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Taxing extractive resources in the transition to a low-carbon future

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Abstract: This paper explores the potential impacts of the transition to a low-carbon future for the taxation of extractive resources. The global debate on climate change has firmly moved on from the question of *whether* countries ought to shift towards such a future to that of *how* they are going to achieve it. Offering a succinct summary of the global community's collective understanding of the challenge at stake and the policy options that are on the table for advancing the transition within the geographic boundaries of their sovereign countries, the paper highlights the overbearing dichotomy that is playing out between the environmental awareness and concerns of high-income and resources-consuming advanced economies and the developmental aspirations of low-income and emerging market economies. It reflects on the global imperative to further the low-carbon transition by means of nation-states pursuing carbon pricing and other downstream-focused policy measures for domestic revenue mobilization in low-income countries.

Key words: taxation of extractive resources, climate change, low-carbon future, carbon pricing, domestic revenue mobilization

JEL classification: F64, H23, L71, L72

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1 Introduction

This paper explores the implications of the transition to a global low-carbon economy for the taxation of extractive resources. At the United Nations (UN) Climate Change Conference of Parties held in Paris in 2015 (COP21), representatives from governments and the multi-national private sector offered almost unanimous public acknowledgement that global changes in climatic conditions are the result of anthropogenic greenhouse gas (GHG) emissions. This marked a turning point, because it firmly moved the global debate from the question of *whether* countries ought to shift towards a low-carbon future to that of *how* they are going to achieve this future. Nearly all 197 states that participated in the conference signed the Paris Agreement, which sets out the benchmark target of limiting global temperature rises to 2°C above the level measured before the Industrial Revolution.[1]

The backdrop to the 2°C target is the warning that exceeding this limit could bear catastrophic consequences for humankind. However, climate scientists have underlined that it is still possible for temperature rises to be contained within this limit, *if* humankind succeeds in radically reducing the carbon dioxide (CO_2) and other GHG emissions it releases. At the aggregate level, keeping within this limit suggests a massive and urgent structural change in the global demand for fossil fuels. At the disaggregate level, it boils down to an equally urgent and fundamental shift in what every person strives to own and consume and, commensurately, what companies produce and invest and how they do so. The signatories to the Paris Agreement have agreed to participate in a process in which they will each set out their commitments for controlling emissions. They have put commitments on the table and will be held to account on these starting from this year (2020). Collectively, the signatories have confirmed the direction of travel. But in terms of actually travelling the journey, the global community has not moved very far, yet.

For the countries and the companies that produce fossil fuels and are dependent on the revenues and other benefits derived from this sector, the Paris Agreement has sounded a wake-up call. It has given rise to the recognition of 'carbon risks', and new terms have been coined in the run-up to and the aftermath of COP21, in particular 'unburnable carbon' and 'climate-stranded assets' (Lahn and Bradley 2016; Manley et al. 2016; Bradley et al. 2018).

The basic idea of unburnable carbon is to quantify the remaining carbon budget that the world can still afford to release in the foreseeable future. The alarmist conclusion has been that the 2°C benchmark target will be missed, if all the hydrocarbon reserves that producers already have on their books are actually produced and burned. One assessment has calculated that 80 per cent of global coal reserves, 50 per cent of global oil reserves, and 33 per cent of global gas reserves would need to remain unburned (McGlade and Ekins 2015). As indicative as these calculations may be, they leave no doubt about the scale of the challenge and they underline the stark reality that a successful transition involves a much greater effort than tinkering at the margins.

The notion of 'stranded assets' is more complex, because it considers the wider implications of the low-carbon transition.[2] In particular, it includes the responses of the financial sector and its long-

[1] In addition to the 197 states that participated in COP21 in Paris, the European Union also signed the Paris Agreement. After Donald Trump took office as President in January 2017, the United States have announced that it will withdraw from the agreement in 2020.

[2] Helm (2015a) offers a critical view.

term focused management of assets and liabilities. For example, Carbon Tracker (2020), an independent financial think tank, distinguishes between 'regulatory stranding' that is based on changes in policy or legislation, 'economic stranding' that arises from changes in relative costs and prices, and 'physical stranding' that is due to distance, as well as the rising risks of floods, droughts, and other natural catastrophes that scientists have been associating with observed changes in climatic conditions.

Carbon risks paint an ambiguous picture for low-income countries that are dependent on producing and exporting extractive resources. On the one hand, fossil fuel producers have been warned that they should prepare for a future of declining tax revenues and other benefits derived from the sector (Manley et al. 2016; Bradley et al. 2018). At risk are not only those least diversified that have become heavily dependent on the sector. But there are also the low-income 'new producer countries' that have been hoping to develop their economies and societies on the back of exploiting their more recently discovered fossil fuel endowments: Mozambique is the prime example for this group of countries.

On the other hand, the transition has also been heralded to bring new opportunities. The future low-carbon economy is expected to be material-intensive, especially if living standards and comfort levels are to be maintained. Demand is expected to increase for those materials that are needed, for example, to produce renewable forms of energy, to electrify the transportation sector, and to improve the energy efficiency of the built environment. On the back of these expectations, the countries that can produce the metal and non-metal elements needed for the low-carbon transition are seen as potential winners (World Bank 2017; OECD 2018a).[3] However, rising demand for such materials possesses its own sustainability challenges, in terms of not only the energy needed to produce them but also their negative environmental and social impacts.

Low-carbon technologies also increase the demand for renewable natural resources. This may be good news for countries that are more generously endowed with renewable natural resources, but it also bears the risk of over-exploitation. As will be discussed later in this article, low-carbon technologies also raise very fundamental questions about the governance and property rights that underpin the exploitation of renewable natural resources. To put it up front, the ambiguity between global carbon risks and the perceived opportunities for producers of natural resources that underpin low-carbon technologies suggests that *all* governments will need to focus more closely and in a much more joined-up manner on *all* of the legal, regulatory, fiscal, and other policies that affect *all* of their natural resource endowments.

At the global level, an overbearing dichotomy is playing out between the environmental awareness and concerns of the high-income and resources-consuming advanced economies and the developmental aspirations of low-income and emerging market economies. Low-income countries, in particular, are caught between meeting the demand for energy and other natural resources from their growing populations and the negative environmental impacts that meeting these needs invariably cause, if they are based on high-carbon and pollution-heavy technologies. Not least, low-income countries are themselves increasingly exposed to these negative impacts. At the same time, these countries are least prepared to avert and mitigate these impacts.

[3] A further development is the heightened focus on recycling and secondary sourcing of materials more generally. This development is related not only to the subject of waste management but also to the concept of a 'circular economy' that uses resources and materials in a fundamentally different way (see OECD 2018b). This includes that secondary-sourced raw materials are less energy intensive than primary raw materials.

This paper focuses on the risks and opportunities that the transition to a global low-carbon economy has in store for taxing extractive resources in low-income Sub-Saharan African countries. The extractives-led development agenda has envisaged that these countries will transform their below-ground hydrocarbon and mineral resources into above-ground assets (Addison and Roe 2018). This agenda has placed a strong focus on re-investing the revenues collected from the fossil fuels and mining sector to provide public goods and services and for these to contribute to building and sustaining more diversified economies and inclusive societies. The above-ground assets that this agenda has focused on include physical and social infrastructure as well as well-functioning political-administrative systems.

