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Macroeconomic effects of carbon prices – a cross-country perspective

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Security through stability.

Macroeconomic effects of carbon prices – a cross-country perspective

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In the fight against climate change, the EU has set ambitious targets for its member states to decarbonize their economies by 2050. While carbon prices are among the proposed policy instruments to reduce greenhouse gas emissions, the carbon taxes currently in place are nowhere near the levels that would reduce emissions sufficiently. We use a globally integrated forecast model to simulate the introduction of carbon prices that reduce emissions to the EU's targets, assuming that carbon prices are the only effective climate policy, while in reality, a bundle of policy measures will be necessary to reach these targets. Then we assess the effects of these prices on GDP and inflation as well as the potential tax revenues generated by these prices. The results highlight the multifaceted impact of high carbon prices within the euro area: We find that we would need a sharply increasing average carbon price – from the actual price of EUR 43/t CO2 in 2024 to EUR 668/t by 2030 – to achieve the planned reduction for the euro area aggregate, although the required price changes vary across member states. The macroeconomic effects seem manageable at the euro area level, with a cumulative GDP loss of –2.2% and a cumulative increase in the consumer price index (CPI) of 6.4 percentage points from 2024 to 2030. However, for countries with a low share of renewable energy capacities and a strong reliance on fossil fuels in production, combined with low incomes, the impact on GDP and inflation may be double the size of the euro area average. For countries that have already undertaken ambitious investments in the green transition the effect on GDP is only half of the euro area average and significantly lower for consumer prices. We show that carbon pricing may be a very powerful tool to reduce emissions. However, the heterogeneity of economic impacts across member states highlights the need for coordinated support and targeted investment in renewable energy capacities, which could be partially funded by the tax revenues obtained from carbon pricing.

JEL classification: E31, H23, Q54
Keywords: carbon taxes, energy prices, inflation, GDP

Since the consequences of humanmade global warming are potentially catastrophic, the reduction of greenhouse gas (GHG) emissions has become an urgent policy objective. Economists have been assessing the economic and financial consequences of climate change and analyzing the contribution of economic activities to GHG emissions as summarized by Nordhaus (2019). Market mechanisms are not sufficient to rein in emissions, therefore Stern (2008) called climate change the biggest market failure the world has seen. The most prominent market failure in this context is the negative externality of GHG emissions: they cause severe damage, but emitters are not held responsible for the effects of their actions. An appropriate instrument to correct this kind of market failure is a carbon price that internalizes the externality by levying compensation for the social costs of GHG emissions on the emitters. This approach follows the so-called "polluter pays" principle. The calculation of the social cost of carbon depends on several variables that cannot be observed but only estimated, like the elasticity of demand or the discount rate as described in Stern and Stiglitz (2021). But even if we know the exact social cost of carbon, the implementation of a carbon price alone might be suboptimal because an excessively high carbon price triggers a huge negative supply shock. Therefore, Acemoglu et al. (2012) propose a mixed strategy combining carbon prices with targeted subsidies for green innovations. Krogstrup and Oman

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(2019) find that while carbon taxes are the most widely proposed measures, removing subsidies may be equally important to alter the relative prices between carbon-intensive and carbon-neutral goods. In a special report (IEA, 2021), the International Energy Agency (IEA) outlined a roadmap for the decarbonization of the global energy sector, which is responsible for ¾ of all GHG emissions. The report states that a swift implementation of several policies is required to reach global net zero by 2050 as pledged by most governments. In addition to carbon prices, the IEA emphasizes the need for regulations and mandates, like speed limits or energy efficiency standards. Current decisions by firms and households often depend on expectations about future prices. Cahen-Fourot et al. (2023) show that uncertainty about, and the heterogeneity of, expected carbon prices can delay firms' investment decisions. Ferrari and Nispi Landi (2022) present the effects of households' expectations on the inflationary impact of carbon taxes: to the degree that households anticipate lower future income because of the carbon tax, they will reduce their current demand.

Carbon prices can be enacted as taxes or as cap-and-trade schemes. Regardless of the institutional setup, a carbon price would make emission-intensive activities and their output more expensive. Under current production technologies, many sectors use emission-intensive inputs, hence carbon prices would cause widespread price increases. Moreover, these price increases may induce demand for higher wages, which could lead to inflationary second-round effects. Metcalf and Stock (2023) estimated the effects of existing carbon taxes in Europe and find no evidence for adverse impacts of these taxes on employment and GDP, and only modest effects on emissions. Brand et al. (2023) analyzed the macroeconomic effects of increasing carbon prices in the euro area using a suite of different models. They modeled the consequences of carbon prices increasing to EUR 140 per ton CO_2 until 2030. The effect on the inflation rate is rather small in most cases, the median of their results does not exceed 0.2 percentage points in any given year. The impact on output is also rather contained, GDP falls to between 0.5% and 1.2% below the baseline in 2030. But not only are economic effects subdued, the reduction in emissions caused by higher carbon prices also significantly falls short of the EU's 2030 target. Running similar simulations for the euro area as a whole, Coenen et al. (2024) find that a carbon price of EUR 375 would be necessary to cut in emissions by 25% by 2030.

The aim of our research is twofold. First, we simulate the macroeconomic effects of carbon prices which are sufficiently high to reduce GHG emissions as targeted by the EU. As central bankers, we are genuinely interested in the inflationary effects of carbon prices and the economic adjustment process. Beyond that, the Eurosystem is committed to assessing how climate risks and the transition to a carbon-neutral society affect our economies. The introduction of significant carbon prices is a central element of the transition process. Second, we analyze the country-specific heterogeneity of these effects. ECB (2021) indicated that existing carbon pricing schemes in euro area countries differ significantly and that higher carbon prices might drive prices and inflation. Negative idiosyncratic shocks like different effects of carbon prices have to be addressed by national policies because the Eurosystem's monetary policy reacts only to aggregate changes in the euro area. We want to assess whether the macroeconomic impacts of high carbon prices pose a challenge to national policymakers.

The rest of this study is structured as follows: In the next section, we explain the price mechanisms that are currently in place and could be enhanced for the purpose of reducing GHG emissions. Then, we present our simulations made on the basis of the Global Economic Model of Oxford Economics, which was also used by Brand et al. (2023). The final section concludes our findings.

