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Climate Change and a Robust Global Climate Policy

Introduction

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FORES

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Introduction

Emissions of carbon dioxide lead to global warming, but science has not been able to say how much. Thus, climate policy must be chosen under uncertainty. In principle, one can think of three different ways of choosing policy in such a situation; i) Wait and see, ii) hope for the best and iii) following a precautionary principle. This report discusses the uncertainty and evaluates these three options. The conclusion is that, although choosing an ambitious climate policy based on the precautionary principle may turn out to have been overambitious, the cost of such a policy mistake is low. The opposite is the case for the other two options: if the scenarios where these policies are optimal do not materialise, the costs to human welfare may be very large. Thus, the precautionary policy, with a transition to climate neutrality over three decades is the only policy that is robust to mistakes.

The greenhouse effect

Increased concentrations of carbon dioxide (CO2) and other greenhouse gases affect the balance between incoming and outgoing energy flows to and from Earth. The fundamental reason is that, apart from direct reflection of sunlight, the outgoing energy flow consists of low-frequency heat radiation. Its frequency corresponds to the resonance frequency of greenhouse gas molecules that start to vibrate when affected by heat radiation and thus absorb the energy. The incoming energy flow in the form of visible sunlight is of much higher frequencies than the resonance frequency of all atmospheric molecules and thus passes through – we can see the sun! More CO2 in the atmosphere implies that heat needs to travel further up in the atmosphere before it can leave Earth as heat radiation. This has a warming effect much like a thicker blanket (see SNS, 2020).

The physics behind the greenhouse gas effect has been known since the early 19th century and contributions from the 1960's were awarded the 2021 Nobel Prize in Physics. The consequences for the climate of changing the atmospheric CO2 concentration was first quantified by the Swedish scientist Svante Arrhenius (Arrhenius, 1896). According to his calculations, an increase in the CO2 concentration by 50%, like the one we currently see, would in the long run increase the temperature between 3 and 4°C depending on latitude and time of year. This number is a bit higher than most current point estimates, but within the uncertainty interval provided by science.

An important finding stressed in the recent 6th report from UN's climate panel IPCC (IPCC, 2021) is that the global mean temperature is approximately proportional to accumulated emissions. This means that each additional unit of emissions contribute to an approximately constant additional amount of warming. However, the proportionality factor is uncertain. The IPCC (2021) states a two-thirds confidence interval from 0.27 to 0.63°C per 1012 ton CO2 (TtCO2). A key factor behind the uncertainty is potentially temporary effects on cloud formation by emissions of particles and aerosols. Given the current global rate of emissions at 0.035 TtCO2 per year (IEA, 2021), it is straightforward to calculate that the global mean temperature increases by 0.1 to 0.22 degrees °C per decade due to the current accumulation of CO2 emissions.

The proportionality between emissions and temperature contrasts with the popular perception that we are close to a tipping point where the global climate would tip over to a permanent hot state. Passing such a tipping point would mean that it becomes too late to halt global warming. In fact, a recent survey shows that 73% of the population in the G20-countries believes that the climate system is close to such a situation (Gaffney et al., 2021). However, this is not in line with scientific research results. The IPCC (Chen et al. 2021, p 1:66) states in its recent 6th report that "there is no evidence of such non-linear responses at the global scale in climate projections for the next century, which indicate a near-linear dependence of global temperature on cumulative GHG emissions." However, the IPCC cannot rule out global non-proportionalities in the longer run. Regional tipping points, such as the Amazon forest dieback and permafrost collapse, do also occur in some model predictions reported by the IPCC. The conclusion is that the longer we keep accumulate greenhouse gases, the more global warming we get and the more serious are damages and risks, but it is not going to be too late to act anytime soon.

Uncertainty on climate sensitivity

The uncertainty about how sensitive climate is to emission is large. Since industrialisation started, we have emitted approximately 2.4 TtCO2 (IPCC, 2021). Given this and the interval provided by the IPCC presented above, we have committed to a warming between 2.4*0.27=0.65 and 2.4*0.63=1.5°C. Thus, either we can emit more than twice as much as we have already emitted before reaching 1.5°C, which at the current rate of emissions would take 70 years, or it is already too late to stay below this target. Thus, the amount of uncertainty about climate change is very large – we simply do not know how much climate change a given amount of emissions will lead to. This applies to what we have already emitted as well as to what we will emit in the future under different scenarios.