The challenge is that climate change—together with broader global environmental concerns—calls for all renewable forms of *natural capital* to be taken into account as part of the stock of above-ground assets that need to be maintained at sustainable levels. This natural capital includes the protection of biodiversity-rich habitats and the quality of soils, air, and water. Essentially, it includes all 'common pool resources' that the earth avails to humankind free of charge and in perpetuity. To date, these assets have not (or at least not specifically) featured in the asset-transformation model. Similarly, even the more recent literature on the taxation of extractive resources has also paid little attention to carbon risks, let alone paid any attention to the wider public fiscal policy implications of the low-carbon transition.[4] Given the emphasis placed on transforming below-ground assets into above-ground ones via the revenues that host countries (should) receive from the extractive industries, these gaps are quite striking.

There are several good reasons for taking a closer look at these issues. First, views on the speed and the geopolitical implications of the transition are conflicting, with some observers suggesting that the transition might be around the corner much faster than fossil-fuel producers are willing to recognize (Stevens 2019). Thus, producers may be poised to face reduced revenues sooner than they expected. For every fossil fuel-dependent country, this could bear not only geopolitical but also domestic political consequences. On the other hand, there is also the view that governments, companies, and individuals are all moving much too slowly to avert the catastrophic consequences that anthropogenic air pollution and other types of fossil fuel-related environmental pollution have in store. Both prospects flag the types of political and social risks and instabilities that business and financial investors loathe.

Second, the sector-specific taxation literature has drawn a firm line between upstream mineral and petroleum fiscal regimes and the downstream-focused taxation of environmental impacts aimed at internalizing negative externalities. Given the overbearing dichotomy described, achieving the low-carbon transition would seem to challenge that dividing line. In any case, what gets taxed is critical for the question of who gets the revenues from policy measures that aim to further the low-carbon transition and, also, what that revenue should be spent on.

Third, although there is the proposition that there will be new winners among those countries that are endowed with the mineral resources that low-carbon technologies rely on, it is not yet clear which technologies will be the most critical for the transition or, indeed, what other technologies may still get invented in forthcoming years. There remains a good deal of uncertainty about what the demand for the materials associated with the low-carbon transition will look like going forward, when exactly this demand might materialize, and for how long it may last. This suggests volatile

[4] The present study has not found any mineral and petroleum taxation literature flagging global warming and climate change as an issue of concern. Nakhle (2008) is an exception, mentioning climate change briefly in her concluding chapter.

prices driven by speculation, which again bears implications for taxing the upstream production of the respective mineral resources.

Fourth, as low-carbon technologies also affect the demand for renewable natural resources, there are broader issues about internalizing negative externalities. This, not least, because excess CO_2 emissions are just one of two types of market failures that beset the exploitation of natural resources.

The paper is structured as follows. Section 2 lays out the policy imperative for the global low-carbon transition and the policy options that individual countries have been and are contemplating, not least in the context of the Paris Agreement. Section 3 reflects on extractive resources taxation and raises very fundamental issues about the prospects for raising revenue on the back of exploiting natural resources. Section 4 discusses four questions of concern to low-income and emerging market producer countries. Section 5 concludes.

2 Policy options for the transition

The Paris Agreement underlined that transitioning to a global low-carbon economy will require progress on three fronts: first, CO_2 and other GHG emissions need to be contained; second, the stock of emissions already released needs to be reduced; third, where people are most exposed to the negative consequences of anthropogenic changes in the climate, measures need to be put in place that allow them to adapt.[5] The global community's collective understanding of the overarching challenge at stake has conditioned how it has set out to achieve such progress.

2.1 Internalizing the negative externalities of excess emissions

When the UK government commissioned the British economist Lord Stern to point the way and lead its seminal *Report on the Economics of Climate Change*, Lord Stern underlined that emissions-induced climate change constituted the greatest 'market failure' that the world has ever seen (in Hallegatte et al. 2013). This failure comprises free-riding: high-carbon energy consumers have drawn private gains and comfort from combusting fossil fuels, while humankind as a collective has increasingly become negatively affected by CO_2 and other GHG emissions. Emissions have exceeded the threshold beyond which the earth's natural capital can no longer absorb and neutralize these as fast as they are released. The planet is warming, and climatic conditions are changing!

In compliance with textbook economics, whenever there is a serious market failure, economists and many policy makers call for collective action to address it. In the case of this specific market failure, the situation has been clear at least since the UN Framework Convention on Climate Change (UNFCCC) was established in 1992: a global emissions control system is needed to contain the release of globally harmful CO_2 and other GHG emissions. In practice, this system would need to be capable of forcing emitters to internalize the negative externalities that they are imposing on others.

[5] Recent comparative research on the impacts of global warming and the weather shocks born by low-income countries has put out the warning that these countries are poised to experience significant output losses that climate adaptation policies also will not be able to mitigate (Acevedo Mejia et al. 2019). It concludes that only global GHG containment limiting further global warming is likely to offer lasting relief from the otherwise predicted, negative economic consequences of weather shocks.

The market-based approach to achieving the internalization of the economic costs of emissions is to charge a sufficiently high price for emissions. Such a price would serve to make emitters pay for the negative externalities that they are causing and where these are produced. These costs would then get factored in and be reflected in the prices of all the goods and services sold. The price mechanism should work against the demand for high-carbon goods and services, because producers and consumers alike would move to seek out low-carbon alternatives. The competitiveness of less-polluting technologies and processes should increase, whereas the demand for high-carbon goods and services should decline. As it would strive for greater energy and material efficiency, the global economy would be incentivized to reallocate its factors of production towards low-carbon technologies and processes. This, in turn, would further stimulate innovation in such technologies and processes.

Beyond pricing emissions, a complementary and more indirect approach would be to pro-actively support the development and the uptake of low-carbon technologies and to constrain, or even outrightly prohibit, the use of high-carbon technologies. These measures require laws, regulation, and fiscal incentives.

To control emissions effectively at the global level, such a system would need to be provided and be enforced as a global 'public good'. The two properties that define such a good are *non-exclusivity*, that is, nobody can be excluded from benefiting from this good, and *non-rivalry*, that is, one person's consumption of the public good does not hinder or deteriorate another person's consumption of the same good. It follows that an effective global emissions control system would need to be comprehensive and inclusive. Ideally, it would apply equally to everybody and it would leave no room for free-riders to exploit competitive advantages on the basis of loopholes in coverage or enforceability.

The obvious practical but formidable question is that of how such a system can be achieved in the real world. First, there is the challenge that emissions are not a problem per se. Emissions are okay as long as the earth's natural capital can capture and neutralize these through photosynthesis and other naturally 'cleaning' processes at about the same rates as they are released. It is merely the *excess* emissions, beyond the sustainable threshold through which human activities are negatively affecting global climatic conditions, pushing the average global temperature beyond the targeted 2°C.[6] The implication is that the identified free-riding problem is not at all straightforward in terms of going after the culprits. While scientists can gauge at what level the accumulative stock of excess emissions becomes problematic, it is much more difficult to attribute this stock to individual consumers. This applies to achieving the *ex-post* internalization of already built-up negative externalities as well as the *ex-ante* internalization of future negative externalities.

