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Editorial

"Carbon pricing" special issue in the European economic review

The 2015 Paris Agreement on Climate Change[1] set an international target to hold average global surface temperature increases (relative to the late 19th century) to well below 2 °C. Stabilising temperature requires long-lived greenhouse gas emissions to be net zero (UNFCCC, 2015). The IPCC (2018) report clarified that net zero around or before 2050 is necessary to limit average temperature increases to 1.5 °C, and around 2070 for 2 °C. The report provided strong arguments that temperatures above 1.5 °C should be viewed as dangerous. The UK government committed in law in June 2019 to achieving net zero emissions by 2050, and the European Council committed to net zero by 2050 at its summit in December 2019.

However, 2050 is within the potential lifespan of much of the existing fossil fuel infrastructure (Pfeiffer et al., 2018, 2016; Tong et al., 2019). To meet the 1.5 °C target, *all* investment from now on, replacements and new, should be consistent with net zero by 2050. Infrastructure is of special importance since such a large fraction of emissions are driven by or associated with infrastructure choices (perhaps around 70% according to the estimate of New Climate Economy (2016)). More broadly, a major economic and structural transformation is necessary—involving every aspect of our economy and society, from where we live and how we produce; from what we consume to how we go from one place to another. It is much broader than how we produce energy and how much energy we use. And there is real urgency in making this happen.

What is the role of carbon pricing in achieving such a structural transformation? Since Pigou's "The Economics of Welfare" (1920), economists have had a predilection for using pricing to correct market failures. After all, when there is a disparity between marginal private costs and marginal social costs, doesn't it make sense to "correct" the market failure by a tax (carbon price) that equates the two? The sole role of the economist then is to calculate the marginal social costs of carbon!

If only life were so simple. Among the many market failures are an incomplete set of risk markets, associated in part with inherent imperfections of information. And the late Marty Weitzman showed that there were circumstances where regulations (quantity restrictions) would be preferable to price interventions (Weitzman, 1974), destroying the presumption in favour of pricing.

Carbon prices alone will not be enough, for four reasons. First, the situation is now urgent, and feasible carbon prices are unlikely to deliver the change required on the necessary timescales. Temperatures are now already over 1 °C above pre-industrial levels (World Meteorological Organization, 2017). The impacts from climate change are becoming ever more tangible. The public and political urgency for action is increasing. The "nationally determined contributions" that countries are implementing as part of the Paris agreement are welcome but insufficient (Climate Action Tracker, 2019). Towards the end of 2021, countries will convene at a major international conference in Glasgow (COP26 of the UNFCCC) to raise their ambition.

Second, feasible carbon prices cannot be relied upon to credibly trigger the necessary scale of structural change in the time scale necessary. Many structural challenges, such as the design of cities, industrial supply chains and production networks, respond weakly, or slowly, or both, to marginal price changes. As the world grapples with the COVID-19 economic rescue and recovery, public spending on clean infrastructure could both restart the economy and steer our economies towards a net-zero emissions world.

Third, the burning of fossil fuels generates lethal air pollution which kills several million people per annum around the world (Landrigan et al., 2018). Many would argue that regulation is a more effective (and more morally suitable) policy to prevent actions that carry high risks of many deaths.

[1] Conference of the Parties (COP) 21 of the United Nations Framework Convention on Climate change (UNFCCC).

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Fourth, new clean technologies (e.g. solar, wind, batteries and other low-carbon technologies, including energy storage) exhibit strong learning-by-doing effects and increasing returns to scale in both production and R&D (Farmer and Lafond, 2016). For example, studies suggest that average solar PV modules prices have fallen by approximately 20% each time the total cumulative installed capacity has doubled (de La Tour et al., 2013; Rubin et al., 2015). Given these effects, and related spillovers, additional policies (such as feed-in tariffs, regulation or standards) can be justified as giving the confidence to make innovations and investments, to realise the potential increasing returns.[2]

Despite these four drawbacks, carbon pricing is a very useful, indeed essential, lever for most countries because it can achieve a great deal at low cost and high efficiency. Carbon prices provide incentives which radiate up and down supply chains and potentially across entire economies, delivering emissions reductions where they make sense. Carbon pricing can also generate useful public revenue during the transition to the green and sustainable economy, a period in which it may be particularly useful given the high level of public investment that will be required (World Bank, 2019) and given that the multi-trillion rescue and recovery packages following the COVID-19 emergency will leave public balance sheets under pressure. And carbon prices, when the resulting revenues are sensibly deployed, can be part of a system that is overall progressive, rather than regressive (Klenert and Mattauch, 2016). Further, the incentives they can bring to "retrofit the economy" can lead to investments, including in research and development, that can spur economic growth, especially in periods of inadequate aggregate demand.