Quantifications of economic effects of climate change tend to point to small aggregate effects, at least relative to projected future growth. The IPCC (2018) reports predicted damage of a few percent. Howard and Sterner (2018) conduct a meta study and conclude that a 3°C increase in the global mean temperature causes damage with a value of 4-11% of GDP. The highly detailed bottom-up study by Feyen et al. (2020) quantifies damage in the EU for 7 categories: human mortality from heat and cold waves, windstorms, droughts, river flooding, coastal flooding, agriculture and energy supply. They find that exposing the current economy to the climate associated with three degrees global warming would impose damages with an aggregate value of 1.4% of GDP. Damages are about twice as large in Southern Europe. They also find a substantial value of adaptation to such a climate change.

Even though point estimates of global aggregate damages are relatively moderate, the effects of climate change in some parts of the world can be very large. This is particularly true in some countries with a large and poor population, making adaptation to climate change more difficult. Furthermore, the uncertainty about the effects of climate change on human welfare is arguably as large or even larger than the natural science uncertainty about climate's sensitivity to emissions. Hassler et al. (2018) provide calculations based on the variation in studies on aggregate consequences of climate change suggesting that the uncertainty about economic sensitivities is about as large as about climate sensitivity when measured in terms of implications for optimal carbon taxes. Furthermore, as stated by Feyen et al. (2020), many mechanisms, such as displacement of people, conflicts and security, extreme weather events and the consequences of passing climate tipping points, are hard to predict and typically excluded from quantitative analyses.

Models for evaluating climate policy

An ambitious climate policy should in its total be seen as an investment. Elements in the policy required for the transition to climate neutrality requires that costs have to be taken upfront and during the transition period. The investment pays off in terms of less climate change as well as co-benefits like better air quality over a long future. The calculation of the costs and payoffs of climate policies requires predictions of how the global economy and the climate evolves over long periods under different policies. For this purpose, Integrated Assessment Models, based on the seminal work by William Nordhaus (1994), are used. These models can be used to derive what is called optimal policies. This means that an objective function in the model is maximised over a set of different polices, e.g., tax rates. The costs and benefits of climate policies and climate change are extremely heterogeneous over the global population now and in the future. It is necessary to aggregate these effects in order to evaluate different policies against each other. The objective function is typically a weighted sum of welfare of different types of individuals living now and in the future.

When interpreting the output from Integrated Assessment Models as well as from any other social science model used for normative analysis, it is important to realize that if a given policy, e.g., a carbon tax rate, is found to be optimal, this is a conditional statement. Given a set of assumptions and a specification of what is to be maximized (e.g., a weighted sum of individual welfare now and in the future), it may follow logically that a particular policy is optimal.

In the case of climate change, the assumptions that the analysis is based on are uncertain and often controversial. How sensitive is the climate to emissions of CO2 and how much weight should be placed on the welfare of future generations relative to that on ourselves? Different answers to such questions can generally not be classified as true or false. Thus, the model output should not be thought of as finding the "truth" about the world. The value of the model instead comes from finding out what conclusions can be drawn from a set of given assumptions and how the conclusions change when assumptions are changed. A transparent example of this is given by Golosov et al., (2014) who derive a closed form formula for the optimal tax rate. This makes it easy to analyze how different assumptions change the conclusion. Figure 1 shows how the optimal tax rate changes as a function of the weight on future generations, as captured by the rate at which their welfare is discounted. The figure shows that the optimal tax rate falls quickly in the discount rate. This reflects that costs are born early, while the benefits accrue to coming generations. With a lower weight on the latter, costs are relatively more important implying a lower optimal tax.

Often a discount rate in the order of 1-2% per year is used in evaluations of, e.g., public investments. It is straightforward to calculate that with a discount rate of 1% per year, the welfare of people living 70 years from now is given half as much weight as our own. The welfare of people living 140 and 210 years from now is given a fourth and an eighth weight respectively. Thus, the welfare weight is halved every 70 years. When the discount rate is 2% this halving occurs every 35 years. Based on such calculations, the Stern report (Stern, 2007) argued that the morally reasonable discount rate when discussing such a long-run phenomenon as climate change should be 0.1%, implying a halving of the welfare weights every 700 years.

