−344
2021	1400	1390	−51	+167	+106
2022	1560	1540	−26	+204	+118
2023	1720	1690	−1	+235	+224
2024	1870	1840	+9	+265	+213
2025	2010	1970	+16	+292	+278
2026	2140	2100	+24	+320	+344
2027	2280	2230	+32	+351	+312
2028	2440	2380	+41	+383	+405
2029	2620	2560	+57	+420	+437
2030	2840	2770	+77	+464	+511
Ø	2010	1971	+9	+257	+237

Notes: MOT = Mineral oil tax. Additional direct, indirect and induced effects compared to a reference scenario where no ETR increase is applied. Rounded and nominal values. Tax revenues are adjusted for demand effects. Source: Own calculation based on MOVE2 (Goers et al., 2015).

5. Conclusion

With regard to high overall GHG emissions and increasing GHG emission in the national transport sector, Austria is facing enormous reduction targets for 2030, and 2050. Hence, increasing energy efficiency and the intensive usage of renewable energy sources are the major approaches for realizing these significant reductions. Further, the focus of GHG emissions abatement within the current Austrian national climate and energy strategy "Mission2030" relies particularly on the transport and building sectors, where the greatest reduction potential exists.

Nowadays, external costs for the increasing climate change are not sufficiently integrated into energy prices. A key objective of the ETR is to correct these price signals and to further internalize the external effects of energy consumption and environmental impacts. Stricter carbon and energy price signals can motivate households and industries to take the climate costs of their actions into account. They would likely consume goods and services with less carbon intensity, and gradually shift to low carbon or zero carbon behavior.

In these contexts, the study shows in the framework of Austria a promising option in order to shift to an environmentally sustainable economy in the short and medium-term. The simulation analysis suggests that the proposed reform for Austria consisting of a mineral oil tax increase and a revenue recycling scheme with focus on leveraging households, employers and supporting key technologies is economically acceptable. As GHG emissions reductions are achieved simultaneously, these results highlight evidence of possible multiple dividends. Further, it reveals the importance of revenue-recycling which is essential for improving the economic effects of the environmental fiscal reform and for facilitating the adjustment process.

We propose a concrete ETR and analyze the economic and ecological effects for Austria by a macro-sectoral model. Revenues are raised via an increase of the mineral oil tax on petrol and diesel comprising a one-off increase of €0.15 per liter in 2020 and a gradual increase of €0.03 per liter per year in the period 2021 to 2030. As environmental taxes can have strong negative impacts on low-income households and exposed businesses, the additional revenues are redistributed via the reduction of non-wage labor costs and the compensation payments for private households. Further, parts of the revenues are used to finance public green investments in thermal renovation and e-mobility. The simulations reveal that this revenue-neutral recycling scheme offers positive impacts on economic growth and employment through higher investments and private consumption. During the period from 2020 to 2030, the ex-ante analyses detect an average increase in GDP of ca. €1 billion per year and in employment of ca. 1300 employees per year. At the same time, higher fuel taxes and climate-friendly advancements in the building sector through thermal renovation and in the transport sector through e-mobility lead to the average decrease of 5.2 million tons CO_2eq per year.

Further, we conclude that green investments could be enhanced by introducing stronger environmental economic policies, such as fossil fuel pricing. Although, it may be difficult to reach agreement with GHG intensive economic sectors. The simulations herein reveal that in sum the economy can benefit from an approach which focuses on revenue-neutrality.

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Conflict of interest

The authors declare no conflict of interest.

References

Austrian Automobile, Motorcycle and Touring Club (2018) Mineralölsteuer. Available from: https://www.oeamtc.at/thema/verkehr/mineraloelsteuer-17914742

Austrian Federal Environmental Agency (2019) Austria's Annual Greenhouse Gas Inventory 1990–2017. Report REP-0672. Vienna: Umweltbundesamt.

Baumol W (1972) On taxation and the Control of Externalities. *Amer Econ Rev* 62: 307–321.

Baumol W, Oates W (1971) The Use of Standards and Pricing for the Protection of the Environment. *Swedish J Econ* 73 : 42–54.

Bointner R, Biermayr P, Goers S, et al. (2013) Wirtschaftskraft Erneuerbarer Energie in Österreich und Erneuerbare Energie in Zahlen. Blue Globe Report #1/2013. Vienna: Austrian Climate and Energy Fund.