Implicit carbon prices can also be designed to be inversely correlated to international oil prices, smoothing out prices faced by consumers. The gyrations in the oil markets, with oil falling from around US $60 to US $20 / bbl in March 2020 provide an illustration of the merits of such an approach to carbon pricing.

The coverage and level of carbon pricing has been increasing over time. Some 20% of global emissions are covered by a carbon price, in the form of a carbon tax or trading system (see Fig. 1). Carbon prices raise over $40 billion for public treasuries (World Bank, 2019). But this is far from the sort of levels required to deliver the rapid change that is necessary.

Increasingly, firms are using their own internal carbon prices, usually substantially higher than those they face (where these exist at all).

This special issue of the European Economic Review builds upon the work of the Stern/Stiglitz High-Level Commission on Carbon Prices (World Bank Group 2017), and an associated conference at L'Ecole Normale Supérieure in Paris, co-hosted by the World Bank and the Agence Française de Développement (AFD).

The Stern-Stiglitz work (2017) examined the question of which price paths could, when combined with other policies, deliver the Paris targets of "well below 2 °C" in the limited time available. That is a strategic goal, agreed by 195 countries, set in the light of an assessment of risks and what might be done, at reasonable cost, to tackle them.[3] The Stern-Stiglitz approach looks at the prices which can take us to the agreed target.

The Issue collects papers presenting novel economic research on carbon pricing, tackling issues related to the design and implementation of carbon pricing, and providing analyses of the international dimensions, with a view to supporting policymakers around the world implementing carbon pricing reforms. Among the many complexities addressed are those related to dynamics, innovation, uncertainty, and distribution. Each are central to the design of an effective and efficient—and politically acceptable—carbon pricing regime, one which has some hope of helping us achieve the objective of limiting the increase in global warming in accordance with the Paris goals.

The questions addressed are framed by the lead paper by Stiglitz (2019). He provides the analytical foundations for a key conclusion of the High-Level panel — shadow prices of carbon may be different across time, over space, and with different uses. This may appear to be a departure from the "conventional wisdom" – i.e. that the first-best carbon price is globally uniform, applying to all sectors, in all countries and at all times. However, Stiglitz shows that his seemingly iconoclastic conclusion actually lies within the mainstream of modern public finance theory once concerns about distribution, innovation, and uncertainty are properly accounted for.

Uncertainty has a range of implications for policy on carbon pricing. Surprisingly, given the immense weight and evidence of two centuries of scientific work on climate change, there are still some who would publicly contest the underlying science. What if the climate skeptics are right? Frederick van der Ploeg and Armon Rezai advance an argument worthy of Pascal to show that even assuming, with some probability, that the science is badly mistaken, appropriate carbon prices are essentially unchanged (van der Ploeg and Rezai, 2019). This finding emerges with conventional utilitarian social welfare preferences and is accentuated — as expected — with max-min or min-max regret preferences.

Extending carbon prices into sectors where carbon prices are currently not being used is an obvious next step for policy makers. Ian Parry considers the costs and benefits of this and other carbon policy reforms, as compared with alternative climate policy measures, including through them dynamic effects, using a streamlined model for the European Union. While his analysis does not account for all the benefits of non-price policies, including through their dynamic effects, nor polit-

[2] The example of the banning of the incandescent lightbulb in Europe is a likely case in point. It was known that alternatives were possible. The clarity of this action led to the deployment at scale of LED lightbulbs, which are now produced at low cost, with high quality and are orders of magnitude more efficient than the incandescent equivalent (European Commission, 2009; UN Environent, 2017).

