FISCAL COSTS OF CLIMATE POLICIES:

Role of tax, political, and behavioural distortions[*]

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ABSTRACT

I focus on the fiscal costs of second-best rather than first-best climate policies. I consider whether using pollution taxes to cut labour income taxes can improve environmental quality as well as boost employment and lower the marginal cost of public funds if lump sum finance is not available. To understand the political feasibility of carbon pricing, I address how recycling revenue can be used to ensure that as many as possible benefit from green tax reform. Next, I discuss the need for intergenerational transfers and public debt and for international transfers to ensure all generations and countries are better off. I then review green spending multipliers from a real business cycle perspective. Finally, I argue that heightened salience of carbon taxes can explain why governments prefer expensive green subsidies rather than implement the polluter pay principle. Furthermore, procrastination and a preference for subsidies over taxes induces unintended global warming. Delaying delay carbon taxes makes the green transition more expensive.

Keywords: social cost of carbon, double dividend, cost of public funds, recycling carbon revenue, political acceptability, international & intergenerational transfers, green spending multipliers, salience of taxes, renewable subsidies, political economy, Green Paradox

JEL codes: Q54, Q58, D91, H23

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The world is on course to unacceptably high temperatures unless emissions are brought down worldwide to zero. In the absence of an ambitious climate policy, temperature in the next twenty years will be 2 to 3 degrees Celsius higher than preindustrial temperatures compared to 1.1 degrees Celsius today. Such temperature increases will radically affect our planet. Large parts of the globe will be faced with extreme temperatures and weather events such as droughts, water shortages, and desertification. Apart from the direct negative effects caused by global warming and extreme weather events, there will be a surge in climate migration towards cooler areas of the globe and increased conflict as people fight for water and access to liveable areas. Agricultural production will suffer unless technical progress leads to cost-effective heat-resistant crops and other adaptation measures. Especially older persons will die earlier more often due as the days with extreme heat and respiratory illnesses increase as the planet heats up. Higher global mean temperatures go together with a fivefold increase in extreme weather events (e.g., flooding, hurricanes, wildfires, heat waves) once global mean temperature has risen to 2 degrees Celsius above preindustrial (Lange et al., 2020). To mitigate global warming, *net* emissions worldwide must be brought down to zero.

I first characterise in section I the first-best climate policies and then argue that little of this has been implemented in practice. The focus should thus be on second-best climate policies as the prevalence of distorting taxes on labour and capital income as well as political imperatives makes first-best outcomes infeasible. Section II discusses the double-dividend hypothesis for when lump-sum tax finance is not available. It analyses whether using pollution taxes to cut labour income taxes can improve environmental quality and boost employment and lower the marginal cost of public funds, all at the same time. Section III deals with the fiscal costs of second-best climate policies within the context of a dynamic general equilibrium macroeconomic model of the economy and the climate. Section IV treats the political feasibility of carbon pricing, in particular the question of how recycling can be used to avoid negative impacts on the lowest incomes and to ensure that as many people as possible benefit from green tax reform. Section V gives arguments for intergenerational transfers and running up debt to make sure that all generations are better off within an overlapping generations framework. It also discusses whether international transfers can ensure that all countries are better off when a global carbon pricing scheme is realised. Section VI surveys the literature on green spending multipliers and climate policy from a real business cycle perspective. The following two sections discusses reasons why politicians implement inefficient climate policies. Section VII argues that politicians procrastinate and prefer green subsidies to carbon taxes. This leads to more rapid extraction of fossil fuel and to unintended accelerated global warming. Also, the tendency to delay carbon taxes makes the objective of meeting a given temperature target more and more expensive. Section VIII suggests that heightened salience of carbon taxes might explain why governments prefer expensive subsidies to make the biggest polluters shift to greener production methods rather than implement the “polluter pays” principle. Finally, section IX concludes.

I. Almost No Implementation of First-Best Climate Policies

In the absence of any other market failures or externalities or income distributional concerns, it is in principle relatively straightforward to deal with the global warming externalities caused by burning fossil fuel. The classic answer to these global warming challenges is to set a common global price on emissions equal to the Pigouvian tax (also known as the social cost of carbon or SCC in climate economics) either via a uniform global carbon price or via a global cap-and-trade permit market and rebate the revenue as lump-sum payments to the private sector. The SCC equals the expected present discounted value of all present and future marginal damages to aggregate production resulting from emitting one ton of carbon today and many papers have attempted to put numbers on it varying from $15 dollars per ton of emitted CO_2 (e.g., Nordhaus, 2008; Golosov et al., 2014) to hundreds of dollars per ton of emitted CO_2 if account is taken of convex damages, climate risk and endogenous growth (Dietz and Stern, 2015; van den Bremer and van der Ploeg, 2021). If the risks of climatic tipping points (e.g., irreversible meltdown of the Greenland Ice Sheet, irreversible grounding line retreat of the West Antarctic Ice Sheet, collapse of the oceanic Atlantic meridional overturning circulation, melting of the tundra's in Siberia, or large-scale dieback of the Amazon rainforest) increase with global warming, the optimal SCC will be various factors higher, even more so if account is taken of the risk of cascading tipping points (e.g., Cai and Lontzek, 2019).