I The EU policy framework for carbon prices

In the Fit-for-55 package, the EU has defined its policies to reduce GHG emissions by at least 55% by 2030 in comparison to 1990 levels. The package includes legislative proposals and initiatives across various sectors to align the EU with its long-term climate objectives outlined in the Paris Agreement. A central part of the Fit-for-55 package is the EU Emissions Trading System (ETS-1), a carbon pricing mechanism operating as a cap-and-trade system by setting a cap on the total amount of GHG emissions allowed within a certain jurisdiction, covering mainly emission from energy, manufacturing, aviation and maritime transport. Emission allowances are assigned to specific industries, with each allowance representing the right to emit a given GHG amount. If a company emits less than its allocated allowances, it can sell the excess allowances to other companies. Conversely, if a company exceeds its allocated allowances, it must purchase additional allowances to cover the excess emissions.

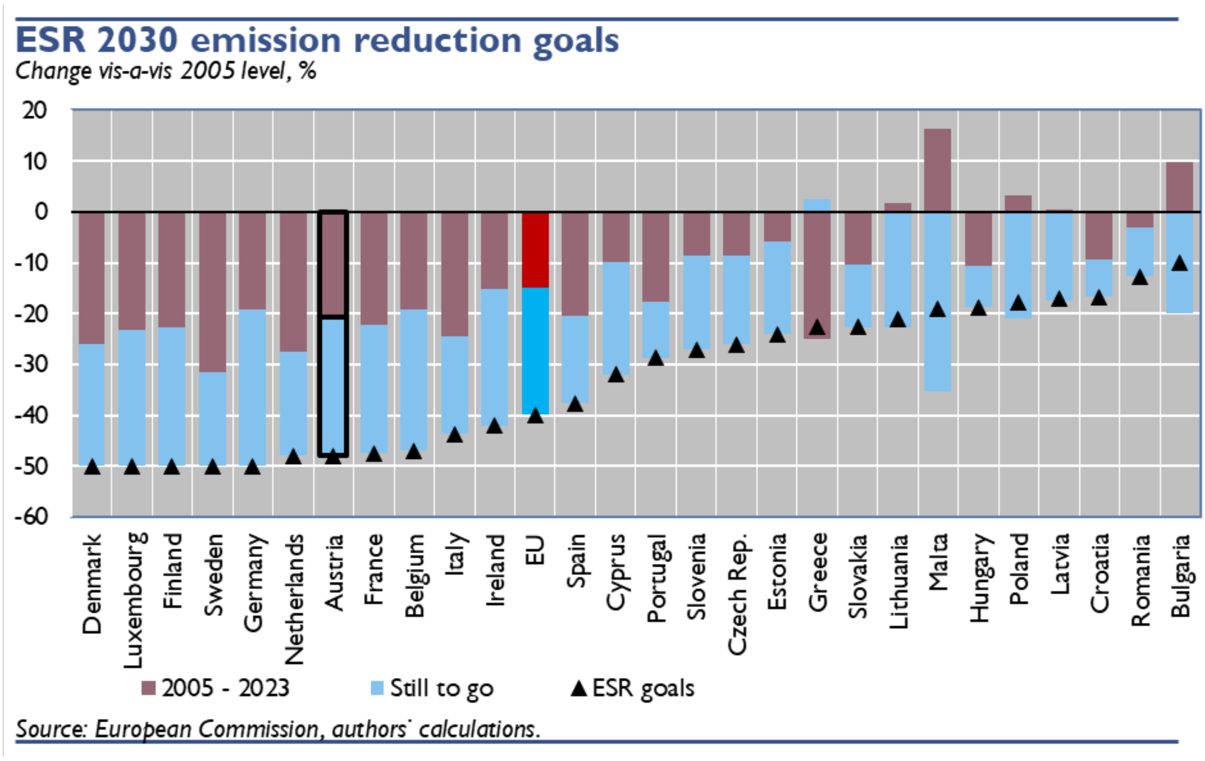
The trade in allowances establishes a carbon price for the capped emissions. Chart 1 depicts the development of the ETS-1 price per ton of carbon dioxide or the equivalent amount of other GHG over the last 15 years. Since the price was below EUR 20 per ton of emitted GHG and the EU's ETS was considered one of the more ambitious carbon pricing mechanisms, Dolphin et al. (2020) concluded that "most of the schemes introduced so far are associated with weak (average) price signals." Currently, ETS-1 is applied in all 27 EU member states, Iceland, Liechtenstein and Norway as well as Northern Ireland for electricity generation. Since its launch in 2005, it has generated revenues from auctions that amounted to more than EUR 150 billion[2].

Chart 1

[2] For more details, see the report on the functioning of the European carbon market by the European Commission (2023).

In addition, EU member states have also committed themselves to reduce emissions in sectors that are not governed by the ETS. The so-called Effort Sharing Regulation (ESR) defines national goals for reducing emissions in domestic transport, buildings, agriculture, small industry and waste. Together, these sectors emit almost 60% of all GHG in the EU. The objective of the ESR is to ensure fair and equitable contributions to the overall emission reduction objectives. Emission reduction goals are set in comparison to the 2005 emission levels. The EU revised the national ESR goals in June 2023 for the years up to 2025[3], in chart 2 we present the resulting national targets. In total, the EU is obliged to reduce its GHG emissions by 40% by 2030 compared to the 2005 level; by the year 2023, about one-third of the intended reduction has already been achieved. Most EU member states must still reduce their emissions significantly, only Greece has already reached its goal. Lithuania, Malta, Poland, Latvia and Bulgaria had not reduced their emissions at all by 2023 compared to the base year.

Chart 2



Some EU countries, e.g. Austria, have implemented national carbon price systems to reach their ESR goals. These price systems either cover emissions which remain not affected by ETS-1 or provide a stronger incentive to reduce emissions in sectors already covered by ETS-1. Partly, these prices will be transferred into a second EU trading system (ETS-2) as of 2027, which will be managed in a market separate from ETS-1 (at least) until 2030. ETS-2 will cover GHG emissions from the building and road transport sectors as well as industrial production. Känzig and Konradt (2023) emphasize that sectors currently covered by ETS-1 are in a better position to pass on cost shocks because of market segmentation in the energy sector and the general dependence on energy.

[3] See Commission implementing decision (EU) 2023/1319 for more details.

2 Model simulations of carbon prices

To estimate the macroeconomic effects of the EU's carbon price policies, we employed the Global Economic Model by Oxford Economics (OE). OE has augmented its semistructural multicountry model with a climate module, which allows us not only to assess changes of macroeconomic variables under different carbon pricing scenarios, but also to estimate how much these price policies would contribute to reducing GHG emissions. Monetary policy follows a Taylor rule based on consumer prices and the output gap.