Breuss F, Steininger K (1995) Reducing the Greenhouse Effect in Austria. A General Equilibrium Evaluation of CO_2-Policy-Options. EI Working Papers, Vienna.

Brons M, Nijkamp P, Pels E, et al. (2008) A meta-analysis of the price elasticity of gasoline demand. A SUR approach. *Energ Econ* 30: 2105–2122.

Druckman A, Jackson T (2009) The carbon footprint of UK households 1990–2004: a socio-economically disaggregated, quasi-multi-regional input-output model. *Ecol Econ* 68: 2066–2077.

European Environment Agency (2018) Transport greenhouse gas emissions. Available from: https://www.eea.europa.eu/airs/2018/resource-efficiency-and-low-carbon-economy/transport-ghg-emissions

Federal Ministry of Austria for Sustainability and Tourism and Federal Ministry of Austria for Transport, Innovation and Technology (2018) #mission2030. Austrian Climate and Energy Strategy. Vienna: Federal Ministry of Austria for Sustainability and Tourism and Federal Ministry of Austria for Transport, Innovation and Technology.

Goers S, Baresch M, Tichler R, et al. (2015) MOVE2—Simulation model of the (Upper) Austrian economy with a special focus on energy including the socio-economic module MOVE2social—integration of income, age and gender. Linz: Energieinstitut at the Johannes Kepler University.

Goers S, Schneider F (2019) Austria's Path to a Climate-Friendly Society and Economy-Contributions of an Environmental Tax Reform. *Modern Economy* 10: 1369–1384.

Goulder L (1995) Environmental taxation and the double dividend: A reader's guide. *Int Tax Public Finan* 2: 157–183.

Goulder L, Parry I, Burtraw D (1997) Revenue-Raising versus Other Approaches to Environmental Protection: The Critical Significance of Preexisting Tax Distortions. *Rand J Econ* 28: 708–731.

Hymel KM, Small KA, Van Dender K (2010) Induced demand and rebound effects in road transport. *Transport Res B* 44: 1220–1241.

Kirchner M, Sommer M, Kratena K, et al. (2019) CO_2 Taxes, Equity and the Double Dividend: Macroeconomic Model Simulations for Austria. *Energ Policy* 126: 295–314.

Köppl A, Kettner C, Kletzan-Slamanig D, et al. (2014) Energy Transition in Austria: Designing Mitigation Wedges. *Energy Environ* 25: 281–304.

Moser S, Mayrhofer J, Schmidt R, et al. (2018) Socioeconomic cost-benefit-analysis of seasonal heat storages in district heating systems with industrial waste heat integration. *Energy* 160: 868–874.

Ottelin J, Heinonen J, Junnila S (2018) Carbon and material footprints of a welfare state: Why and how governments should enhance green investments. *Environ Sci Policy* 86: 1–10.

Pearce D (1991) The Role of Carbon Taxes in Adjusting to Global Warming. *Econ J* 101: 938–948.

Shammin M, Bullard C (2009) Impact of cap-and-trade policies for reducing greenhouse gas emissions on US households. *Ecol Econ* 68: 2432–2438.

Sims R, Schaeffer R, Creutzig F, et al. (2014) Transport, In: Edenhofer O, Pichs-Madruga R, Sokona Y, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge, New York: Cambridge University Press.

Statistik Austria (2019a) Ökosteuern. Available from: http://statistik.gv.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/umwelt/oeko-steuern/index.html

Statistik Austria (2019b) Kraftfahrzeuge—Neuzulassungen. Available from: http://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/strasse/kraftfahrzeuge_-_neuzulassungen/index.html

Steinmüller H, Tichler R, Kienberger T, et al. (2017) Smart Exergy Leoben: Exergetische Optimierung der Energieflüsse für eine smarte Industriestadt Leoben. Vienna: Austrian Climate and Energy Fund.

Tichler R (2009) Optimale Energiepreise und Auswirkungen von Energiepreisveränderungen auf die oberösterreichische Volkswirtschaft. Analyse unter Verwendung des neu entwickelten Simulationsmodells MOVE. Linz: Energiewissenschaftliche Studien.

Titelbach G, Leitner G, van Linthoudt J-M (2018) Verteilungswirkungen potentieller Verkehrsmaßnahmen in Österreich. Research Report. Vienna: Institute for Advanced Studies.

Yeo S (2019) Where climate cash is flowing and why it's not enough. *Nature* 573: 328–331.