As will become clear, this policy prescription is an ideal one but will in practice be very hard to implement due to international free-rider problems and to the problem of getting current generations to make sacrifices today to lower temperature for the benefit of future generations. To complement such a coordinated worldwide effort to implement ambitious first-best carbon pricing, renewable energy subsidies and climate finance are needed. Unfortunately, world leaders have failed to achieve this. This can be seen from very low and fragmented carbon pricing with very little coverage. Nordhaus (2020) notes that the average carbon price in the global economy, taking account of the huge differences in the level of carbon pricing and in its coverage, is a mere $1.7 per ton of emitted carbon dioxide. This is many times lower than typical estimates of the SCC. More surprisingly, it is much lower than the fossil fuel subsidies which amount to $10 per equivalent ton of emitted carbon dioxide. Parry et al. (2021) estimate that fossil fuel subsidies in the global economy were $5.9 trillion in 2020 or 6.8 percent of world GDP. These subsidies are expected to rise to 7.4% of GDP in 2025. Hence, the actual price of carbon may well be negative rather than positive. The world economy is thus addicted to fossil fuel with huge expenditures on fossil fuel subsidies and very little on renewable energy subsidies. Furthermore, international climate deals such as the Kyoto agreement have collapsed, and international climate treaties have run out of steam. It is thus no surprise that, despite a dip during the corona pandemic, global carbon emissions and fossil fuel exploration are rising relentlessly with little prospect of getting global warming under control.

I therefore focus on less ideal, second-best climate policies by allowing for tax distortions, political feasibility of carbon pricing, intertemporal and intergenerational deals, and effects of salience and political constraints.

II. Can Carbon Pricing lead to Double Dividends?

One reason that first-best climate policies are highly unrealistic and unlikely to be implemented in practice is that there are other distortions in the economy such as taxes on labour income. Various commentators have suggested that a double dividend will emerge in the sense that, if the revenues from pollution taxes are used to lower labour income taxes, environmental quality improves, and employment rises due to the cutting of income taxes. However, this double dividend hypothesis is in general incorrect. Bovenberg and De Mooij (1994) and Bovenberg and van der Ploeg (1994) show using a public finance model with homogenous agents, who like the government consume both green and dirty goods, that greening the tax system while cutting taxes on labour income and starting out from an optimum will improve environmental quality but will lower employment. Since a pollution tax is a less efficient way to raise public revenue, increased environmental concern will lead the government to set a higher pollution tax, a lower tax on labour income, less employment and economic activity and a cleaner environment. If it is easy to substitute between private consumption commodities and leisure, and difficult to substitute between clean and dirty goods, a “red” public dividend emerges in the sense that public consumption expands while private consumption contracts. This is due to a fall in the marginal cost of public funds.

If the economy is not in a social optimum but in a sub-optimal situation where labour income tax rates are too high and pollution taxes are too low, green tax reform is more likely to lead to double dividends. This is analysed in economies in which there is involuntary unemployment due to wage rigidities or structural unemployment caused by hiring costs (Bovenberg and van der Ploeg, 1996, 1998). If there are fixed factors of production or if the burden of taxation can be shifted away from workers towards those without employment in the formal sector, green tax reforms are more likely to yield a double dividend with a boost to jobs. Environmental tax reform succeeds in shifting the tax burden away from workers in the formal sector when higher energy taxes reduce earnings in the informal sector by reducing labour productivity. More generally, the green dividend occurs at the expense of more inequality. Useful surveys on the extensive double dividend literature can be found in Goulder (1995) and Bovenberg and Goulder (2002).

III. Fiscal Costs of Climate Policies: A Dynamic General Equilibrium View

Following the pioneering work of Goulder (1995) and Goulder and Hafstead (2017), Barrage (2019, 2020, 2021) introduces distorting labour income and capital taxes in the integrated assessment models developed by Nordhaus (2008). This allows her to consider fiscal costs and the double dividend literature discussed in section II. She thus provides the dynamic policy and general equilibrium analysis needed to study the interaction between carbon taxes and distorting taxes on labour and capital incomes. This allows her to look at second-optimal funding of spending on climate adaptation measures to limit adverse impacts of global warming on production (e.g., protection of transport infrastructure) and on utility (e.g., protection of national parks). Fiscal costs may lower such spending and thus lead to higher damages from global warming. More generally, fiscal impacts raise the welfare costs of unmitigated climate this century. Taking account of the need to finance revenue by distorting taxes, boosts welfare costs of business-as-usual climate change. The exact figures reported in Table 1 below are provisional due to the many uncertainties surrounding adaptation costs and the role of government and due to the employed stylised integrated assessment model. Still, this type of analysis of the fiscal costs of climate change is crucial to better understand the practical obstacles to the implementation of climate policies.