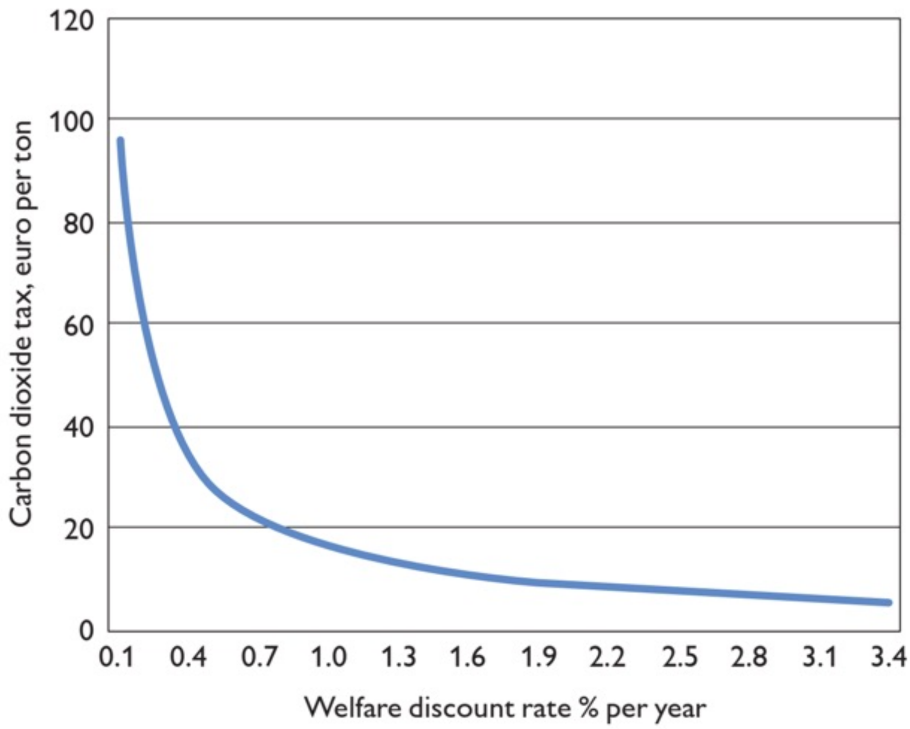

Figure 1. Optimal CO2 tax as a function of the discount rate for future welfare. Source: SNS (2020).

Climate policy and uncertainty

Seeing an ambitious climate policy as an investment, an immediate complication is that the return to it is highly uncertain. It may be that the sensitivities discussed above are low, in which case the return is low. It may alternatively be the case that the sensitivities are high, in which case the return of a sufficiently speedy transition to climate neutrality will turn out to be high.

In many cases, the optimal decision about an investment with uncertain returns is to postpone the decision (Pindyck, 1991). For postponement to be an optimal strategy, two conditions must be satisfied. First, since the value of postponing derives from learning about the uncertainties, waiting must reduce the uncertainty. Second, the payoff should not be negatively dependet on postponing the investment decision.

In the case of climate policy neither of these two conditions appear satisfied. First, the range of uncertainty about the climate sensitivity did narrow somewhat when comparing the 5th and 6th report from the IPCC, but not very much. In a longer perspective, uncertainty has not been reduced much. Since predictions need to be based on models rather than actual observations, uncertainty can hardly be fully resolved until we observe the consequences, i.e., when it is too late to avoid them. Second, in case sensitivities are high, the damages caused by largely irreversible climate change increase over time. Delaying may also require a faster transition to climate neutrality, which we know will be more costly since the economy is rigid in the short run. Thus, waiting is likely not going to lead to a more informed decision but may require a more costly and risky transition.

A key complication when analysing climate policy is that the uncertainty is of a kind that is often called Knightian (Knight, 1921). This means that no objective probabilities can be put on different possible outcomes. This contrasts with the case of risk, when such probabilities exist. Under risk, a probabilistic approach can be used where future outcomes are weighted by their respective probabilities. Such an approach is typically used in public finance when the social value of risky investments is evaluated. If climate uncertainty is Knightian, it is questionable whether analyses based on the assumption that objective probabilities can be postulated provide good policy guidance. The IPCC does use explicit probabilities when they write about ranges of uncertainty, but arguably, these are much more judgmental than objective.