One approach is to attribute negative externalities to those who have caused emissions in the past and contributed to the built-up stock.[7] In international climate policy debates, low-income and emerging market economies have argued for this position vis-à-vis the more advanced economies.[8]

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[6] One estimate suggests that the world is emitting about 2.5 times what climate scientists would consider a 'safe' level of emissions (Spence 2020).

[7] The G20 countries are estimated to emit about 80 per cent of the GHGs added to the existing stock every year. These countries that are under the most pressure to wean themselves of their high per capita fossil fuel consumption levels and their annual demand as well as emissions levels are expected to peak sooner than those of the non-G20 countries.

[8] Along these lines, Berners-Lee (2019) has proposed that a global agreement on the remaining carbon budget should be reached and that priority should be given to low-income countries developing their resources. This would offer some form of compensation for the fact that they have historically contributed least to global warming, but they will be affected most by the dwindling prospects of fossil fuel-led development.

Yet, historical attributions are not quite straightforward. Technological developments brought about on the back of high-carbon economies have delivered improvements in living standards globally that may not have been possible without the build-up of this stock. In the language of economists: there have also been positive externalities, and these have been shared. In any case, the overarching challenge is of a complex but also collective nature. This makes it all the more puzzling that the question of internalizing the negative externalities of emissions has only focused on the downstream end of the fossil fuels value chain: not much consideration has been given to what happens at the upstream end of exploiting a particular type of common pool resource.

The second problem for the real world is the warning spelt out by economic theory that public goods in general are notoriously undersupplied. The story goes that rational economic agents are prone to free-riding and will shirk compliance, unless there is a sufficiently strong authority that can undermine this behaviour through some form of physical or normative coercion. In this case, limiting emissions to a level that sustains the present climatic conditions requires a global authority to set and successfully enforce a comprehensive and all-inclusive emissions control system.

As there is no such global authority with this power at the present time, there is only voluntary international cooperation between sovereign nation-states.[9] Obviously, this is why the global community has resorted to reaching a voluntary agreement among the governments of these states. At the same time, it is also why it has taken the global community several decades to get to the point where it was proclaimed a major achievement that nearly all countries and the European Union have signed the Paris Agreement. To put it bluntly, the global community has had to settle on the inferior second-best option of assigning sovereign national governments with the responsibility of somehow compelling those residing in their jurisdictions to internalize (at least some of) the economic costs of emitting globally unsustainable levels of CO_2 and other GHGs.

2.2 National policy options

The mainstay of the Paris Agreement is that signatory nation-states have agreed to a process in which they will each set out and implement national climate action plans that achieve the collective target of limiting global temperature rises to 2°C above pre-industrial levels. At the heart of this process lies the nationally determined contributions (NDCs) that each party has committed to prepare and then implement. The NDCs capture each signatory's post-2020 climate actions. Since 2015, the respective governments and the European Union have submitted their national plans to the UNFCCC, whose role it is to collate and monitor the actual progress made.

The national climate action plans, based on which the signatory governments aim to deliver their NDCs, take into account the particular domestic circumstances and capabilities. For the respective governments, the overriding political imperative is to achieve the agreed targets without undermining national economic and social development. Ideally, policy makers would like to be able to claim that citizens will not get worse off. Instead, the transition should unleash new economic and social opportunities.

In theory, this political imperative suggests that economic and social development needs to be de-coupled from burning fossil fuels and destroying more of the environmental habitats that produce oxygen and sequestrate and capture carbon naturally. However, at the global level the consumption of fossil fuels and, thus, the release of CO_2 and other GHGs has not yet seen a significant dent

[9] This is not to say that global environmental and climate change movements have not played an important role in putting pressure on governments, companies, and consumers to take global warming and climate change seriously. They have done so in terms of pushing for a normative shift, convincing consumers that high-carbon consumption may no longer be socially acceptable and that regulatory and fiscal measures will reflect this.

(BP 2019). The recent growth in global GHG emissions has been driven by rising prosperity in emerging market economies and low-income countries.[10] Nevertheless, per capita energy consumption in these countries still trails a long way behind that of the OECD and, especially, the G20 countries. In addition, the global youth lives in low-income countries, and it is there that urbanization is progressing most rapidly and where economic and social development is most pressingly needed. It would seem quite obvious that it is impossible to meet the Paris Agreement's 2°C target on the back of expanding the deployment of (the still) dominant high-carbon technologies in low-income and emerging market economies and also increase the global demand for materials.[11]

In the meantime, some countries have proclaimed that they have already successfully entered the path of decoupling their economic growth from energy consumption. For example, several European countries have pointed out that they have nearly halved their per capita emissions, starting from around 2005 (Spence 2020). Critics are not convinced. They argue that energy consumption has merely been shifted abroad: high-carbon production processes have been shifted out of OECD countries and into emerging market and low-income economies (Moreau and Vuille 2018).[12] In short, OECD countries are importing products that have been manufactured elsewhere but with embodied energy, the respective emissions of which have been released elsewhere.

With the NDCs committed under the Paris Agreement kicking off from this year (2020), national governments have had, and will continue, to work out how they are going to deliver on the commitments they have submitted to the UNFCCC. They have various options. Along the lines of the two complementary approaches already flagged, these options include market-based measures that aim to put a price on carbon and more indirect measures that support the development and uptake of low-carbon technologies or reduce the stock of CO_2 that is already present in the atmosphere. Both approaches have been used in parallel at the level of individual countries as well as at the level of supra-national and sub-national regions. Drawing on a recent report published by the International Monetary Fund (IMF 2019), the remainder of this section outlines these options.

Pricing emissions

The International Energy Agency and several other international expert organizations have supported the market-based approach that sees levying a price on carbon as the most effective solution for reducing global emissions. If companies must calculate their prices including the cost of emissions, they would be incentivized to invest in, as well as to invent, cleaner and more energy-efficient technologies, materials, and processes.

Experts have estimated that a price of about US$70 per tonne of CO_2 released would be required to reduce global demand to a level that would be compatible with the scientific advice of keeping temperature rises within the 2°C target. By comparison, all the currently pursued national and regional measures that involve some form of carbon pricing have been estimated to add up to an average global carbon price of just about US$2 per tonne of CO_2 (IMF 2019).[13] The size of this

[10] For data showing that in terms of consumption the typical low-income country contributes very little to global carbon emissions, see BP (2019) and IEA (2019).

[11] OECD (2018a) captures this dilemma.

[12] Helm (2015c) maintains that decoupling is impossible by relying on the low-carbon technologies that are currently in use. He argues that these technologies are simply too costly. Bleischwitz et al. (2018) maintain that some countries have been (or are) reaching a point of material saturation.

[13] For a discussion with focus on the United States, see Kennedy (2019).

gap illustrates that the measures put in place are falling well short of what they ought to be. It also gives an indication of the scale of the further policy measures that will need to be put in place going forward.[14]

Carbon can be priced in several ways. Looking back, national governments have focused their climate policies on areas where carbon is most visibly emitted. This focus has often come on the back of at least some bottom-up pressure from organized environmental interest groups. Under the heading of 'environmental taxation', governments have targeted the very downstream end of the value chain, imposing taxes and fees where fossil fuels are most obviously consumed.