The employed quantitative model in Barrage (2020) is highly aggregate but does allow for various types of public spending, taxes on labour income, capital income taxes, energy and emissions, and the marginal cost of public funds or MCPF (the welfare cost of raising an additional unit of public revenue). In most integrated assessment models, the government has access to lump-sum finance so that MCPF = 1. With distorting taxes, the MCPF typically exceeds one due to the excess burden (marginal deadweight loss taxation). The MCPF differs depending on which distorting tax is used to finance public spending, but efficiency requires the MCPFs to be the same for the different sources of taxation. Table 1 reports the results for (i) first best and (ii) second best depending on whether lump-sum are available or not, (iii) second best with the further restriction that labour income taxes are fixed, and (iv) second-best with the further restriction that capital income taxes are fixed, each time for both optimal ("OPT") and business as usual ("BAU") depending on whether energy and carbon taxes are optimised or not.

Table 1 confirms that optimised global carbon pricing yields very large welfare gains. More importantly, the fiscal impacts increase these welfare gains by up to 33%. The largest welfare differences occur when labour income taxes are fixed with capital income taxes the residual mode of public finance (scenario (iii)). In that case the MCPF is high and welfare gains from carbon pricing increase by $7.1 trillion (2005 prices) compared to the commonly reported first-best carbon pricing (scenario (i)). These welfare gains do not only reflect the use of carbon taxes to raise public revenue. In line with the double dividend literature discussed in section II, second-best carbon pricing is lower than first-best carbon pricing. However, Table 1 also suggest that unmitigated climate change requires higher public spending on adaptation and that higher income taxes are needed to fund this increase. For example, if labour income taxes are fixed (scenario (iii)), effective capital income taxes must increase by almost 4%-points, thus raising the marginal costs of public funds from 1.4 to 1.5.

Table 1: Fiscal costs of climate change

Scenario	Carbon & energy	Capital tax	Labour tax	MCPF	Adapt Y (%GDP)	Adapt U (%GDP)	Carbon tax	Welfare
(i)	BAU OPT	0 0	0 0	1.00 1.00	0.65% 0.22%	0.11% 0.05%	0 $76/tC	 $21.7 T
(ii)	BAU OPT	3.5% 3.6%	42.7% 42.4%	1.07 1.06	0.68% 0.24%	0.09% 0.05%	0 $62/tC	 $23.3 T
(iii)	BAU OPT	37.5^ 33/7%	38.4% 38.4%	1.53 1.42	0.68% 0.24%	0.07% 0.04%	0 $51/tC	 $28.8 T
(iv)	BAU OPT	34.6% 34.6%	38.9% 38.5%	1.06 1.06	0.67% 0.24%	0.09% 0,05%	0 $61/tC	0 $22.4 T

Notes: “Adapt Y” and “Adapt U” refer to adaptation measures to protect aggregate production and utility, respectively, against global warming impacts. Welfare is initial (2015) equivalent change in aggregate consumption relative to business as usual (measured in trillions 2005 dollars). BAU refer to no carbon or energy taxes until 2115. The capital scenarios under scenario (ii) represent the average of the high 2025 rate (57%) and then converging to 0% afterwards. The carbon tax is measured in dollars per metric ton of carbon. To convert them into dollars per ton of emitted carbon dioxide multiply by 12/44.

Source: Barrage (2020)

Fried (2022) also takes a dynamic macroeconomic analysis to study climate policies. Her focus is on adaptation investments to curb damages from extreme weather. She allows for federal government, local government, and private agents to quantify the relationship between adaptation capital, federal disaster policy, and climate change. For example, federal aid for disaster relief cuts net costs to localities with extreme weather and substantially decreases incentives to invest in adaptation capital. Still, she finds that the federal subsidy for adaptation more than offsets the moral hazard effect. Adaptation lowers the welfare cost of the effects of permanent changes in the severity of extreme weather by 15-20 percent.

An exciting recent study extends the macro public finance model with distortionary taxes on labour and capital income used by Barrage (2020, 2021) for heterogenous agents, and assumes that lump-sum payments and finance cannot be individualized (Douenne et al., 2022). They derive the first-best policies and characterize and compare these with the second-best fiscal and climate policies, where the latter correspond to the Ramsey optimal policies subject to an incentive compatibility constraint. The optimal climate taxes are now equal to the sum of a Pigouvian tax to internalise damages from global warming to utility corrected by the MCPF to allow for distortionary taxes *plus* a Pigouvian tax to correct for damages to productivity which depends on growth rates of the MCPF. They then find that with heterogenous agents the time path for second-best optimal carbon taxes is throughout below the time path for first-best optimal carbon taxes (and below the time path for second-best optimal carbon taxes with homogenous agents). Climate policy is thus less ambitious since it conflicts with income distributional concerns.

IV. Political Acceptability of Green Tax Reform

As can be witnessed from the Yellow Vests protests in France and elsewhere, carbon taxes are unpopular because they hurt the poor disproportionally. The literature discussed in sections II and III cannot tackle this policy challenge, since the public finance and dynamic macroeconomic models that are used consist of homogenous agents (the "representative" consumer and firm). From a political perspective, it is crucial have a heterogenous agents' perspective and to allow for the effects of green tax reform on the income distribution. This way one can model the regressive impact of carbon taxes and the disproportional impact of global warming on the poor. One way of moving forwards is to use the new macroeconomic models with heterogenous agents (e.g., Douenne et al. (2022) or the HANK models), especially if they can deal with systemic as well as idiosyncratic risks of climate change. This is still on the frontier of macroeconomic research, so here I adapt a more partial equilibrium public finance perspective.