Under Knightian uncertainty, robust, rather than optimal, policies should be looked for. The former are policies that yield acceptable outcomes under most and preferably all possible future scenarios. The opposite to a robust policy is one that is optimal under some scenarios, but very bad under others. A robust policy can be seen as a cheap insurance for a risk that is hard to quantify, both in terms of its consequences and its probability of occurring. In some situations of Knightian uncertainty, no robust policy exists. Such situations are called wicked problems – whatever choice is made, the consequences can be grave.

A robust climate policy

In the discussion about climate policy, there are many non-robust policies proposed. Some, such as de-growth, an immediate ban on fossil fuel, and replacing the market with central planning, are beneficial and arguably even optimal if climate sensitivities are very large and we are near global tipping points in the climate system. These types of policies are, however, non-robust since they are very costly in case the sensitivities are low or in line with best guesses. Other proposals are to wait and see, in the hope that climate sensitivities are low. If these hopes come true, waiting may turn out to have been optimal, but if they do not, we would sorely regret that climate actions were not taken earlier. Thus, policies based on waiting are not robust either.

If all possible climate policies belong to either of these two categories, the problem of dealing with climate change is wicked. Then it would likely not be possible to come to an agreement on what is the right policy to choose. Fortunately, however, the problem is not wicked – robust climate policies exist. An admittedly stylised demonstration of this is Hassler et al. (2018 and 2020). They use a global integrated assessment model and calculate the optimal tax under both the assumption that climate and economic sensitivity to emissions are at the upper and the lower end of their respective likely uncertainty intervals. In the former case, the optimal tax is about as large as the current Swedish level (110 Euro/ton of CO2 equivalent to 0.25 euro per litre of gasoline) and should grow at the rate of global GDP growth. In the opposite case of low sensitivity, the optimal tax is not very much above zero. In search for a robust climate policy, Hassler et al. (2021) then calculate the social cost if policy ex-post turns out to be erroneous for the two cases. Thus, what is the cost of having chosen a high carbon tax, when the low was the optimal and conversely, what is the cost of having chosen a low carbon tax if the high were optimal? The consequences of such policy mistakes also depend on how easy it is to substitute between fossil and green energy. If the two energy classes can easily be substituted, failing to price emissions correctly is more costly since the difference in use under the correct versus the incorrect tax becomes larger. The results are depicted in Figure 2.

As seen in the figure, the costs are highly asymmetric. Specifically, the cost of the ambitious climate policy based on a global carbon tax at approximately the current Swedish level is not very high even if it turns out that it was not necessary to have such a high tax. On the other hand, setting a low carbon tax when it should have been set high has major consequences in terms of climate damages that could have been prevented, especially in the case where green and fossil energy are good substitutes.

The reason for the low cost of setting too high taxes is that the economy in the longer run (over a few decades) is quite flexible. In the shorter run, energy use is almost proportional to GDP and the source of the energy cannot be changed. But this is not the case in the longer run, Hassler et al. (2021b).