Road transportation is the one sector where levies and taxes reach a coverage of nearly 100 per cent (OECD 2019). However, the effective tax rates applied vary considerably across countries. They are generally considered too low to truly reflect the sector's negative externalities, especially when local air pollution is taken into account. Meanwhile, fossil fuels consumption in other segments of the transportation industry has hardly been taxed at all. These include, in particular, maritime and international air transportation.[15]

Some countries have made progress on pricing emissions by taxing the weight of carbon released. The IMF's stocktake established that 16 countries had introduced some form of explicit carbon tax in 2018, applying a CO_2 price of between US$5–35 per tonne released (IMF 2019). However, carbon taxes have typically been applied only to selected sectors and/or industries. Yet, judging from the political debates that have taken place over the past year in the European Union and several of its sovereign states, more countries are in the process of considering direct carbon pricing. They are debating at what level and scale direct taxes or fees should be introduced and how fast it would be politically feasible to increase these.[16]

As governments are considering options against the background of the political and social acceptability of the respective consequences in the contexts of their particular country, the main drawback of taxing emissions is that it hits the less-privileged harder than the better-off, even though the former tend to use less energy in absolute terms. This regressive effect puts national political leaders under pressure to set out how they might offer mitigation and redistribute the burden of direct taxation by means of drawing on social policies. This pressure has prompted several proposals on so-called tax-and-dividend and 'new green deal' packages.[17] Typically, these packages propose to combine a drastic tax increase on the nationally charged price for carbon with some form of socially responsible redistribution of some of the collected revenue back to citizens. For example, this could happen in the form of proposed universal basic income schemes. These schemes have divided opinions greatly, not least because proposals reflect a fundamental change to familiar uses of tax systems, especially in terms of what gets taxed and whose comfort levels and privileges are affected in the short-term (Sandbu 2018). The proposed schemes also touch

[14] The slightly good news is that in many major economies a price of US$35 per tonne could already lead to significant CO_2 production cuts and get countries close to their NDC pledges (IMF 2019). Along the same lines, OECD (2019) has calculated that significant pro-climate behavioural changes should set in at carbon price of about 30 euros per tonne. On the other hand, there are countries with current energy mixes that would require a carbon price of above US$70 per tonne to achieve what they have pledged.

[15] From this year (2020), members of the International Maritime Organization have committed to reduce the use of shipping fuel with a high sulphur content. For a discussion on the aviation industry, see Powley et al. (2019).

[16] For a discussion on this challenge, see Mountford (2019).

[17] Note that in the United States, the Carbon Leadership Coalition refers to this idea as a 'fee and dividend' proposal, reflecting that in this national context pricing carbon emissions has been communicated as imposing an environmental fee.

upon many vested interests who fear immediate losses more than they appreciate potential future gains.

Reflecting on this, the IMF (2019) has suggested that if the first-best solution of direct emissions taxation is not deemed acceptable second-best options could provide an alternative. One such alternative is cap-and-trade (CAT) schemes. These schemes price carbon by placing a quota on carbon emissions. Quotas are enforced by issuing permits to targeted emitters. These are, effectively, granted a 'right to pollute'. By limiting the overall amount of permissible emissions, governments can create a market for pollution rights. Industries and companies that find it easier to cut emissions by investing in more carbon-efficient production processes and energy solutions can then sell their excess rights to others who find it harder to reduce theirs.

Political stakeholders have tended to favour CAT schemes because political acceptability is not too difficult to achieve, as long as pollution rights are grandfathered and the targeted industries receive their initial pollution rights free of charge. The flipside is that such schemes are not comprehensive, and they are costly for the authorities. This, not least because they are complex to administer and generate no revenue. In addition, the markets for pollution rights created so far have not resulted in the sort of carbon price that would be necessary to seriously bring down emissions.[18]

Other measures

Beyond pricing emissions, other measures are aimed at making the continued deployment of high-carbon technologies relatively more expensive than alternative low-carbon technologies. One set of measures aims to bring down the price of low-carbon technologies, for example, by reducing their costs, fostering their further development, and encouraging their faster uptake. This can be achieved with subsidies and incentives schemes as well as targeted public funding for certain low-carbon technologies.

Mandatory requirements for the installation of energy-efficient technologies and adherence to energy-efficiency standards in the built environment are additional measures that seek to regulate emissions by limiting or outrightly forbidding certain high-carbon technologies. Such measures also enjoy political and social acceptability, *if* they are seen to contribute to alleviating negative environmental impacts that people experience in their local (urban) environments, such as improving air quality and containing associated public health concerns. Quite obviously, there are limited political gains to be made from opposing a ban on the use of diesel vehicles in densely populated urban areas where people, and especially children, experience respiratory stress. Rolling out low-cost, low-carbon energy solutions in highly populated urban areas has evolved into an issue that even the governments of emerging market economies have come to care about (Stevens 2019). At the other end of the spectrum, such regulatory measures are more difficult to introduce and implement in large countries where people are used to travelling long distances and rural populations are politically relevant.

At least in part, these types of measures have also been discussed under the headline of 'green' industrial policies (Hallegatte et al. 2013; Rodrik 2014). The drawback has been that such policies often entail picking and choosing technologies that are deemed suitable for the low-carbon economy. Critics have warned of the risk that, once introduced, benefiting industries and sector lobbyists will seek to influence governments to continue providing respective support, even if and when there are good reasons for ceasing such support. In addition, measures may also tie-in public

[18] For a view on CAT schemes, see Helm (2017).

funds that could be invested more strategically to push innovation and the development of the next generation of low-carbon technologies.

For example, Helm (2015b, 2015c) has pointed to subsidies promoting high-cost wind farms and environmentally questionable biofuels. In his view, well-meaning but ill-informed environmental lobbyists have supported these technologies on the back of the assumption that prices for fossil fuels are set on an upward trajectory because they should eventually and unavoidably run out. He critiques that, first, this ill-guided 'peak oil' hypothesis has resulted in brushing aside and ignoring the lack of competitiveness of some of today's preferred low-carbon technologies. Second, the intermittency problem of wind and solar power generation requires other sources of energy or technologies (i.e. batteries) to make up during downtimes. In the best case, batteries and other forms of energy storage will in future be able to provide sufficient top-up supplies during such times. However, in the worst case, back-up electricity generation relies on dirty coal and/or expensive spare capacity supplied by gas-fired power plants. Helm (2015b, 2015c) warns that betting too early on the wrong types of low-carbon technologies is expensive for consumers. It also undermines addressing the actual problem at stake, as it may undermine the political and social acceptability of more effective measures that could really support the transition.