The model includes limited sectoral disaggregation. It simulates the demand for various energy sources, including gas, oil, coal and renewables, across different sectors such as households, firms and transport, but ultimately aggregates these demands at the macroeconomic level. The model assumes adaptive expectations and exhibits Keynesian characteristics in the short run, with sticky prices and output driven by aggregate demand. In the long run, the model aligns with neoclassical theory, where prices fully adjust and equilibrium is determined by supply-side factors such as productivity, labor and capital. Energy demand is modeled in detail, with functions for oil, natural gas, coal, and electricity depending on GDP, prices and energy efficiency for individual countries. These energy demand forecasts are then translated into carbon emissions. Hence, decarbonization efforts primarily focus on the energy sector level. The model also captures the impact of higher energy prices on total factor productivity, which in turn affects potential output and business investment. Additionally, the model adjusts post-tax fossil fuel prices that encourage a shift in consumption toward low-carbon alternatives to the extent of price increases dependent on the carbon content of fuels and energy efficiency. The data coverage in the OE model enables us to simulate only 13 of the 20 euro area economies (see table 1), but these countries together account for 98% of the euro area's output and 97% of its GHG emissions.

The ETS periodically distributes carbon allowances to firms, which allows them to determine the timing of their emissions within the limits of their allowances. Future reductions in carbon emissions are anticipated as the regulator progressively reduces the total number of allowances issued. This reduction in allowances is expected to drive up ETS prices as the market adjusts. Although the model does not explicitly incorporate a cap-and-trade system, it functions similarly to such a tax. The primary focus is on how the carbon tax impacts energy prices and consumption patterns, rather than on the allowances themselves.

The benchmark for our simulations is OE's baseline scenario, which reflects current policies as well as policy commitments that are backed up by measures and believed to be sufficiently detailed. Carbon prices are expected to increase moderately. Specifically, the OE baseline scenario forecasts a gradual increase in the ETS-1 price from EUR 78 per ton of CO2 in 2023 to EUR 88 per ton by 2030. Additionally, the scenario includes the introduction of emission pricing under ETS-2 starting in 2027, set initially at EUR 44 per ton of CO2. Even in the baseline scenario, we observe a GHG reduction by 44% in 2030 compared to 1990 while mean global warming is projected to reach 1.9 degrees Celsius above pre-industrial levels in 2050. While OE's original baseline scenario assumes the same carbon price for all countries in the euro area as an average ETS share coverage is assumed, we considered an individual price path for each member state in the euro area.

From a monetary policy perspective, it is interesting to note that the price changes that were implemented in the model do not require a significant monetary policy response to keep inflation at the target rate of 2%. Assuming a continuous increase in carbon prices over the whole period until 2030, the OE simulations yield an inflation rate and a monetary policy rate which are firmly anchored in the years after 2027.

2.1 GHG emissions under the Effort Sharing Regulation

In a first step, we assess the state of national efforts under the ESR, which target the emissions from sectors not covered by the current EU ETS. Table 1 compares the share of national GHG emissions covered by the ESR (column 1) with the share of GHG emissions covered by national carbon price schemes in total emissions (column 2). ESR shares vary significantly from country to country, depending on the sectoral composition of national production and the prevalent modes of energy generation. Countries where energy-intensive manufacturing sectors contribute more to GDP tend to have a higher share of emissions covered by the EU ETS. The more heating and transportation are fueled by renewable energy, the lower the emissions under the ESR. Not all member states have chosen to implement carbon prices as a policy instrument to reduce emissions. Only in Germany and Austria, more than half of the emissions covered by the ESR are subject to national carbon price schemes (note that emissions under ETS pricing are usually not taxed by national authorities, hence, all the emissions under national taxation fall under the ESR).

Based on the OE baseline scenario, we assume that countries that have not introduced legislation for national carbon taxes are assumed to continue without. Nevertheless, these assumptions result in an increase in carbon prices for most ESR sectors in 2030 because of the introduction of ETS-2. Given these carbon price increases, we find that 5 of the 13 euro area member states covered by the OE climate model fail to achieve their national effort sharing goals: Spain, Austria, France, Ireland and Germany. This may seem counterintuitive at first, since some of these countries have implemented comprehensive national carbon prices and other countries that meet their emission reduction targets according to our simulations have no national carbon price scheme (see column 2 in table 1). But whereas most national carbon price schemes were introduced in 2017 or later, some countries used to have much higher excise duties on fuels long before. According to OECD (2023), Italy and the Netherlands, for example, have not introduced a national carbon tax, but their fuel excise taxes result in higher effective carbon prices than in Austria or Germany.

Table 1

Effectiveness of national EU policies

Country	Share of emissions covered by ESR	Emissions under national CO2 prices	ESR emission reduction target by 2030	Estimated ESR emission reduction by 2030*
	%			
Finland	60	13	-50	-84
Netherlands	59	1	-48	-57
Italy	65	0	-44	-57
Belgium	64	0	-47	-57
Germany	**56**	**40**	**-50**	**-48**
France	**81**	**35**	**-48**	**-40**
Ireland	**70**	**0**	**-42**	**-40**
Portugal	75	36	-29	-37
Austria	**63**	**43**	**-48**	**-33**
Spain	**70**	**2**	**-38**	**-32**
Slovakia	57	0	-23	-31
Croatia	72	0	-16	-31
Greece	60	0	-23	-24

Source: European Commission, authors' calculations based on OE.

Note: Countries in bold will not manage to achieve their national effort sharing goals in 2030.

** According to OE baseline scenario.*

Countries which were hit hard by the economic crisis that started in 2008 recorded a severe reduction in economic activity, which in turn drastically lowered their GHG emissions. In Greece, real GDP shrank by 26.5% and GHG emissions sank by 33% between 2008 and 2013. None of the countries that were most severely affected by the great recession have recorded pre-crisis emission levels since. Hence, the decision to take 2005 GHG emissions as the reference value for ESR targets benefits these countries. In contrast, large countries, such as Germany or France, reached their highest GHG emission values in the early 1990s. Although Austria reached its GHG emission peak in 2005, the country is far off the 2030 relative target despite a comparatively high share of sectors covered by national carbon prices (which were introduced as late as 2022).