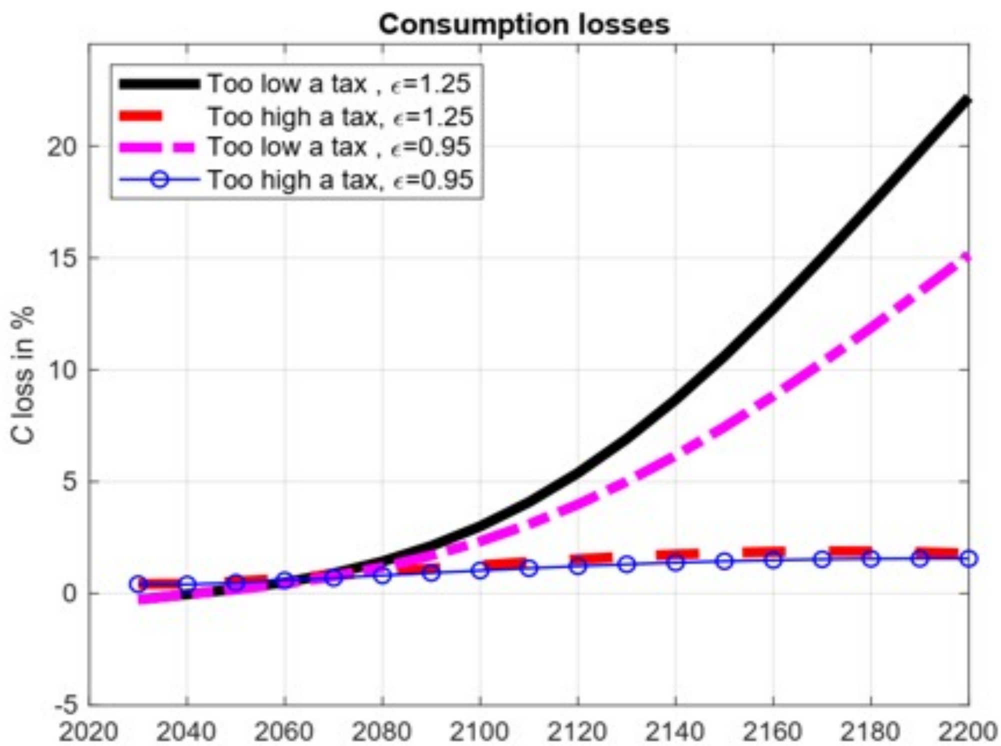

Figure 2. Cost of policy mistakes. Source: Hassler et al. (2021a). The substitutability between green and fossil energy is denoted ε.[1]

That a policy based on pricing of emissions is effective and need not be economically costly is corroborated by substantially more detailed analysis in IMF (2020). Their model includes distributional concerns and realistic short-run frictions which imply a need to complement the carbon pricing policy with other policy instruments. Specifically, the contractionary effect of the introduction of carbon pricing is counteracted with a debt financed green investment program initially at a level of 1% of GDP and phased out over 10 years. A quarter of the revenues from carbon pricing is used for targeted transfers to poor households particularly affected by carbon pricing and higher energy prices. This policy package in combination with a realistic amount of carbon capture and storage implies that the world can reach carbon neutrality by the mid of the current century. This is done without negative effects on GDP except for Russia and the OPEC countries.

According to the analysis by the IMF (2020), neither India nor China need to sacrifice economic growth during the transition to climate neutrality. This is important, since without these countries participating, it becomes practically impossible for the rest of the world to stop climate change. Hassler et al. (2021b) argue that even a 20 times higher carbon tax in the rest of the world is not sufficient to compensate for the absence of carbon taxes in China.

1 ε is the elasticity of substitution, i.e., how many percent relative use falls for a percent increase in the relative price.

The IMF (2020) also show that subsidies to green energy and green technology development cannot substitute for carbon pricing. The fundamental reason for this is that policies that make green energy cheaper increase the use of green energy but do not by themselves outcompete fossil energy. For the latter to happen, a price on emissions is necessary. This should not be taken as necessarily implying that subsidies to green energy and to green technology development are bad. First, such polices can make the transition smother with less popular and political resistance. Second, energy infrastructure and R&D are areas where the unfettered market solution often is suboptimal. However, these results warn against putting faith in the idea that such policies can make carbon pricing unnecessary.