Other measures also include those aimed at reducing the accumulated stock of CO_2. For example, resources policies targeting more sustainable land-use practices, such as avoiding deforestation and increasing natural CO_2 storage through re-forestation or moving away from industrial farming to more sustainable farming practices. At the global level, probably the most prominent effort is the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism developed by parties to the UNFCCC. This ecosystem services scheme offers low-income countries incentives to reduce emissions from forested lands and to seek out low-carbon paths to sustainable development (see United Nations 2020). Support for carbon offset schemes has also become a corporate response to the climate change critique that companies face. For example, ENI is but one of several oil and gas companies that have announced investing in planting forests to offset some of their carbon emissions. Another example is the Carbon Offsetting and Reduction Scheme for International Aviation, which the International Civil Aviation Organization established in 2016 as a climate mitigation measure for the industry.

Critics see offset schemes making little of a difference (Cavendish 2019) or they challenge them on moral grounds (Sandel 2012). Helm (2015b), in turn, calls for a much bigger picture view on offset schemes with the aim of keeping the earth's stock of *natural capital* constant, by investing all or at least a good part of the revenues gained from depleting non-renewable resources on conserving and restoring the earth's renewable natural capital.

2.3 Summary

Conceptually, it is clear that the global community is set to further the transition to a low-carbon economy on the basis of addressing the market failure that has led to the excess emissions that have caused the greenhouse effect and global warming. The proposed remedy is for countries to work together towards a global emissions controls system that is provided as a public good and focuses on internalizing negative externalities at the point where emissions are produced. In the absence of a global authority that can enforce such a scheme, national governments are in charge of choosing and combining national climate policies, taking into account the political and social acceptability of such policies within their national borders. Within those borders market-based pricing of emissions is seen as the first-best solution to driving the low-carbon energy transition, supported by complementary 'green' industrial policies that aim to incentivize the uptake of low-carbon technologies, as well as other measures that strive to increase natural and technology-driven ways of capturing and storing CO_2. Regulations on permission levels, or outright bans have been

least favoured, as their acceptability is tied to relevant constituencies experiencing positive trade-offs in their immediate local environments.

Unsurprisingly, national climate policies have largely been discussed and evaluated under the heading of environmental taxation and regulations, where measures are applied at the downstream end of the fossil fuel value chain. The most common examples include motor fuel taxes, CAT schemes, or tax credits for renewable electricity generation. Public investments and subsidies have also been focused on encouraging the adopting of low-carbon technologies and expanding the use of public transportation. However, the overarching objective to internalize the negative externalities that excess emissions cause does not prescribe that carbon pricing and other measures need to be applied at the downstream end. They could also be applied at the start of the fossil fuel value chain.[19] Thus, the next section shifts the focus on taxing extractive resources.

3 Taxing extractive resources

There is a large body of literature on how extractive resources should be and are taxed.[20] Broadly speaking, this literature covers the different types of fiscal regimes that have evolved over time; the types of fiscal instruments that governments can and have been applying and how they can and have been combined; the factors that affect the relative bargaining power of investors vis-à-vis host governments; and administrative considerations that host governments may take into consideration when they design, improve, or reform their fiscal regimes and tax instruments.[21]

The foundation of this literature is its focus on taxing *upstream* production (e.g., the mining of ore bodies or the drilling for and the extraction of oil and gas). Taxing the sector with the view to internalizing its negative environmental externalities in *downstream* uses is hardly mentioned at all. However, if it is mentioned, then it is usually in the context of improving the energy efficiency of production processes; for example, by means of introducing fiscal measures aimed at containing gas flaring,[22] encouraging companies to invest in lower-carbon production technologies for extraction, or drawing on locally produced renewable sources of energy to power refining and processing facilities.

3.1 Taxing the upstream 'economic rent'

The theory of taxing extractive resources draws on the concept of economic rent to serve as the basis for determining the optimal level of taxation for the sub-soil gifts that nature has provided to humankind to exploit free of charge. Economic rent is defined as 'that portion of value added that exceeds the opportunity cost of all the factors of production' (Crowson 2008: 305).[23] This opportunity cost includes the cash costs of production and the minimum required return on the

[19] Notably, IMF (2019) briefly mentions the option of taxing emissions at the upstream end of the fossil fuel value chain production in passing, before focusing solely on taxing emissions downstream.

[20] This literature includes, for example, Nakhle (2008), ICMM (2009), Daniels et al. (2010), and Otto (2017).

[21] For a partial review, see Dietsche (2019).

[22] For a US-focused review of this subject, see Rabe et al. (2020).

[23] Crowson (2008) explains: 'economic rent' differs from 'profit'. The latter is the reward to capital and, thus, is narrower defined; 'economic rent' also differs from 'value added', which is the reward to all factors of production (land, labour, capital) and, therefore, a measure of the contribution a project makes to gross domestic profit. See also Nakhle (2008).

capital that investors provide for exploring, developing, and operating extractive resources projects. The logic is that extractive resources projects generate economic rents as soon as prices cover opportunity costs. At this point, project investors receive a payment in excess of the minimum payment that is necessary to keep the required factors of production in their present use. The policy conclusion is that, in principle, governments could tax away these rents and not lose any investment or production. Such taxation would not affect the decisions of investors, because to ensure that projects are economically viable, they would already have factored in all the risks and would have assessed the compensation they need to receive.

In the real world, it has been proven difficult to put the theory of taxing economic rents into practice. Governments struggle to determine what the project-specific rents are because this requires making assumptions on variables for which they hold limited information. For example, this includes assumptions about the project-specific opportunity costs of capital and future product prices. In consequence, there are very few, if any, real-world examples where the theoretical concept of taxing the economic rent has been put into practice. Nevertheless, the concept has underpinned several conclusions.

First, it has supported the argument that governments should strive for fiscal regimes that are flexible and progressive. That is, the government tax-take should adjust to volatile prices so that, when prices rise, governments are ensured to receive a rising share of the economic rent generated; when prices fall, the government tax-take should decline to ensure that taxation does not undermine projects' economic viability.

Second, the uncertainty about which low-carbon technologies will in future prove to be most cost-effective and able to outcompete the prevailing high-carbon technologies and early-generation low-carbon technologies has implications for the prices of those minerals that provide the inputs for the material-intensive low-carbon economy. For several reasons, these prices can be expected to display high volatility (Renner and Wellmer 2019). The implication is that the fiscal regimes applied to prospective low-carbon-supporting minerals also need to be designed flexibly and progressively. Thus, an expected global increase in demand alone is not a sufficient argument for governments to justify increasing the tax-take. There will be other competitive producers seeking to grab a bigger share of these evolving markets.

Third, the host countries that are expected to suffer first from 'economic stranding' are those whose projects are high-cost. Because prices for those assets likely to be stranded are expected to fall as a result of supply outstripping demand, it makes each producer want to take the safer route. This means that selling fossil fuels at a lower price today is more favourable than taking the risk of not being able to sell these resources at all in future. Thus, if fiscal regimes are not designed flexibly, they increase the risk of economically stranded projects. This, in turn, will put pressure on governments to relax their fiscal terms.

Fourth, it can also be argued that the threat of climate risks will dampen the relevance of the concern that host governments have been receiving too little revenue from the sector after offering investors overtly generous fiscal terms. Arguably, this concern has been supported at least implicitly by the proposition that governments can tax away all of the economic rent that investors generate without this undermining economic viability. In the context of countries' eagerness to attract investors, the risk had been that they had offered companies fiscal terms that taxed less than the economic rent, especially when prices were rising from the early 2000s until about 2014. As valid as this concern may have seemed until recently, looking forward it would appear to become less relevant: fossil fuel producers will be competing in a race to the bottom. This should shift the concern towards the question of how host countries should invest the declining revenues that they can still earn during the transition.