2.2 Fit-for-55 price scenario 2025 – 2030

In the next step, we assess what carbon prices are needed for the euro area countries to reach their Fit-for-55 targets. This is clearly a hypothetical exercise, since we know that the decarbonization of our economies will require a combination of different policy measures as indicated by Acemoglu et al. (2012) or IEA (2021). These measures include technology policies, mandatory energy efficiency standards, transport regulations or investments in infrastructure. But the results of our simulations may serve as a benchmark for the macroeconomic impact of these policies since some of them (e.g. energy efficiency standards) are rather difficult to simulate in macro models. In our simulations, we do not assume any additional investments in cleaner technologies or the expansion of renewable energy capacities, given that the simulation time frame is considered too brief to accommodate significant advancements in these areas. In the short run, economic effects of carbon prices are easier to model than other policies that might involve regulatory changes, subsidies or technological advancements. While other measures in the Fit-for-55 package (such as energy efficiency improvements, renewable energy targets, or transportation electrification) are crucial for long-term decarbonization, they often require more time for planning, investment and deployment, making them more suitable for medium- to long-term strategies.

Our simulations follow the line of Brand et al. (2023), who estimated the effects of higher carbon prices with a suite of different models, among them the OE model. They assume a carbon price increase from EUR 85/t of CO2 in 2021 to EUR 140/t of CO2 in 2030 for all countries in the euro area[4] and a milder carbon price path for the rest of the world. Comparing their results to a scenario assuming no carbon prices at all, they find a GDP loss of around 1% by 2030 and higher inflation by around 0.1 percentage points per year, while the reduction in CO2 emissions is around 5% and, hence, fails to reach the Fit-for-55 targets.

Based on our calculations of carbon prices needed to reach the targets, in our scenario, we assume an annual price increase of EUR 90 per t/CO2 for ETS-1 and ETS-2 starting in 2025. Hence, we assume that allowances under ETS-1 will have a price of EUR 180/t CO2 in 2025, which will rise by EUR 90/t CO2 each year until a final price of EUR 630/t CO2 is reached in 2030 (and is held constant after 2030). The price path for ETS-2 starts in 2027 with the same price as under ETS-1 in that year, namely, EUR 360/t CO2. In analogy, allowances under ETS-2 reach a final price of EUR 630/t CO2 in 2030. For each EU country i, the setup of the emission-weighted carbon prices p_i^{ETS} per t/CO2 under the integrated ETS system is as follows:

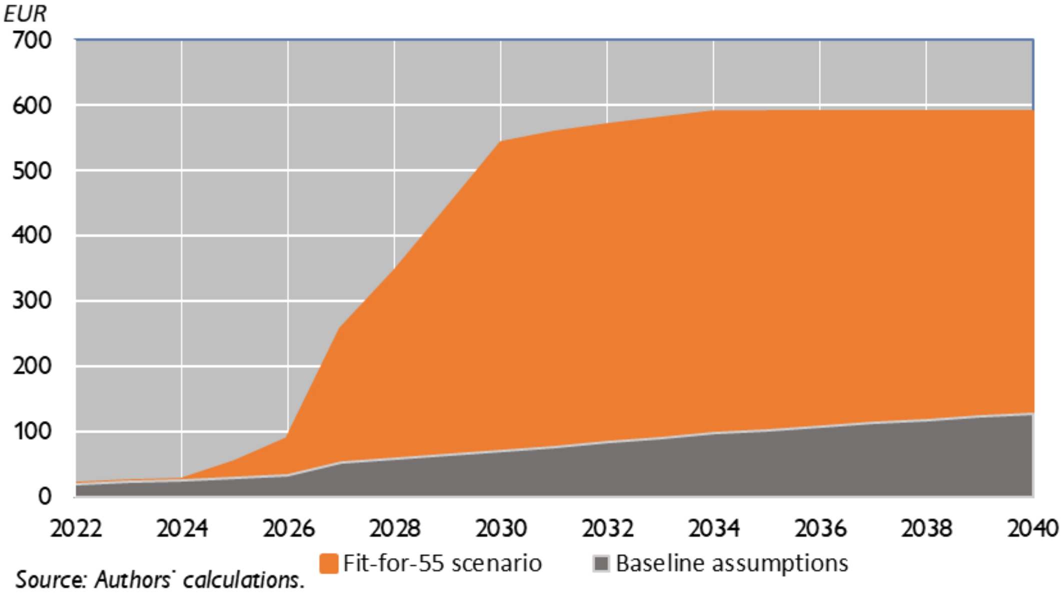
$$p_i^{ETS} = (p^{ETS-1} \times s_i^{ETS-1}) + (p^{ETS-2} \times s_i^{ETS-2})$$

with p^{ETS-1} and p^{ETS-2} representing the prices per t/CO2 for the sectors covered by the corresponding ETS system and the emission-weighted shares s_i^{ETS-1} and s_i^{ETS-2} are assumed according to the sectoral coverage of the ETS system, which differs for each EU country i. ETS prices are assumed to partially generate some government revenue (i.e., contributing to national budgets) and parts of the ETS revenues are assumed to go directly to EU modernization and innovation activities as well as to the EU's Social Climate Fund. The average government revenue from the current p^{ETS-1} is EUR 53/t CO2 in 2025 and, according to our simulation, this revenue will increase to EUR 541/t CO2 in 2030. In contrast to the baseline assumptions by Brand et al. (2023), we use the OE baseline scenario (as of Q4 2023) as a benchmark to measure the effects of higher carbon prices. This benchmark includes a mild increase in carbon prices over the projection horizon (see chart 3). We consider this a more realistic comparison than a scenario without any carbon price increases at all since several countries have already announced their intention to increase carbon prices over the coming years. According to the OE baseline scenario, the baseline for countries outside the EU also allows for increasing carbon prices if these have been announced or implemented sufficiently.

[4] The IEA World Energy Outlook (IEA, 2022) presents a "net zero emissions by 2050" scenario which assumes that advanced economies with net zero emissions pledges (like the EU) introduce a carbon price of 140 USD by 2030, which will be raised further to 205 USD in 2040 and 250 USD in 2050.