[3] There could be said to be an implicit optimization behind the choice of that goal, but it is perhaps best viewed as a sensible policy in the light of all the information available and the uncertainties we face. In a world of certainty and diminishing returns, the marginal cost of reduction of carbon emissions would be equal to the marginal damages at an optimum. That is not the world we live in. Ours is far more complex.

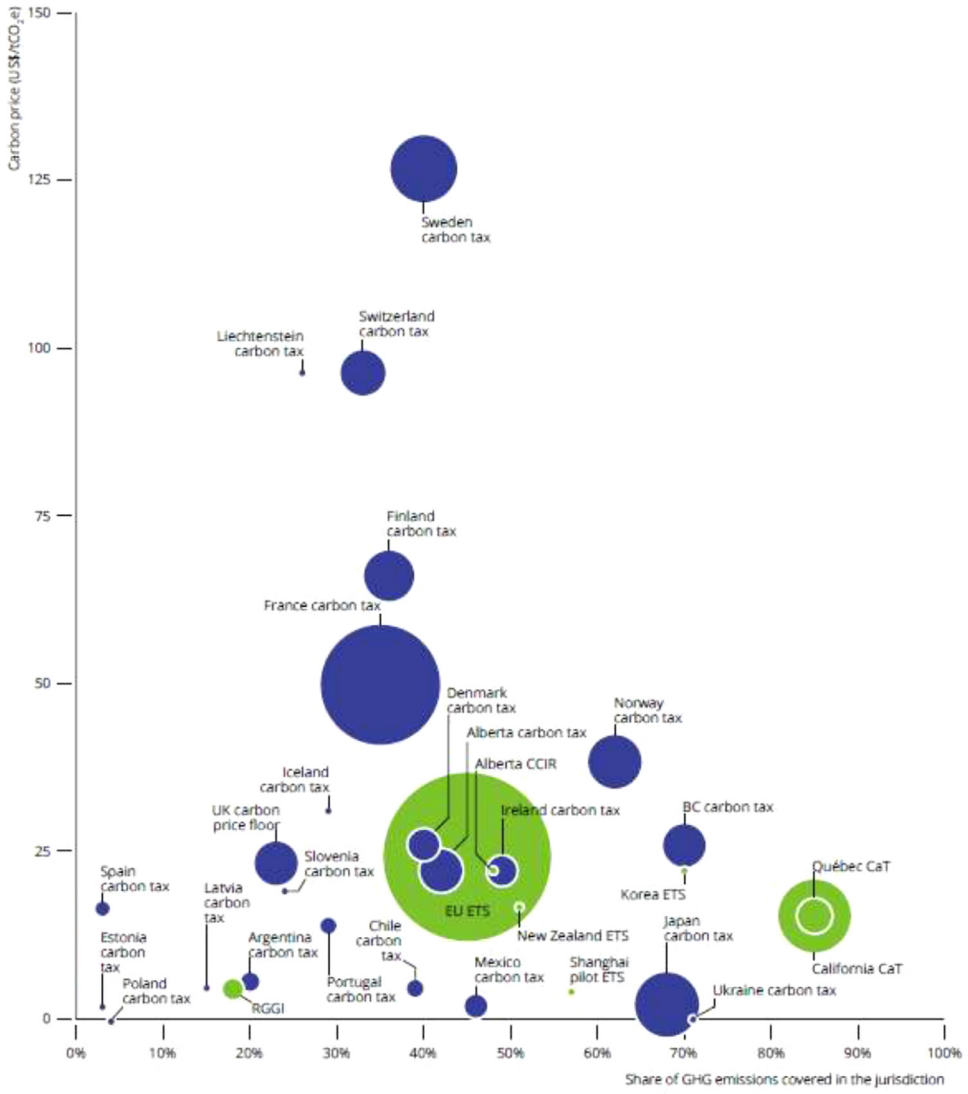

Fig. 1. Carbon prices and share of emissions covered by carbon pricing in selected economies.
Source: World Bank, 2019. Note that the size of the circles reflects the amount of government revenues, except where such revenues are below US $100 million in 2018 in which case the circles are of equal size. For more information see World Bank, 2019.

ical feasibility, it does show the possible significant welfare gains from lifting and broadening carbon prices across all EU member states (Parry, 2020).