3.2 The cost of capital

Included in the opportunity costs that the definition of economic rent refers to is the cost of capital. That cost is sought to be reflective of the investment risks that investors are concerned about and the alternative investment opportunities that they could also realize in other sectors, industries, and countries. Thus, the cost of capital directs attention to the financial sector and its position vis-à-vis climate change and carbon risks.[24]

The financial sector's exposure to climate-related risks is twofold (Grippa et al. 2019). First, it is exposed to physical damages to property, infrastructure, and land that result from changes in the climate. Here, the financial sector (in particular, insurance companies) is exposed to an increased risk of defaults in their loan portfolios and the associated declining asset values. There is also the problem of reduced diversity in financial institutions' portfolios, because the events that give rise to climate-induced physical risks are correlated.

Second, the financial sector is also exposed to transition risks related to (i) changes in and the impact of climate policies, (ii) advancements in low-carbon technologies and how fast these will be adapted and by whom, and (iii) changes in the sentiments of consumers and markets more generally as they adjust their economic decisions to the evolving low-carbon economy. Risks materialize on the asset side, such as via excessive exposure to firms whose business models are, in principle, not built around the economics of the low-carbon transition.

As the physical and transition risks are interlinked and feedback on each other, it explains the financial sector's avant-garde position in seeking to understand and factor these risks into its resource allocation decisions. There has been a rise in pledges and commitments to reconsider and refrain from investing in certain high-carbon ventures (e.g., new coal facilities). It would seem that the cost of capital is rising for projects and investments that are not considered supportive of the low-carbon transition. Unfortunately, it is beyond the scope of this present paper to take a closer look at what has and is currently happening in the financial sector. But it suffices to say that the sector still faces many challenges in incorporating climate-related risks into its financial stress testing and to develop the legal and regulatory tools and voluntary standards required to ensure consistent reporting on climate-related risks and for this to inform decision-making. Industry commentators underline that the current state of affairs is one of iterative learning-by-doing. A push is also coming from environmentally conscious investors who are keen to capture new opportunities associated with investing in low-carbon technologies.

To conclude, it may be purported that, if the cost of capital for high-carbon industries rises and financial resources are starting to move elsewhere, it erodes the basis of taxing upstream production. This, in turn, raises more fundamental questions about the tax base on which high-carbon producer countries will be able to rely in future. If producer countries had ensured that they invested their proceeds from exploiting below-ground assets into other forms of sustainable above-ground assets, then they would have expanded their tax bases.[25]

3.3 Internalizing negative externalities upstream

The question of what the governments of fossil fuels producing countries can tax to raise revenues in future prompts an even deeper enquiry into the basis for taxing extractive resources. Essentially,

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[24] Mitchell et al. (2015) were among the first to point to this sector's critical role in recognizing carbon risks and factoring these into the allocation of financial resources.

[25] One of the few countries where this may apply is the usual suspect: Norway.

upstream-focused taxation takes place at the point where sub-soil common pool resources get turned into private goods that can be sold and traded as commodities. To recall from economic theory, the properties of private goods are that they are *rival* and *exclusive*. This means that if one person uses such a good, another person cannot also use it. Second, it would have to be relatively easy and cheap for the person making use of such a good to exclude another person from this use. A gallon of oil or a bar of gold can be sold and traded and a consumer can use it in different ways, much like a bunch of tomatoes or a tonne of cereal is harvested, sold, and consumed.

Common pool resources and the problem of exclusive access

In their original state, common pool resources (including fossil fuels *in situ*) are similar to public goods: they do not fully meet the properties of being *rival* and *exclusive*. Thus, in standard economic terms their use gives rise to a market failure that needs correcting. As in the case of clean air, common pool resources are provided by nature free of charge and in perpetuity. The difference lies in the possibility to achieve *exclusivity*, which in the case of clean air is impossible to achieve. For common pool resources, however, exclusivity can be achieved in principle, because an authority with a monopoly over the use of power can devise institutional arrangements that can grant individuals sufficiently clear and secure private property rights to these resources.

A key factor for achieving such exclusivity is transaction costs. These, in turn, are conditioned by the type of common pool resources in question and the number of potential users. The rule applies that the more 'open access' a resource is, the more difficult it is to achieve exclusivity.[26] For example, it is more difficult to regulate and policy overfishing in the oceans than it is to regulate fishing in a small lake where a local community or their local government can more easily control access.

In the case of renewable natural resources, the problem of restricting use is tied to the imperative of sustaining the resource base. The resource can only be used up to a certain threshold level. Beyond that level, their use turns into over-exploitation where the resource is no longer able to sustain itself and continue to avail its fruits or other benefits to humankind free of charge and in perpetuity. For example, once a lake has been overfished by some users, the fish stock declines and everybody who has been fishing will be worse off. In addition, beyond the fish there are repercussions for the wider biodiversity of the lake. The same applies to forests, where deforestation is not only about harvesting timber at a rate that is faster than that at which trees can regrow, including their capability to turn CO_2 into oxygen. It is also about the loss of the habitat for all the plants and creatures thriving in the forest environment.[27] Thus, just as in the case of clean air, if critical thresholds are exceeded some users' free-riding comes at a cost for everybody else, including, in particular, future generations.

Selling and trading extractive resources

As soon as they are sold and traded, most mineral and some petroleum resources are turned into materials until they are discarded. Discarding happens either sooner or, if recycling takes place, later. At this point, these resources turn from being assets into environmental liabilities. Most hydrocarbon resources are combusted to harvest energy, in which case the emissions from this process turn into an environmental liability straight away. In both cases, one could argue that, as

[26] There is a large body of literature on the governance of common pool resources focusing on the nature of 'open access' problem and how communities and societies can and have managed access with the help of developing respective institutions. A useful source on this subject is De Moor (2015).

[27] There are many other examples, including the decline in bees and other insects and the degradation of soils.

they get used, produced extractive resources turn into liabilities that the earth's natural capital is somehow left to deal with.

Extractive resources are a special category of common pool resources, because their accumulation happened over very long periods of time. These periods are too long for humankind to consider the use of these resources at the same rate at which natural processes renew them. The problem remains, though, that once these resources are known to exist, potential users have an incentive to capture and claim them ahead of others who want to do the same. On the back of this problem, a substantial body of research has evolved that has investigated the historical process of turning extractive common pool resources into private goods by means of authorities with a monopoly over the use of power to provide the institutional arrangements that allowed exclusive property rights over such resources to be granted to individuals. In other words, the creation of exclusive private property rights over the use of extractive resources has been seen as a solution to a fundamental market failure.

Not least, the ability of nation-states with a monopoly over the use of power to grant and enforce such rights within their geographic boundaries was a critical pre-condition for the Industrial Revolution. The rules underpinning these rights gave explorers the certainty that they could lay claim on these resources once they had discovered them and that they could source the factors of production needed to exploit them and take them to market.[28] Critically, it is typically national-level authorities that provide the legal and regulatory frameworks assigning private ownership to enable sub-soil common pool resources to be turned into tradable private goods above the ground.