A key idea is to rebate revenue of carbon taxation via lump-sum payments or "climate dividends" to all citizens to lower the cost of higher energy prices and thus lower the cost of living. Such "tax-and-distribute" policies aim to maximise fairness and political viability, since cash transfers benefit the poor disproportionally and help to make carbon taxes politically acceptable. Handing money directly back to citizens has the benefit of a visible and transparent increase in income for all. This especially benefits lower income groups compared to if the revenue is used to lower government debt or increase most types of public spending. Empirical studies suggest that most households benefit from "carbon-tax-cum-dividend" or CTCD policies. For the United States 70% of households benefit (Horowitz et al., 2017) and for Germany this figure is 67% (Edenhofer et al., 2019). This double dividend of green taxes and lower income inequality suggests that a CTCD policy is attractive politically.

However, a rigorous assessment of such CTCD policies must take account of behavioural effects. First, a carbon tax curbs purchasing power and lowers labour supply and taxable income, which erodes the tax base. The government thus has less funds for lump-sum rebates or must raise labour income taxes. If labour income taxes are increased to fund the carbon dividend, labour supply and the income tax base drop even more, thus reducing the financial means for handing out climate dividends further. Furthermore, income inequality increases. Second, a carbon tax induces households and firms to substitute away from carbon-intensive goods. If demand for carbon-intensive products falls a lot in response to carbon taxes, emissions fall a lot but then there is little carbon tax revenue and less scope for rebating climate dividends. However, if substitution for clean products is more difficult, carbon pricing is not very effective in greening the economy but very good at raising public revenue. The carbon tax can then be used to finance substantial lump-sum carbon revenues, thus lowering inequality.

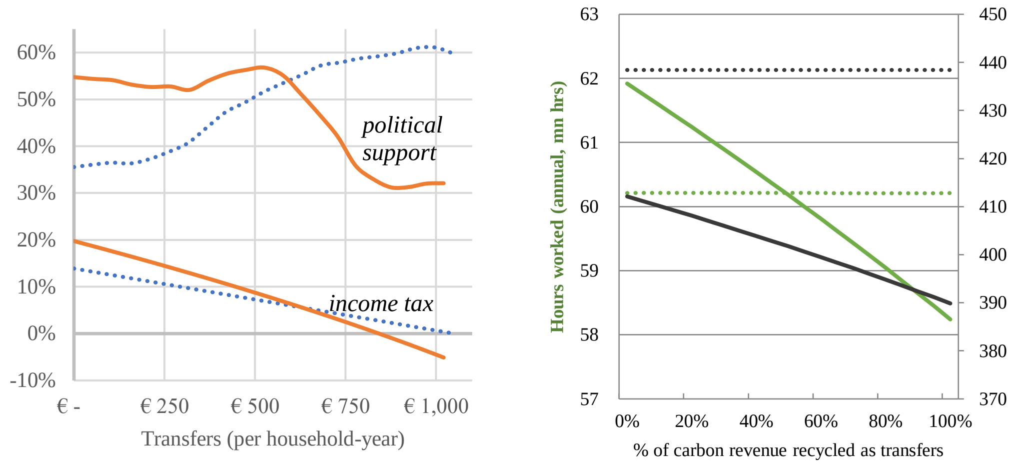
Such behavioural effects alter the political arithmetic of carbon taxation: if *all* revenue is used for lump-sum rebates, income tax revenue fall by more than the increase in carbon tax revenue. The carbon dividends must then be *negative*, which increases inequality. Hence, part of carbon tax revenue must be used to lower income taxes to prevent a falling or boost labour supply because this helps to finance climate dividends. To improve both efficiency and equity, carbon tax revenue must be used to simultaneously cut labour income taxes and hand out climate dividends.

These effects have been quantified using detailed micro data on German household expenditures by van der Ploeg et al. (2021). They find that only 30% of people benefit from a simple carbon-tax-cum-dividend policy. There is thus *no* political majority for carbon taxation. However, if half the carbon tax revenue is used to cut income taxes and the other half to fund climate dividends for all, more than half of people benefit from carbon taxation. The government might then, with the right communication, be able to get a political majority for carbon taxation.

Figure 1 plots the population share that gains from a carbon tax of €100 per ton of CO_2 against the share of carbon tax revenue used for climate dividends instead of lowering income taxes. The dashed (blue) and solid (orange) lines indicate the share without and with behavioural effects in consumption and labour supply. Popular support increases in the share of carbon tax revenue distributed as climate dividends when there are no behavioural effects.