The mechanisms used to implement carbon prices—the policy design– can be particularly important for their success, in terms of their public and political popularity, their equity and their economic efficiency. Parry looks at some of the options for the implementation of explicit carbon prices – through taxation or trading systems – and compares them to existing implicit prices, such as road fuel taxes.

Two other papers in the issue also develop the theme of policy design. Maia King, Bassel Tarbush and Alexander Teytelboym ask which sectors should be prioritized for carbon pricing (King et al., 2019). They observe that a carbon tax on a given sector affects emissions via three channels. First, the taxed sector will shift to cleaner inputs, and the fall in sectoral demand reduces production (and thus emissions) of all its suppliers. Second, because the sector's output price rises, buyers shift away from that sector to cleaner sectors. Third, if the tax is rebated to consumers, they will consume proportionally more from every sector (*ceteris parabis*). With this model of the intersectoral linkages of an economy, the authors show that targeted carbon taxes may be more effective (i.e. deliver a larger reduction in aggregate emissions from a marginal tax reform) than economy-wide taxes, reinforcing the earlier argument against relying on uniform carbon pricing.

A second paper on policy design by Sascha Kollenberg and Luca Taschini examines an important feature of carbon trading schemes (Kollenberg and Taschini, 2019). Until 2019, carbon prices in the EU ETS had been below €10 for several years,

due in large part to overallocation (including failing to adjust allocations to falling activity as a result of the financial crisis of 2008-2010.) rather than impressively cheap abatement. Policymakers were concerned that with such weak price signals, European companies would make inadequate long-term decisions. The new "market stability reserve" (MSR) removes permits from the market when there are too many, and returns them when there are too few, leading to a more responsive effective supply curve. Kollenberg and Taschini alert policymakers to some of the potential flaws in specific MSR designs (e.g. an MSR which preserves the total cap may be counterproductive) which in the event were avoided by policymakers.

Carbon prices can have a long-run impact on economic structure. Carbon prices affect technology choices, which in turn affect human capital formation. Suppose that a cleaner economy is also a higher skill economy, where human intellect is deployed to digitize the control of energy services and to capture free energy in ever more efficient and clever ways from the wind and the sun. Kirill Borissov, Lucas Bretschger and Alexandra Vinogradova show that with a feedback between skills and technology choices, a temporary carbon price might be enough to shift the economy permanently to a higher skill, cleaner equilibrium (Borissov et al., 2019).

Borissov, Bretschger and Vinogradova also explore the international linkages in such a model. They find that with inter-country knowledge spillovers, policies in developed economies can trigger complementary increases in skilled labour in less developed economies, aiding the transition. Arguably, the experience over the last two decades where support for renewable energy in rich countries has led to significant manufacturing bases in developing economies, particularly China, bear this story out.

Key questions relating to climate-friendly innovation merit further research. Historic progress on wind and solar costs – which is continuing – holds great promise for the future transition to net-zero emissions, and yet, in these cases, carbon prices have not been the key policy driver of progress. Advances in short- and long-term energy storage, and conversion of renewable energy into chemical form are also central, and while a portfolio of research and development support is vital, the economics of pulling these technologies through to the point where the carbon price takes over as the main driver of policy is not addressed here. Policies to incentivise technologies and practices that remove greenhouse gases from the atmosphere are now necessary and have real potential (Hepburn et al., 2019). Here, carbon pricing to incentivise CO_2 removals, rather than to disincentivize CO_2 emissions, may have a very significant role, but this is a key lacuna in this issue.

It is nevertheless remarkable that striking technical progress has taken place on the back of weak policy. It could be much more powerful with stronger policy. It does seem however, that a shared understanding of where the world can and should go can drive progress.

Climate change is a global challenge, requiring global collective action. Suitable international agreements need to create incentives for wide and deep participation. Two papers in the issue focus on such questions. Ulrike Kornek and Ottmar Edenhofer propose a design feature of international environmental agreements that might simultaneously increase participation and compliance (Kornek and Edenhofer, 2020). It is well known that transfer payments from a multilateral compensation fund can support public goods provision. The core idea here is that transfers to member countries increase with their contribution to the public good (here reducing emissions), and that countries leaving the fund are punished by the remaining members decreasing their provision of the public good. With these incentives, voluntary participation and compliance in an international climate agreement would be enhanced and can even lead to social optimal carbon abatement. This novel mechanism is worth further consideration by existing and new international funds.