Chart 3

ETS price paths in different scenarios*



Source: Authors' calculations.
** ETS prices refer to the government-revenue generating share of carbon prices*

In addition to p_i^{ETS}, each country may or may not introduce a national carbon price $p_i^{national}$. The total emission-weighted effective carbon price per t/CO2 for each country is calculated by:

$$p_i^{CO2} = \left(p_i^{national} \times s_i^{national}\right) + p_i^{ETS}$$

with $s_i^{national}$ representing the shares of emissions in country i covered by a national pricing mechanism (note that p_i^{ETS} has been calculated by using the shares of emissions under each ETS, therefore, no further weighting is required). We considered a price path for each member state in the euro area based on prices which are already in effect (starting in 2025).

Table 2 shows the evolution of the price required to meet the Fit-for-55 scenario, p_i^{CO2} for each country as well as the emission reduction compared to 1990 values. The average p^{CO2} for the euro area is EUR 668 in 2030, which results from a price increase of EUR 581 compared to the baseline scenario in 2030. We find a strong heterogeneity in emission reduction across euro area member states, with Finland leading by a considerable margin of -94% while Ireland shows the lowest reduction with only -14% in GHG emissions. According to the IEA (2023), Finland has already set one of the most ambitious energy targets, a legal obligation to reach carbon neutrality by 2035. The country is making progress toward this target and has one of the lowest levels of reliance on fossil fuels among IEA member countries. Ireland, by contrast, introduced a carbon tax as early as 2010, but still faces challenges in reducing its emissions. According to the IEA, natural gas will remain an element in Ireland's energy mix for the next decade, particularly to meet peak electricity demand. When looking at the aggregated results, the euro area would manage to reduce its emissions in line with its Fit-for-55 targets by 55% by 2030, which is an additional reduction of 11 percentage points compared to the baseline. Here, it should be noted that the euro area countries that we analyze already cut their GHG emissions on average by 34%

between 1990 and 2023, with Finland, Germany and Slovakia having recorded the strongest reductions, whereas in Ireland and Spain, total GHG emissions were growing over that period.

Table 2

Carbon prices and emission reduction in Fit-for-55 scenario in the euro area

Country	Carbon price		GHG emission changes compared to 1990*	
	2025	2030	2023	2030
	EUR		%	
Finland	101	736	-53	-94
Germany	123	759	-48	-67
Belgium	79	679	-17	-66
Slovakia	95	750	-46	-66
Netherlands	91	732	-32	-60
Italy	76	665	-44	-60
Croatia	61	601	-26	-50
France	70	518	-29	-42
Portugal	70	573	-15	-24
Austria	112	697	-15	-24
Spain	67	626	9	-22
Greece	88	721	-29	-15
Ireland	66	622	19	-14
Euro area	**84**	**668**	**-34**	**-55**

Source: Authors' calculations.

** Compared to 1990 values according to the Fit-for-55 package.*

The macroeconomic effects of the required carbon price increase seem manageable at the aggregate euro area level. We see that in the Fit-for-55 scenario, GDP in the euro area drops by -2.2% until 2030 when compared to the baseline (see chart 4). The CPI in the euro area increases cumulatively by 6.4 percentage points by 2030 (see chart 5). The stronger rises in the CPI are due to the ETS-1 increase in 2025 and the ETS-2 introduction in 2027. The reduction in output depresses disposable personal income, but this income decline does not curb effective demand so much that it counterbalances the effects of the high carbon prices on the CPI. Inflation rates pick up only temporarily, returning to their anchored levels rather quickly; this is in line with the findings of Brand et al. (2023) and Coenen et al. (2024), who also report a transitory rise in inflation because of increasing carbon taxes. The simulations by Coenen et al. (2024) are most comparable to ours since they also estimate the effects of reducing carbon emissions by 25% from 2022 to 2030 and find that this would require increasing carbon taxes to EUR 375. In our Fit-for-55 scenario, the price of EUR 668 yields an emission reduction of 31% from 2022 to 2030.
Since the carbon tax is a cost-push shock to the economy, we would expect the price competitiveness of the affected countries to deteriorate, which consequently depresses the growth contribution of net trade. This effect is dampened by the fact that most euro area countries trade mostly with other euro area countries, and all of them are exposed to the same cost-push shock. For example, Austria conducts more than half of its international trade with the other 12 euro

area countries listed in table 2. Austria's trade balance is estimated at +1.8% of GDP in 2023 and would decline slowly in the baseline scenario but remain positive, whereas in the Fit-for-55 scenario, the trade balance turns negative in 2028 and the deficit increases continuously thereafter. Exports are projected to decline by 4% until 2030 in comparison, but imports would also be lower in the Fit-for-55 scenario – by about 2.5% – until 2030, with imports of fuels declining strongly for obvious reasons.