The philosophical insight gained from this is not only that it has required authorities with monopolies over the use of power to address the problem of non-excludability by setting and enforcing the rules that define who can explore, produce, and trade sub-soil resources. It also means that the solution to one market failure has given rise to another market failure. Specifically, it has created the challenge of what to do with the environmental liabilities of excess CO_2 and all the other extractive resources-based waste. Most illustrative is the example of nuclear waste, but also that of tailing dams and discarded hydrocarbon-based plastics. The historic mistake consists of rights granted at the national level without also assigning commensurate *duties* in relation to the negative externalities that these rights give rise to. One can argue that the institutional arrangements that the governments of nation-states have devised to grant private property rights over energy minerals have much to do with the large-scale free-riding on emitting excess CO_2 and other GHGs (as well as producing plastics and other harmful material waste) that has happened since the beginning of the Industrial Revolution and, later, the invention of the combustion engine.

The link to taxation is that these nationally granted resource property rights are critical to establishing who is to pay taxes for the upstream production of extractive resources: the duty to pay taxes rests with the entity that has been granted the right to explore and exploit. Strictly speaking, with that right the same entity is also granted an implicit right to pollute, which it is passing on to the purchaser of the produced fossil fuels. There is never any duty attached to internalize the negative externalities caused by the granting of these rights. This problem is simply passed downstream for environmental taxation to pick up imperfectly at the other end of the value chain.[29]

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[28] For a review of the literature on the history of resource property rights, see Dietsche (2013).

[29] Not dealt with here, but equally a matter of un-internalized externalities is the subject of the negative environmental and social impacts that local people may suffer around project sites. This is a separate topic that this paper cannot

In conclusion, the solution to one type of market failure has offered opportunities for free-riding that have been passed down from the upstream end of exploring and exploiting sub-soil national resources to the downstream end. This happened largely unhindered until, starting in the 1990s, the recognition grew that the other type of market failure (i.e. excessive CO_2 and other GHG emissions) can no longer be ignored.

Essentially, this pitches two types of social values against each other. First, there is clearly a social value in exploring and exploiting sub-soil common pool resources that justifies devising and enforcing institutional arrangements that allow these resources to be turned into private goods so that they can be used to support economic and social development. Second, there is an equally, if not more, important social value in ensuring the earth's renewable common pool resources are conserved and restored to ensure that this natural capital can, first and foremost, sustain itself.

Humankind depends on this natural capital to be managed in a manner that ensures sustainability. Hence, there is a collective responsibility for ensuring that the organized use of monopolized power granting exclusive rights to common pool resources is put towards the sustainable governance of these resources. It should follow that, if that power rests with nation-states, they are each and jointly responsible for shaping their respective legal, regulatory, and fiscal policies to this effect. It is obvious that in the short-run governments are hesitant to review the institutional arrangements that have underpinned the free-riding, because they fear that this would be politically and socially unacceptable. However, this does not weaken the argument that a major institutional shift of the scale that brought about the Industrial Revolution is bound to have to happen at some point in the not-too-distant future.

4 Discussion

This section addresses four questions that are aimed at weaving together the policy imperative for the global low-carbon transition and the national-level policy options that were discussed in Section 2, with the reflections on taxing extractive resources offered in Section 3.

4.1 How comprehensive and inclusive is the global emissions control system?

The first question comes back to how comprehensive and inclusive (or rather, how deficient) the current global emissions control system is. Section 2 laid out the reasons why dealing with the properties of *non-exclusivity* and *non-rivalry* that underpin the climate change challenge requires that this system is provided as a public good and that it covers excess emissions *comprehensively* and *inclusively*. That section already flagged some of the critical issues, including how to define *excess* emissions, attributing historic and present responsibility, and the absence of a global authority that can set and hold users to account.

In short, the answer is that comprehensiveness and inclusiveness are compromised, because the global community must rely on the voluntary commitments from sovereign national government. Not every government has whole-heartedly signed up to the process, nor can those who have signed up ignore the political and social acceptability of the measures that scientific experts advise as necessary to meet the commitments agreed. An illustration of the later are the politically favoured CAT schemes that several OECD countries have adopted, but that cover only certain industries and that independent observers have judged as ineffective. Measures to internalize the

cover at the level of detail it deserves. However, it is worth mentioning that sometimes local taxation, including different forms of quasi-taxation, could be seen as efforts to achieve the internalization of negative local externalities.

negative externalities of emissions have mainly targeted those sectors where introducing such measures has been less controversial. This has meant that many pertinent sectors have been excluded, in particular the coal and coal-burning industries and the maritime and air-based transportation sector.

A key issue for the global emissions control system is the scope for competitive positioning of production locations across jurisdictions with different (implicit) carbon prices and regulatory environmental standards. Even with some countries setting and achieving more ambitious and comprehensive carbon emission targets than others, carbon-intensive production can move across national borders and already has moved to jurisdictions that are less concerned about (or feel less responsible for) their contributions to this historically accumulated global problem. In other words, high-carbon production moves to locations where downstream environmental taxation is relatively light or non-existent.

Two options have been put on the table for addressing non-rivalry in terms of undermining competitive advantages based on cross-country differences in effective carbon pricing. The first calls for 'carbon border adjustments', also referred to as 'carbon border taxes' (Fleming and Giles 2019). The idea is to impose a charge on the carbon estimated to be contained in imported goods and services. The carbon embodied in these goods and services will be released in a geographic location different from that where the goods and services have been produced.

The second option is to agree an international 'carbon floor price' that seeks to balance the differences across countries in terms of their contexts and their carbon pricing and other emissions-related policy measures. In contrast to the unilateral imposition of a carbon border tax, this option seeks to share the burden of the low-carbon transition from bottom-up. By agreeing a global (or regional) carbon floor price, individual countries would retain the flexibility of adopting additional measures supporting a higher domestic carbon price, not least to meet respective NDC commitments. At the same time, the governments of countries where it is more difficult to gain political and social acceptability for any type of carbon pricing would gain a minimum basis to start from and then gradually progress. Some international policy advisers favour this second option, because it is less likely to contradict World Trade Organization rules (IMF 2019). In addition, there is also the fear that carbon border taxes could entice some governments to abuse them to protect certain domestic industries.

4.2 Who gets the revenues and how are these spent?

Environmental taxation pursued by national governments to contain the demand and consumption of fossil fuels downstream drives a wedge between (i) the prices that producers realize at the wellhead or the mine and provide the basis for taxation and (ii) those that are paid by the consumers, combusting fossil fuels further down the value chain. The obvious implication is that declining prices for upstream production puts the governments of producer countries under pressures to revisit their fiscal terms to avert the risk of economic stranding as they are scrambling for a share of a declining market. At the same time, the consumer countries at the downstream end of the value chain are contemplating how they should best use the revenues that they can collect, at least temporarily, from applying environmental taxation in the form of carbon pricing and other measures, including carbon border adjustments. In plain words, while the more advanced countries that have progressed furthest on pricing carbon see the revenues raised from downstream environmental taxation as income that they can spend to compensate those most exposed to the end of the carbon emission free-riding era, it leaves low-income producer countries entirely exposed to the political and social risks that the transition presents for them. Perhaps, this is one outcome that one would *not* expect nor want from the internalizing of negative (carbon) externalities.