Figure 1. Political and economy-wide effects of revenue recycling schemes

(a) Political support & income tax (b) Labour supply & dividend (Euros)

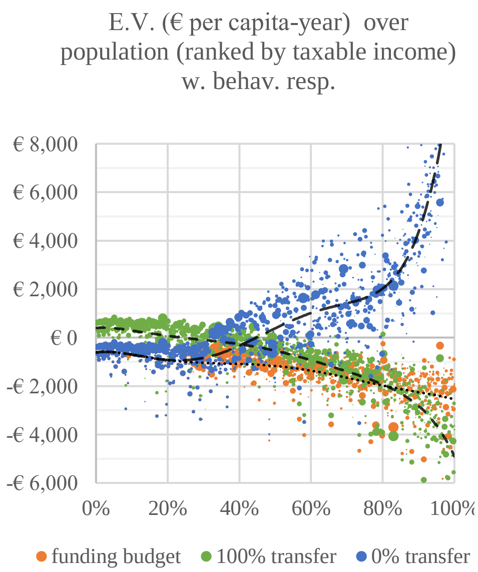


But with behavioural effects, support is stable at 55% as the share of carbon tax revenue handed out as dividends rises to 50%. For higher rebates, support falls rapidly to 30% as many households change from being in favour to against. As the share of revenue distributed as dividends increases, the size of the dividend and the percentage reduction in taxes increases (see lower part of panel (a)). With no behavioural effects, the maximum climate dividend is €1,150 annually. With behavioural effects, the maximum climate dividend falls to €1,020. Income taxes can be cut by at most 20% since lowering taxes boosts employment and efficiency. The additional tax revenue permits a cut in taxes by a further 5%-points. Since carbon taxes curb real wages, households reduce consumption and work less, and the government must increase taxes. Hence, taxes at their current level can only fund a rebate of 80% of overall carbon tax revenue. Higher levels require *increases* in the income tax of up to 5%.

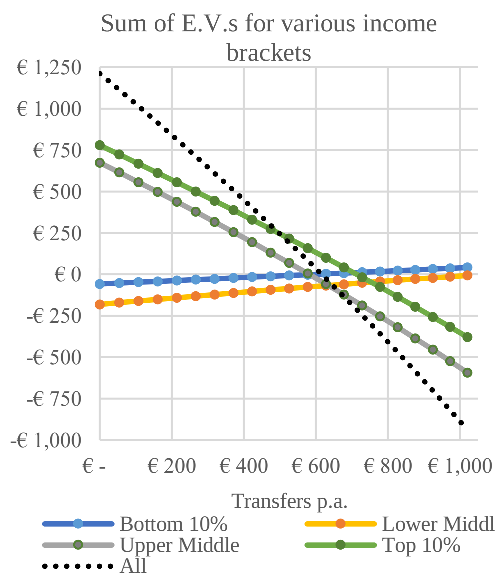
Figure 2 plots the distribution of equivalent variations (E.V.'s) for various policy scenarios ranked by taxable income with sizes of dots denoting the relative weights in the population. If no revenue is handed back (in red), all household lose with all dots and the dotted trend line below the zero axis. If proceeds are used to cut income taxes (in blue), households, whose income is too low to pay income taxes, remain in the same position as before, visible by the dashed trend line following the dotted one for the bottom 30%. But the higher the income, the larger the benefits of lower tax rates with the top 15% gaining significantly.

Figure 2: Who gains from tax of €100/CO_2 depends on recycling scheme.

(a) Per-capita equivalent variations



(b) Sum of equivalent variations



If carbon taxes are recycled as dividends (in green), the distribution of winners and losers flips with lower-income households mostly gaining and higher-income households mostly losing out. The lower revenue from carbon taxation amplifies the distributional effects at the top and middle parts of the income distribution. If revenue is used to lower income taxes, more benefit and those at the top who benefitted before gain even more. Conversely, a CDCT scheme benefits the poor relatively more and increases the percentage of the population losing out. As a result, the majority favours using carbon tax revenue to lower income taxes as seen in Figure 1.

In general, the bottom half of the population prefers to avoid carbon taxation unless revenue is recycled back to them via dividends. The opposite holds for the upper 50% of the income distribution. Given the large variation of E.V.'s even within income groups, the analysis of the top and bottom half of the population is only indicative of the support dynamics shown in Figure 1. Still, the top 10% are significantly better off than the next 40% and the rest of the population.

The climate dividend is commonly set to the revenue generated from carbon taxation. However, this does not take account of the knock-on effects of taxation nor of the value people attach to money changes. Using a household's E.V. as measure and summing E.V.'s across all of society overcomes both shortcomings. If this sum is positive, those better off can compensate those worse off. The dashed black line in Figure 2 shows that this depends on the policy package. Only if less than 60% of tax revenue are disbursed as transfers, the sum of the E.V.'s is positive. For such a policy to be implemented, the top 50% of households must compensate the bottom 50% of households.

A similar analysis on United Kingdom data yields a more pessimistic policy conclusion: rebating carbon tax revenue by raising social security, lump-sum rebates, or lowering income tax rates implies that only, respectively, 35%, 19%, and 11% of households are better off (Paoli, 2021; Paoli and van der Ploeg, 2021). Policy conclusions thus do not necessarily carry over to other countries.

There is a voluminous literature on the effects of recycling carbon tax revenue. Fried et al. (2021) and van der Ploeg et al. (2021) consider the effects of carbon tax on welfare and derive optimal carbon tax recycling schemes. Typically, the regressive impact of carbon taxes is weaker or even reversed if a lifecycle perspective is taken. A regressive impact can also occur in general equilibrium if carbon tax revenue is used to cut capital income taxes (Williams et al., 2015; Goulder et al., 2016). An interesting recent study is Goulder et al. (2019), who analyse the impacts and equity-efficiency trade-offs of a carbon tax across US household income groups.