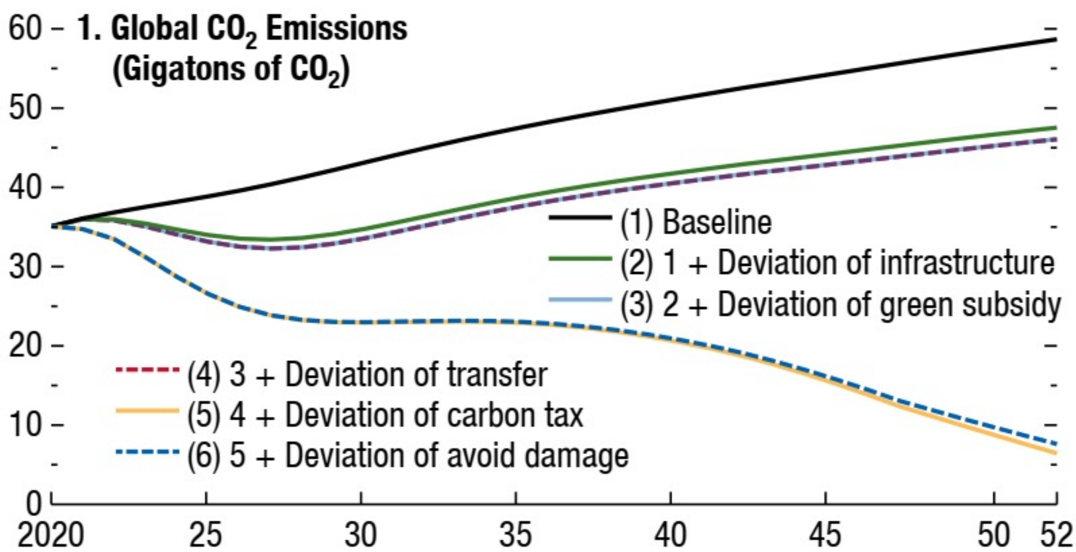

Figure 3. The figure shows the impact on emissions of successively adding parts of the policy package for climate neutrality by 2050. It is only the addition of a carbon tax that makes emissions fall over time.

Is global carbon pricing realistic?

Few argue with the claim by economists that carbon pricing is the most efficient policy to reduce and eventually halt climate change. It is often argued, however, that a global agreement on a carbon emission price is an unrealistic vision. Unfortunately, this view has had the consequence that a serious international negotiation on carbon pricing has not yet started. When it does, there are several reasons for realistic optimism about the possibility to reach an international agreement.

First, the recent agreement by the G7 countries to implement a global minimum corporate income tax rate shows that international agreements on minimum tax rates are possible. An agreement on a minimum carbon tax may be slightly less efficient than if the agreement is on a common rate. However, as discussed in Hassler et al. (2021a), the marginal effect of carbon pricing on emissions is decreasing in the rate. Thus, it is key to get at least a modest price (and removal of fossil subsidies) in place everywhere.

Second, while it is necessary to come to an agreement on at least a minimum level of carbon tax, there is no need to agree on complementary policies. In some countries, it may be the case that compensatory transfers to some groups of individuals are necessary for political acceptance. In regions like EU, these might involve transfers between Member States. In other cases, a carbon dividend to every individual might be the right choice. Similarly, policies to facilitate a smooth transition by subsidies to green infrastructure, e.g., charging facilities for electric vehicles, might be important but need no international agreement. Each sovereign may choose an outright tax or an emission trading system. If, like in the EU, the layer is chosen the system should include some mechanism to ensure that prices do not become too low.