Finally, concerns that carbon pricing might damage – rather than enhance – international competitiveness persist in many countries, and border-carbon adjustments (BCAs) are a logical design feature to level the playing field while supporting the international trade regime (Helm et al., 2012; Stiglitz, 2006), providing incentives for otherwise recalcitrant countries to participate. Alaa Al Khourdajiea and Michael Finus consider the use of BCAs as part of international environmental agreements (Al Khourdajiea and Finus, 2020). They find that if treaties are open, BCAs can lead to stable climate agreements with wider participation, including potentially full participation.[4]

The special issue is not comprehensive and even in the areas touched upon by the papers, there is far more to be done: we have just scratched the surface. For instance, the High-Level Commission itself did not address the issue of the optimal time path of carbon prices. In this special issue, Stiglitz notes the value of incentivizing innovation *early* and suggests that it may be desirable to have high prices early on, a result reinforced by Borissov et al. (2019). There are other complexities in the dynamics of pricing and regulation[5] moving to electric cars reduces carbon emissions more if electricity is produced with renewable energy. Sequencing matters. Modern behavioral economics suggests that our preferences are endogenous (Mattauch et al., 2018), but we have little basis of knowing what kinds of policies will be most effective in changing preferences in ways that are more conducive to mitigating climate change. Public understanding will surely have a role to play.

Further research is vital on increasing the political and public acceptability of carbon pricing, in particular through commitments on the use of the resulting revenues (Klenert et al., 2018). Until concerns about distribution and equity are put first in policy design, rather than as an afterthought, and until there is greater understanding of the perceptions of the fairness and efficacy of different measures, protests at such pricing are likely (Rubin and Sengupta, 2018). Making progress is only partly about policy design that is more sensitive to distributional issues. It also requires a thoughtful approach to the

[4] See also the report (September 2019) of the Carbon Pricing Leadership Coalition, which shows that apart from a few trade-exposed energy intensive industries, the competitiveness effects are small.

[5] See also Stern (2018).

procedural fairness, inclusiveness and communications of the reforms. Success also requires an understanding of the strong resistance from vested interests to carbon pricing reforms, along with developing approaches to overcome the strategies that are regularly deployed to stymie attempts at progress. Similar considerations apply to policy reforms to remove fossil fuel subsidies, which remain remarkably persistent despite their economic illogicality—they both distort the economy and use scarce government revenues (Coady et al., 2018).

Understanding possible political reaction should be based on an understanding of the relevant political circumstances and history. The protests of the *gilets jaunes* in France were also against inspections of older vehicles, lower rural speed limits and, more fundamentally, the difficulties facing local populations in smaller towns and rural areas, including those arising from declining manufacturing, problems that were perceived to be ignored or at least given insufficient attention by the elites and Paris. Moreover, climate policy cannot be set apart from other aspects of a broader policy framework: if there is a perception more broadly that policies are directed at benefiting an elite, then there may be more intense reactions to climate policies which have the potential to hurt even small numbers of those who have not been doing well. These histories underline the importance of an approach to change which is inclusive and puts cohesion at centre stage.

Finally, carbon pricing is just one part, albeit very important, in an overall strategy for the fundamental changes involved in moving rapidly to an economy with net-zero emissions. This is a strategy for structural change and a rapid transition to a new form of growth. It is crucial to invest in people and places who are and will be affected or dislocated in these changes. Inclusive strategies are possible: all can benefit from the new, cleaner and more efficient ways of producing and consuming that are at the heart of the transition to the zero-carbon economy and meeting the other sustainable development goals. But public policy will be essential in bringing these outcomes.

We believe that this issue of the European Economic Review represents a collection of papers reflecting valuable and novel economic thinking on carbon pricing that we hope will be of use to policymakers in the coming years and will catalyse further research in an area that is of vital importance to our society.

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