V. How to Make All Generations and Countries Better Off

Another essential departure from first-best climate policies is to face the two key challenges of making sure that every generation and every country is better off. First, current generations are asked to make sacrifices by switching to more expensive green fuel in their homes and businesses to curb temperature and damages for the benefit of future generations. Why would they agree to climate policies if it is not in their interest except if they are ideologically committed to the green transition to save our planet? Second, countries which are very poor may find it hard to impose carbon pricing as this will hurt their citizens who are already struggling. Countries with large reserves of oil, gas, or coal (e.g., the Gulf countries, Russia, Nigeria, and Algeria) or with heavy carbon-intensive industries relying on coal (e.g., steel or cement (e.g., India) are also unlikely to agree on a high and growing carbon price for the global economy. To pull current generations and countries averse to carbon pricing across the line, transfers will be needed from future to current generations (by running up government debt and future generations paying higher taxes to service the debt) and transfers will be needed from richer countries who find it easier to transition to a green economy to poorer, fossil-fuel-rich countries that rely on carbon-intensive industries. The key question is whether from an intergenerational and global perspective the Kaldor-Hicks criterion is satisfied so that the gains from the winners are big enough to compensate the losses and that climate policy can benefit all humankind regardless of year or place of birth.

A first attempt at investigating the distributional impacts of a carbon tax on current and future generations is Fried et al. (2018). They find that for agents born into the future steady state the expected non-environmental welfare costs are lowest if carbon tax revenue is used to cut pre-existing distorting taxes. But for the agents currently alive the largest welfare gains are obtained if carbon tax revenue is recycled as lump-sum rebates. They conclude that in designing carbon tax reform policy makers must not only focus on long-term outcomes but also on the transitional welfare effects of the policy. Finding reforms that benefit all generations is computationally very challenging but has recently become feasible (Kotlikoff et al., 2021a).

Kotlikoff et al. (2021b, 2022) eschew a normative in favour of a positive analysis which looks for fair Pareto-improving carbon tax reforms in a world which is not populated by intergenerational altruists. They use a multi-country, overlapping generations model of the economy and the climate to study the optimal welfare-improving policies that have a uniform effect on all generations and countries. Their model allows cooler regions to benefit from global warming while warmer regions are hurt by it. Their model also allows for costly extraction of fossil fuel and rapid technical progress in renewable energies. They then show numerically that this can be implemented via a global carbon tax of \$100/tCO_2 rising in real terms at about 1.5% per annum in combination with a carefully designed intergenerational and international transfers. This policy package rapidly ends coal production, halves the duration of oil and gas production, curbs global emissions, limits global mean temperature to 1.5 degrees Celsius relative to preindustrial levels, and raises welfare of all current and future agents in the global economy by over 4%. This is an astonishing finding, albeit that the effects would be less stark if transfers had to be financed by distorting taxes rather than by lump-sum finance and that there may be time inconsistency issues to be dealt with if future generations do not want to pay higher taxes to service the accumulated debt. Some of the transfers that are needed require, for example, that poor countries like India need to make very large transfers (as share of consumption) because they gain the most from global carbon taxes. Whether this a realistic outcome of the model is a matter for further debate. Another important lesson of this analysis is that delaying the implementation of this policy package until 2040 cuts the uniform welfare gains from 4.35% to 2.73% and leads to higher carbon emissions and temperature.

VI. Green Spending Multipliers: A Business Cycle Perspective

Should spending on green projects be procyclical or countercyclical? If policy makers maximise welfare, they set the carbon price equal to the expected present discounted value of all present and future damages resulting from emitting one ton of carbon today, i.e., the social cost of carbon. But one would expect that business cycle effects wash out when calculating the social cost of carbon in which case optimal carbon pricing is roughly proportional to trend GDP (e.g., Golosov et al., 2014; van den Bremer and van der Ploeg, 2021). Hence, in a recession (boom) one would not lower (raise) the price of carbon. On the other hand, if policy makers have a net zero target for emissions, they must pin the future carbon price at the end of the green transition to the cost of full decarbonisation. The efficient carbon price should then grow at a rate equal to the (risk-adjusted) interest rate (e.g., van der Ploeg, 2018; Gollier, 2020; Olijslagers, et al., 2022). But here low and high emissions during future recessions and booms should also wash out, so again the carbon price should not depend on the state of the business cycle.

Still, many have argued that climate policies and especially green spending should be procyclical. The argument is that, if the economy is in a recession, green spending multipliers are higher than multipliers for public spending on carbon-intensive projects and therefore stimulate the economy more in a recession. There is not much empirical evidence for this, although Batini et al. (2021) do offer support for the hypothesis that building back green is better. They find that output multipliers for renewable energy investments are larger (1.1-1.5) than for fossil fuel investments (0.5-0.6) with over 90% probability so that mitigating global warming (and reversing biodiversity loss) should not conflict with economic prosperity.