Chart 4

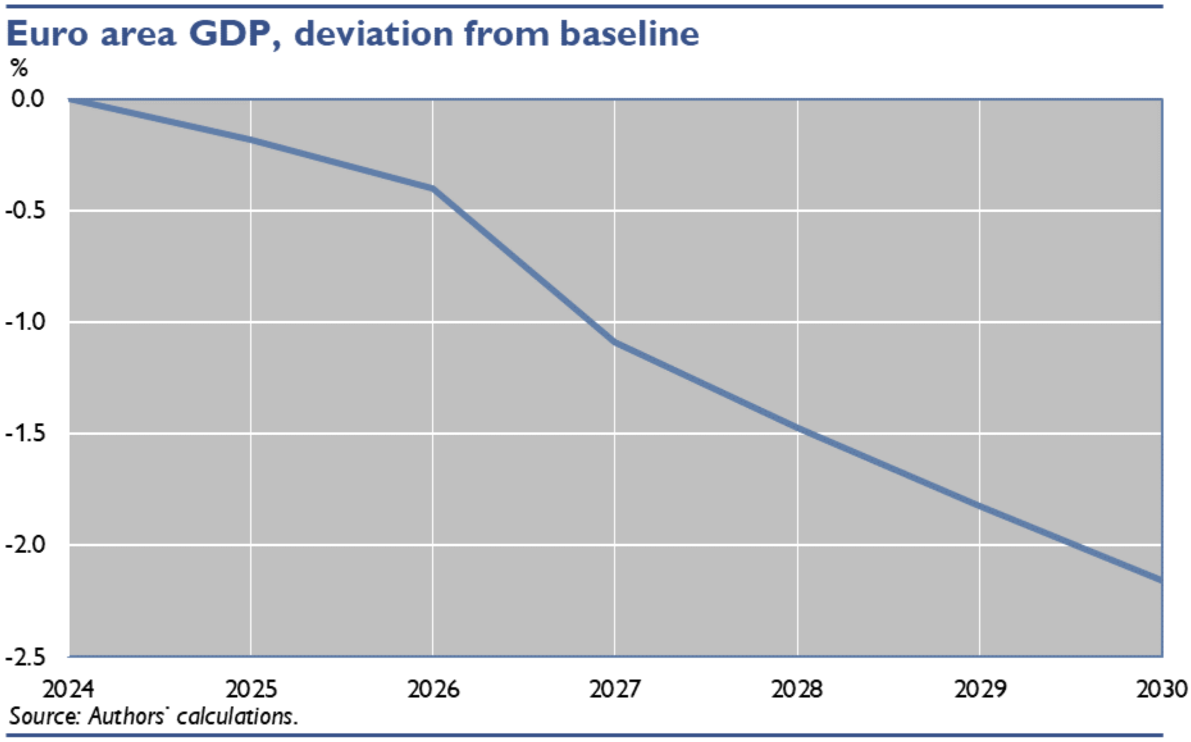
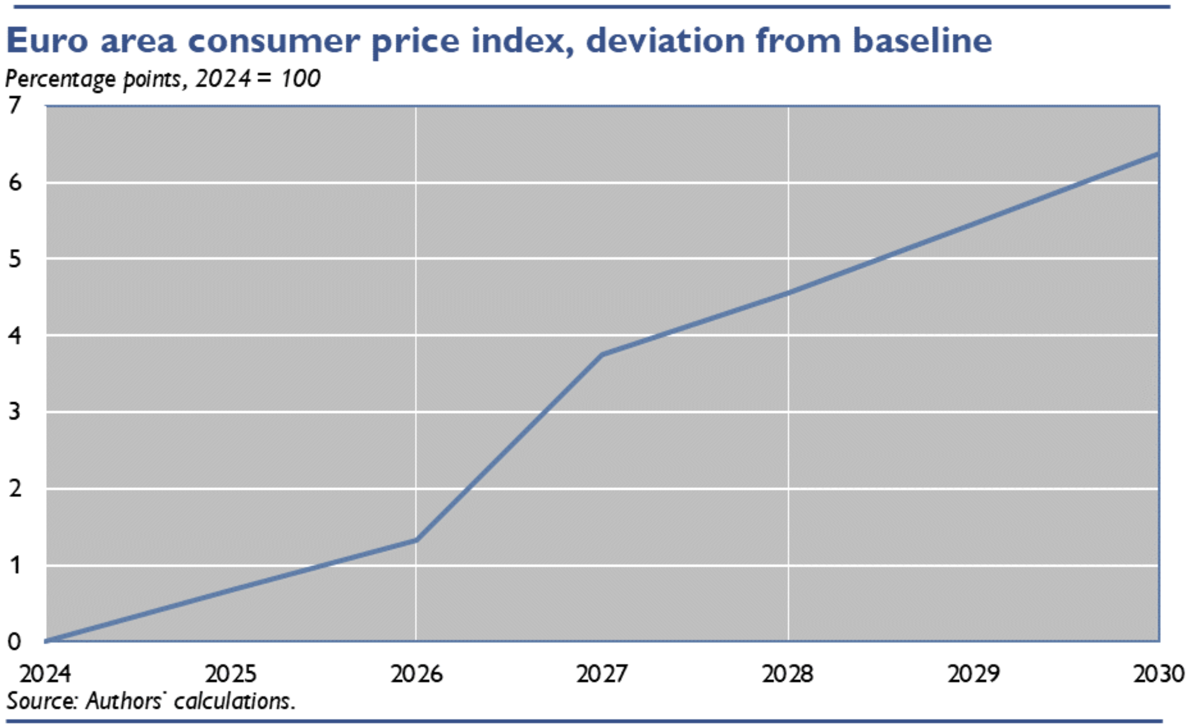


Chart 5



The varying impacts on GDP and CPI across EU countries reflects the fact that renewable energy adoption and reliance on fossil fuels varies among member states. Chart 6 shows a comparison of how big the simulated impact on GDP is on the national level. While for Ireland, we see a decline in GDP compared to the baseline which, at less than -1%, is significantly below the euro area average, for Slovakia, we see a GDP loss that is more than twice as high as the average, namely almost –5%. According to the IEA, the contribution of renewable energy sources to Slovakia's energy mix remains lower compared to some other euro area members as Slovakia still uses a significant amount of fossil fuels, especially natural gas and, to a lesser but still significant extent, coal (31% of total emissions in Slovakia come from fuel combustion). Moreover, Slovakia's economy relies heavily on carbon-intensive industries such as steel, cement, and chemicals (26% of total energy-related emissions come from manufacturing). It should be noted that our simulations do not incorporate an increase in the capacity for renewable energy production because this would warrant an explicit policy change and our aim was to isolate the price effects of a tax increase under ceteris paribus conditions. However, the share of renewable energy in electricity production does increase in Slovakia, but this is only due to the decrease in the fossil component of electricity production because of higher prices.