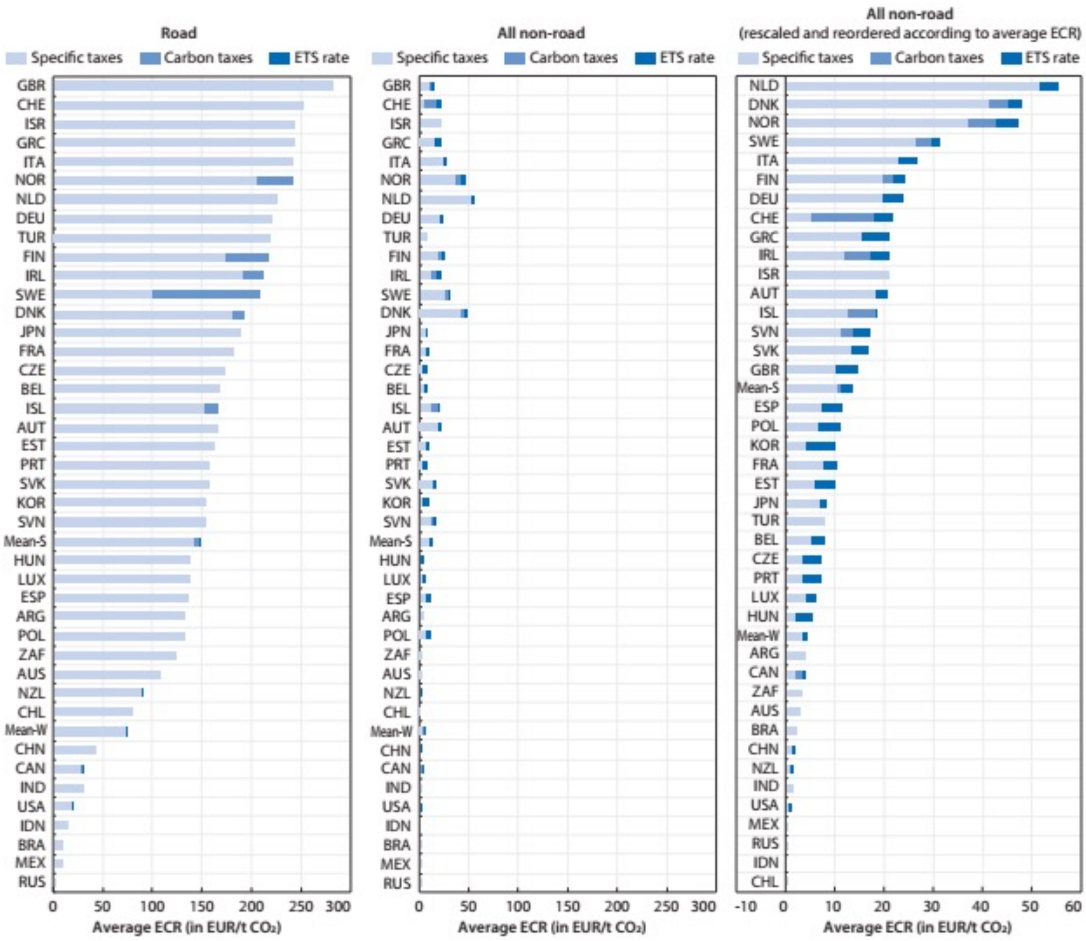

Figure 4. Effective carbon prices (ECR). Source: OECD (2016).

Third, it is often claimed that the introduction of comprehensive carbon pricing will lead to popular protests against higher fuel prices like those by the "yellow vests" in France. However, at least in the OECD, the problem of no or too low emission prices mostly apply to other sectors than transport. Figure 4 demonstrates that the average effective price of carbon emissions tends to be much higher on fuel used for transportation than emission prices in the rest of the economy. The left panel plots the effective price on emissions of CO2 for fossil fuel used for vehicles. The middle and right panels show the effective prices for all other purposes.

Although the calculations behind the data in the figure do not take into account the recent increase in the price of emissions allowances within the EU Emission Trading System, it is still generally the case that it is industrial and power sectors where emission prices need to increase, not fuel used for transportation. Certainly, also here political pressure and lobbying can be an obstacle but businesses in these sectors are arguably more afraid of unilateral carbon taxes than common ones that do not distort their competitiveness.

Conclusions

Emissions of carbon dioxide positively affect the balance between energy flows to and from Earth. The resulting surplus leads to global warming but how much is and will likely remain highly uncertain. Waiting for more precise knowledge about how sensitive the climate is to emissions and how sensitive human welfare is to climate change is, however, a highly risky strategy. The reason for this is twofold. First, climate change is proportional to accumulated emissions and while waiting, emissions continue to accumulate. Second, waiting may imply that a transition to climate neutrality may need to be done faster. Since the economy is rigid in the short run but quite flexible in the longer run, a fast transition is much more difficult and costly.

In a situation of high uncertainty and lack of objective probabilities for different possibilities, a robust policy is highly valuable. Such a policy provides good, but not necessarily optimal, outcomes for a large set of possibilities. An international agreement on a minimum price on emissions complemented by other polices such as subsidies and transfers chosen at the discretion of national decision makers is a robust policy. Relative to other strategies for dealing with climate change it has limited if any negative economic consequences. It may prove to be highly valuable if climate sensitivity is higher than best guesses and the possibility to adapt to climate change is more difficult than what may be anticipated. In other words, a price-based climate policy is a very good insurance. It does not cost much and is very valuable in bad cases.

The European Commission and the European Parliament have proposed to create an emission trading system for transportation and heating, implying that these sectors would face a union-wide common emission price. If implemented, it endows the union with a tool to control all fossil emissions and phase them out in an efficient way. In the longer run, it seems reasonable to assume that new emission trading system will be merged with the existing EU ETS. If an agreement can be reached, it would show that also a large group of countries with quite heterogeneous preconditions for the green transformation can agree on a common policy. It is a step towards what must be the overarching goal of the union – to phase out fossil fuel globally.

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