Some real business cycle and macroeconomic models have been used to better understand the fiscal effects of climate policies. For example, Castellanos and Heutel (2019) put forward a computable general equilibrium model of the United States economy to study the unemployment effects of climate policy under both labour mobility and immobility across industries. They show that the effect of a carbon tax of $35/tC on aggregate unemployment is small and does not depend on whether labour is mobile on immobile (0.2–0.4 percentage points). When labour is immobile across sectors, they find that the effect on unemployment in fossil fuel sectors is much larger (a 24%-point increase in the coal sector). Omitting labor mobility frictions thus leads to under-prediction of sectoral unemployment effects. They also find that returning carbon tax revenue through labour tax cuts can dampen or even reverse negative impacts on unemployment.

Various other studies have studies business cycle aspects of climate policies. For example, Gibson and Heutel (2020) study unemployment, environmental policy, and business cycles using a dynamic stochastic general equilibrium real business cycle model with both a pollution externality and congestion externalities from labor market search frictions that generate unemployment. With an emissions tax and tax or subsidy on job creation both market failures can be dealt with, and the efficient outcome can be achieved. Without a vacancy policy to address the congestion externalities, the emissions tax is substantially affected both in steady state and over the business cycle.

Annicchiarico and Di Dio (2015) deal not only with the fiscal but also with the monetary aspects of climate policies. They use a New Keynesian model to show that a cap-and-trade policy typically dampens macroeconomic fluctuations. They find that the optimal environmental policy response to shocks depends on price stickiness and on the conduct of monetary policies. More recently, Annicchiarico et al. (2022) and Krusa (2021) have used a New Keynesian macroeconomic model with financial frictions based on Gertler and Karadi (2011) to study the role of financial regulation and monetary policy during the transition to a green economy. Annicchiarico et al. (2022) find that green quantitative easing programmes help to stabilise the economy after a financial shock and that differentiated capital requirements help to mitigate the severity of a financial crisis. Krusa (2021) shows that if there are no proper carbon pricing and climate policies in place, central banks may want to impose stricter capital requirements on carbon-intensive industries. Importantly, they would not impose laxer capital requirements on upcoming green industries as this would increase macroeconomic volatility and lower welfare.

Van der Ploeg (2021) gives an extensive survey of the macro-financial implications of the green transition including the business cycle aspects of climate policies. Annicchiarico et al. (2021) survey a wide variety of approaches from real business cycle to New Keynesian models including open-economy models, issues of monetary policy and financial regulations, and the impacts of policy on volatility and how to design policy to adjust to cycles.

VII. Procrastination and Subsidy Bias Induce Green Paradox Effects

Politicians tend to procrastinate and leave unpopular climate policies for their successors (a lot of "blah blah" as Gretta Thunberg has said in response to the recent Glasgow Summit). The economy will thus bring fossil fuel extraction forwards and thereby accelerate global warming. This has been coined the Green Paradox by the economist Hans-Werner Sinn; for a survey of the extensive literature on this topic, see Sinn (2015) and van der Ploeg and Withagen (2015). The point is that to the extent that the incidence and burden of future carbon taxes is shifted to consumers rather than fossil fuel producers, fossil fuel production and consumption are shifted to the present. Hence, if the elasticity of the supply of fossil fuel is small and more of the burden of carbon taxation falls on producers of fossil fuel rather than on consumers of fossil fuel, Green Paradox effects are relatively large (van der Ploeg, 2016). In the longer run when fossil fuel producers can more easily adjust reserves and production, the burden of carbon taxation falls on them and Green Paradox effects are smaller. Procrastination of climate policies thus accelerates global warming in the short run and makes the ultimate target of keeping global mean temperature below 1.5 or 2 degrees Celsius relative to preindustrial more costly to achieve.

Green Paradox effects also occur if for electoral reasons politicians prefer renewable energy subsidies over price signals. In that case, temperature can be kept below target but it will be a more costly policy than pricing carbon at the outset and letting the price of carbon grow at a rate equal to the (risk-adjusted) interest rate (cf. the Hotelling rule). Green Paradox effects are thus from a climate perspective a short-run inconvenience but from a fiscal perspective they raise the costs of climate policy.

VIII. Heightened Salience of Carbon Tax Distorts Climate Policy Mix

Just like procrastination of policies and a preference for the carrot rather than the stick can lead to inefficient and distorted climate policies, this will be the case if there is a heightened salience of carbon taxes. For example, survey evidence suggests that the French largely reject a CTCD policy, since they wrongly think this policy is regressive and ineffective from a climate perspective, and information campaigns have little effect (Douenne and Fabre, 2022). A more realistic analysis needs to abandon median voter reasoning and take account of heightened salience.

The textbook answer to the global warming challenge is to set the carbon tax equal to the SCC and rebate the revenue as lump-sum payments. There is no need to subsidise green energy unless there are learning-by-doing effects in the production of renewable energy or other production externalities that need to be internalised to ensure efficiency. However, the Yellow Vest protests indicate that this policy prescription is disastrous for any politician who wishes to get re-elected. People seem to have an excessive and almost irrational dislike of carbon taxes even when it leads to the required substitution away from carbon-intensive towards green commodities. Utility experienced by people is thus different from the utility used for decision making. Heightened salience of carbon taxes implies that the adverse effect of carbon taxes on experience utility is higher than that on decision utility. Governments should then abandon the first-best policy prescription and take account of these behavioural facts (e.g., Farhi and Gabaix, 2020; Moore and Slemrod, 2021).