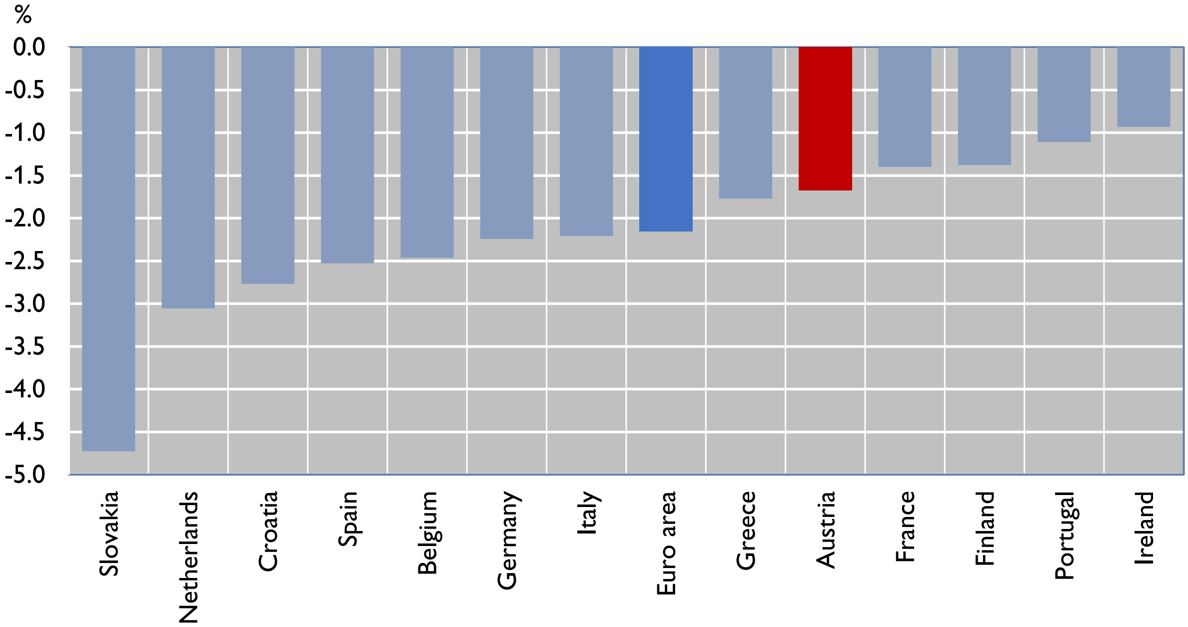
IEA data also highlights that Ireland has the lowest energy intensity per GDP by far (which is lower by 69% when comparing 2000 to 2020 values). Besides energy intensity, sources of energy also explain why some countries' GDP is affected less by higher carbon prices. While the primary source of energy is nuclear power in France, Portugal's domestic energy production is characterized by a diverse mix of renewable energy sources, particularly hydropower, wind and solar energy. Austria is below the euro area average when it comes to GDP impacts, as Austria's energy mix is characterized by a high share of renewable energy, particularly hydropower.

According to Eurostat, 33.8% of Austria' gross final energy consumption was generated by renewable sources in 2022 (compared to an EU average of 23%).

In chart 7, we see a comparison of the CPI effect at the national level. Here, again, Slovakia shows the highest effect by far, with a cumulative increase of consumer prices of 16.8% over the whole period compared to the baseline. The energy sector, and particularly the fuel component of energy, plays a significant role in Slovakia's consumer basket, while a very mild effect of around 4.3% to 4.6% can be observed for France, Finland and Portugal, where fuels do not have such a significant role in the consumer basket. This is in line with the findings of Känzig and Konradt (2023), who also find a stronger price response in countries with a more carbon-intensive energy mix.

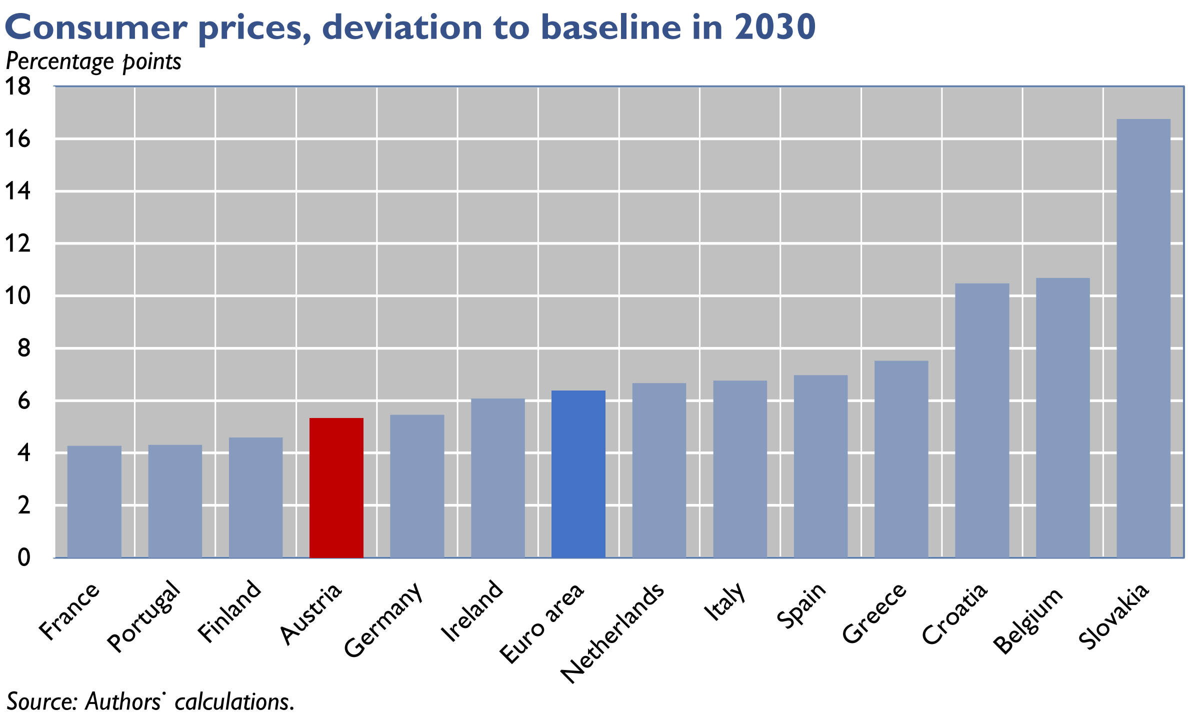
Chart 6

GDP levels, deviation to baseline in 2030



Source: Authors' calculations.

Chart 7



Revenues from carbon pricing are used by member states for national and EU-wide climate action measures. We examined how much in revenues relative to GDP member states could obtain from carbon prices in the Fit-for-55 scenario (see chart 8). At the aggregate level, the 13 euro area members included in our analysis would obtain EUR 2.62 trillion in revenues from 2025 to 2030, which corresponds to EUR 2.07 trillion in additional carbon tax revenues under the Fit-for-55 scenario compared to the baseline. National carbon tax revenues depend on the carbon intensity of the economies. n 2025, almost all national carbon tax revenues are below 1% of GDP, but by the end of the decade, Slovakia might generate revenues of more than 5% of GDP. For Austria, the expected tax revenues increase from 0.8% of GDP in 2025 to 2.7% in 2030. Other sources of tax revenues might decline temporarily due to the negative effects of carbon taxes on output, but these effects are rather modest in our simulations.

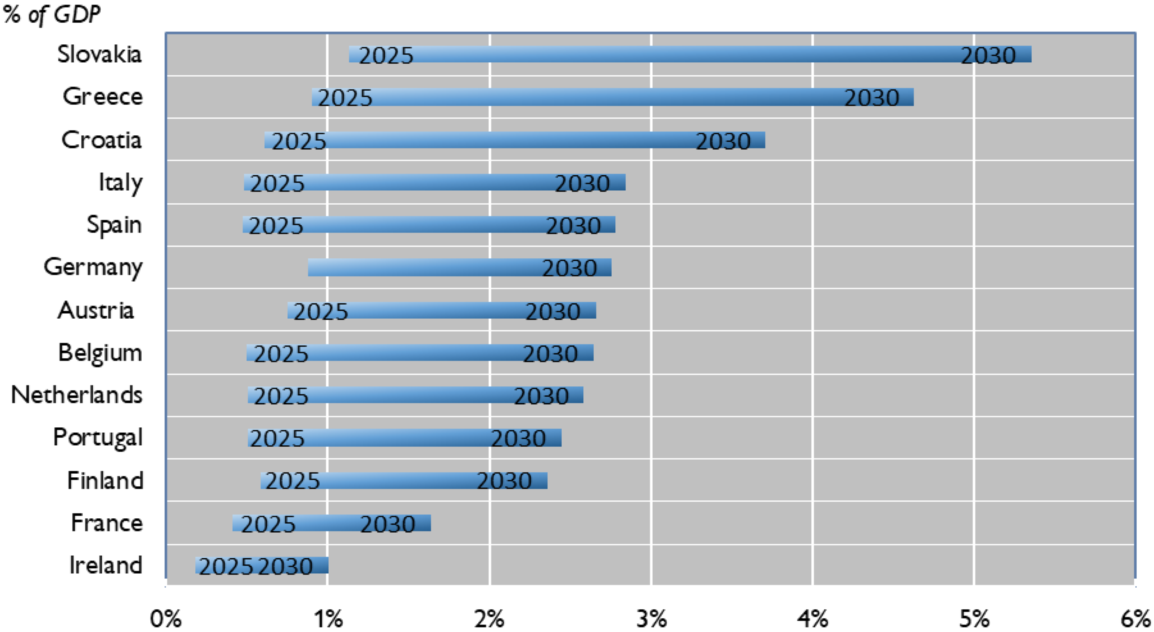
Since future revenues from carbon taxes will reach significant levels, governments will be faced with the political questions of what to do with these funds. The European Environment Agency estimates that the required investments in the sustainable transition amount to EUR 520 billion per year from 2021 to 2030 (EEA, 2023). The revenues from carbon taxes could cover almost half of these financing needs. In practice, however, it is probably necessary to recycle most of these revenues back to taxpayers to raise the social acceptability of carbon taxes. To assess the political economy constraints for carbon taxes, Muth (2023) compares 30 carbon pricing mechanisms at the national level and finds that a hybrid strategy of combining compensatory transfers to taxpayers with targeted spending on climate-related projects is most effective. For the simulations presented in this paper, we assume the national governments use the additional revenues from higher carbon taxes to reduce their sovereign debt levels, which does not induce any positive demand effects. Governments recycling their revenues back to households would strengthen demand, thereby pushing prices up; hence, our results can be seen as a conservative

estimate of the inflationary effects. But of course, the effect also depends on the behavioral response: if the recycled revenues are spent on less energy-intensive equipment (e.g., more efficient refrigerators), the long-term impact might be disinflationary. Känzig and Konradt (2023) also stress the importance of recycling channels for the macroeconomic effects of carbon prices.
According to the International Carbon Action Partnership, roughly 20% of ETS-1 revenues go to the EU's Modernisation Fund and its Innovation Fund. According to the European Commission, legislation provides for 25% of ETS-2 revenues going to the Social Climate Fund, which is also included in the Fit-for-55 package. Hence, out of the EUR 2.62 trillion which, according to our analysis, could be generated in total from national as well as ETS revenues, EUR 207 billion are intended to directly go to the aforementioned funds.

Chart 8

Carbon tax revenues 2025-2030 under the Fit-for-55 scenario

% of GDP



Source: Authors' calculations.

3 Conclusions

The results of our simulations show that a carbon price of EUR 668/t CO2 in 2030 would be required to reach the EU's Fit-for-55 targets for GHG emission reduction if the carbon price was the only policy instrument to trigger the necessary changes. Overall, the impacts that reaching the Fit-for-55 targets in 2030 has on GDP (a cumulative loss of 2.2%) and CPI (a cumulative increase of 6.4 percentage points) seem contained, but the economic repercussions are not uniformly distributed among the countries of the euro area. From a monetary policy perspective, it is important to note that inflation rates will pick up only temporarily.
Countries which have already made substantial investments in renewable energy and, hence, have a robust renewable framework will experience relatively mild economic impacts. More resilience can also be observed for countries which rely more on non-fossil energy sources like nuclear energy, such as France. Countries which have introduced effective carbon reduction policies in

the past overachieve the Fit-for-55 targets by far in our simulation. Conversely, countries with a heavy reliance on fossil fuels and carbon-intensive industries face stronger economic repercussions. Impacts on CPI are mainly driven by the energy component of consumption, and hence, low-wage countries face harsher outcomes. The projected GDP decline for Slovakia is more than twice as high as the euro area average, and the CPI is expected to rise cumulatively by 16.8 percentage points, also more than twice as high as the euro area average. This strong contrast underscores the challenges faced by countries with less diversified energy portfolios and a greater dependence on carbon-intensive industries, in particular, if incomes are low. While carbon pricing is a crucial tool for achieving the EU's climate goals, the great difference in economic impacts across member states highlights the need for coordinated support and targeted investment.

High carbon prices would generate substantial tax revenues. In our scenario, revenues of EUR 207 billion obtained over five years would be allocated, as intended, directly to the EU's Modernization Fund and its Innovation Fund as well as the Social Climate Fund, with the remaining revenues distributed among national governments. Political economy considerations about the use of these tax revenues are a valid concern but are outside the scope of our paper[5]. Key areas for national investment should be (a) increasing the share of renewables in the energy mix (the EU's Fit-for-55 goal is a minimum 40% share of renewables in the EU's overall energy mix by 2030), as well as (b) the mitigation of socioeconomic impacts of the transition on vulnerable households, micro-enterprises, and transport users, in particular, in countries where carbon taxes have high effects on consumer prices.

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[5] Coenen et al. (2024) state that the recycling of carbon tax revenues can have important effects on inequality and consumption demand. They explicitly take these into account by modeling more and less constrained households and show that an even distribution of carbon tax revenues among all households has a regressive effect.

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