As noted in section I, carbon pricing in the global economy is very low and fragmented and renewable subsidies are tiny while fossil fuel subsidies are rife. Governments when stepping up climate action seem to prefer to pay hefty sums of money to persuade the fossil-fuel-based industries to invest to emit less rather than to raise the price of carbon emissions. Heightened salience and carbon tax aversion can explain such topsy turvy climate policies. Of course, this is to deny that the political economy of lobby groups or sequencing of climate policies to get enough winners from the green transition plays a role too but here I highlight salience.

Heightened salience of carbon taxes implies two departures from the usual optimal policy prescriptions. First, the optimal carbon tax must be set below the SCC and may even be negative, thus explaining the low prevalence of carbon pricing and fossil fuel subsidies in the global economy. Second, the optimal subsidy on green energy or clean products should be strictly positive or higher than what is necessary to correct for production (e.g., learning-by-doing) externalities and other market failures in the production of green products. This explains the tendency of governments to prefer the carrot of green subsidies to the stick of carbon taxation. This makes climate policies more expensive with a higher marginal cost of public funds since the government must rely more on distorting labour income taxes. Modest degrees of salience radically change the optimal climate policy mix by reducing carbon taxes below the SCC and introducing subsidies for green production. If salience is large enough, the carbon taxes turn into fossil fuel subsidies. Hence, salience can explain why there is so much resistance to carbon pricing and why governments seem to rely in practice so heavily on fossil fuel subsidies and more on subsidies to get carbon-based firms to switch to renewable energy rather than use the carbon pricing incentive.

More work is needed on the role of salience of carbon taxes in dynamic macroeconomic models with heterogeneous agents and overlapping generations to obtain a combined a realistic general equilibrium and public finance perspective. Heightened salience of carbon taxes may matter more in the short than the long run.

IX. Concluding Remarks

The most efficient way to encourage the green transition is to price carbon via a carbon tax or market for emission permits and, if there are learning-by-doing effects in the production of renewable energies or other production externalities in the green sector, subsidies for renewable use and green R&D. Governments should credibly commit for the next three decades to such a package of policies that will ensure that global mean temperature does not exceed 1.5 degrees Celsius relative to preindustrial. To make such policy packages politically attractive, some of the revenue must be used to mitigate the adverse distributional effects of carbon pricing. To do this, the government must take account of tax, political, and behavioural distortions in the design of its climate policies. Without this it will never be possible to first understand and then step away from a world which hardly prices carbon emissions, and rather gives substantial subsidies to the use of coal and other fossil fuels, and offers very little renewable energy subsidies.

A proper design for greening the tax system requires one to balance the effects on efficiently raising public revenue, equity, and bringing emissions down to net zero. This requires an analysis that looks at the effects on intra- and intergenerational distributional impacts, efficiency, and the climate. Representative agent models are not fit for this task. What is needed are dynamic micro-founded macroeconomic models which can track the full distribution of incomes across households and ideally can also track the full impacts of all the different types of firms in the economy. Most likely one would then complement a gradually rising carbon tax with international transfers to induce those countries that have little incentive to green their economies to price carbon and with transfers from future to current generations, by running up government debt, to ensure that all generations are on average better off after with carbon pricing. Furthermore, recycling carbon tax revenue must be done judiciously to ensure lower incomes are compensated and as many households as possible gain from green tax reform.

Households and corporations have strong behavioural biases which policy makers must take account of. An important one is the heightened salience of carbon taxes, which may prompt policy makers to have too low carbon taxes or even fossil fuel subsidies and to have excessive subsidies for renewable energy production. This tendency is reinforced by politicians' tendencies to procrastinate and to prefer the carrot to the stick. These political economy distortions also inadvertently bring forward emissions and thus increase the ultimate cost of achieving climate goals.

Although I have highlighted second-best distortions in carbon pricing resulting from distorting taxes, political economy and behavioural biases, the same issues arise in climate policies more broadly. This is the case for inclusion strategies such as the way carbon tax proceeds are recycled and for technical standards. Furthermore, public infrastructure investment (e.g., connectors for transporting hydrogen, charging stations), public-private partnerships, green R&D, and guarantee and surety schemes and lending programmes are also subject to the problems of distorting taxes and political and behavioural biases. It is therefore even more important that every effort is made to improve information required for an efficient and just green transition, i.e., standards and disclosure requirements and data on emissions per firm and per household. A broader analysis should also take account of a broader set of market imperfections such as informational frictions, short horizons of policymakers, and the public-good aspects of energy research and green infrastructure. Such analysis can also benefit from recent insights in policy transition risks. Governments should give clear and strong signals that they are serious about making the green transition. If not, there will be a lot of funds funnelled into the wrong, carbon-intensive sectors of the economy with consequent risks of stranded financial assets, thereby illustrating the problem of the tragedy of the horizon (e.g., Carney, 2015). Clarity about future policy is thus essential.

The studies discussed above indicate that studying the fiscal aspects of climate policies is a rich field which combines public finance, dynamic macroeconomics, political economy, and psychology. More work in this field is needed to move away from the abundance of naïve first-best analyses of climate policies.

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