Recognizing the doubled-up market failure laid out in Sub-section 3.3, Helm (2015b) proposes another solution. This involves the natural capital being properly accounted for, measured, and valued. Only then will it stop the present situation where natural capital is being ignored as an uncharged factor of production that is assumed to renew itself in perpetuity, irrespective of how humankind uses it. The proposed 'aggregate natural capital rule' is that a good part of the revenues earned from exploiting sub-soil natural resources should be spent on conserving, restoring, and even increasing the earth's stock of renewable common pool resources. Helm's (2015b) thoughts on this matter contrast with the various policy options discussed by IMF (2019). The latter places its focus exclusively on options that target carbon production in the mid-stream and downstream and how the revenues collected on the basis of these options could be used to ensure political and social acceptability in those countries where hydrocarbon use per capita is high. In turn, Helm's (2015b) view is that the negative externalities should be internalized from the outset so that all factors of production are properly costed and allocated in a more environmentally sustainable manner. Not least, if the rights to pollute were paid for upstream, the global cost of excess carbon and other GHG emissions would already be internalized at the point of extraction and it would be possible to recognize there and then whether a resource can be produced under the global carbon budget that scientists advise on.

These thoughts may seem far-fetched given their political–economic implications. But they do raise the question of whether producer countries have the option of moving towards internalizing the globally negative externalities of emissions at their end, even if indirectly. For example, what would it take for producer countries to price the carbon contained in their fossil fuels at source and then to pass to the downstream a carbon credit that is recognized as an NDC component? Might this be feasible on the condition that the revenues raised are put towards conserving, restoring, and growing natural capital?

4.3 How fast is the transition evolving and can countries still invest in diversification?

There are diverging views on how fast the transition is likely to evolve and, thus, how much time low-income producer countries have left to expand their tax base and look for other sources of revenues. Of course, looking back one could get the impression that the transition is progressing all too slowly and that not many tangible improvements have been achieved in the past three decades. Business would almost seem to continue as usual. On the other hand, there have been plenty of micro-level self-congratulations on localized efforts to support renewable energy generation and improve energy efficiency, although these have not made much of a dent at the global level.

The current approach would seem seriously insufficient to keep emissions within the 2°C target. In as much as OECD countries are pointing out their energy savings, they are dwarfed by the unmet needs for energy and materials in low-income and emerging market economies and especially in the larger Asian economies. Despite the Paris Agreement and the NDCs that countries have committed to, there is pessimism that national climate policies and action plans will fail to add up to what a theoretically necessary comprehensive and inclusive global emissions control system should achieve.

The positive signs are with the financial sector internalizing negative externalities into the cost of capital and allocating resources, accordingly, as discussed in Sub-section 3.2. There is also the hope that research and science will be able to evolve low-carbon technologies to compete with high-carbon technologies on cost to the extent that they will outperform the latter and be adopted on economic grounds much faster than would seem possible at this point in time. Helm (2015b, 2015c) remains hopeful, even as he points to the global challenge of the energy demand of some 9 billion people not being able to be met merely by relying on the dominant high-carbon

technologies. He suggests that a much more ambitious re-think of carbon pricing is necessary to save the planet from global warming and that the search for future low-carbon technologies aimed at harvesting the power of the sun should be much more intensified. In addition, phasing out the most polluting of all fossil fuels, especially coal, is key. To date, coal has been kept outside nearly all carbon pricing measures. A key risk for containing global temperature rises is that some of the most highly populated emerging market economies are still heavily dependent on coal-fired power stations, including China, India, and South Africa (IMF 2019), and seem likely to remain so dependent (Romsom and McPhail 2020).

At first sight, Stevens (2019) sounds less positive. He has purported that the energy establishment, and in particular national oil companies, may be seriously underestimating the speed and depth at which the transition is already unfolding. This puts some countries at a higher risk than others. Producers in the Middle East and North Africa are particularly exposed, as their economies are the least diversified and the most dependent on continued demand. At another level, however, Stevens (2019) sees the financial sector's exposure and responses to carbon risks as an important driver that is reinforced by opportunities associated with investing in low-carbon and low-cost energy production technologies that can be widely used and produced. Noting that the costs for renewables and technological advances in electricity storage have been falling, he underlines that their availability is also much more diffuse than conventional high-carbon sources of energy. This may offer new opportunities for some regions where achieving political and social acceptability for a low-carbon approach to building energy infrastructure is easier to achieve. In addition, there is also a powerful geopolitical transition under way where rivalry over access to and control of the supply of oil is fading away as renewable sources of energy become more widely used and produced.

In the past, the producer countries that have received good shares of the economic rent generated have often spent these on consumption rather than investments. With their increased exposure to carbon risk, they should ideally already have diversified much more than most of them have. Meanwhile, the new producer countries, where projects have just or are yet to come onstream, have little time left to diversify. The question of how they could achieve diversification is not new and many component responses have long been suggested but are far from easy nor straightforward to implement. They include, for example, broadening the tax base; re-assessing energy-related investments, including ceasing the subsidization of the use of fossil fuels and high-carbon sectors; promoting improved competitiveness; and investing in skills and capabilities that transfer across sectors (Manley et al. 2016).

It is obvious, that the faster the transition progresses, the less time producer countries will have to invest their remaining extractive revenues in diversifying above-ground assets. But it also turns the table for the preoccupation that has prevailed until recently: that producer countries are at risk of receiving *too little* revenue from the sector. The silver lining comes in the form of paying attention to a risk that few observers pointed to in the past. Namely, that if countries receive *too much* revenue from the sector—in the sense of high revenue dependence—it quells the efforts that they would otherwise put into broadening the tax base and forging more socially constructive political–economic settlements that would supress rent-seeking and squander.

Multinational businesses have recognized that they too have a key role to play in moving the global economy much faster towards achieving a permanent reduction in the demand for fossil fuels and, simultaneously, to speed up the pace at which less carbon-intensive sources of energy are developed and deployed. Lord John Browne, the former BP chief, expressed this with his recent comment that the energy transition now felt like it had collapsed in time. Energy companies need to move faster than had been expected until just recently (O'Dell 2019). They need to decide whether to branch faster into renewables or focus on cutting carbon out of their existing

operations (Sheppard 2019). Not only have several of the international oil and gas companies announced commitments to invest heavily in renewable energy and to reduce the carbon footprint of their operations (e.g., see Lund 2019), some companies may also start to take an interest in how the host countries in which they have been working for many years are approaching the energy transition and in what role companies could support them.[30]

4.4 What is the impact of the uncertainty about low-carbon technologies of the future?

With respect to the role of low-carbon technologies, there remains great uncertainty about their relative competitiveness and the associated growth of demand for specific types of mineral resources and materials as well as renewable natural resources. For the producers of mineral resources this gives reason to be cautious about propositions that suggest them as the obvious winners. There may be an increased or a sustained global demand for certain metals and other extracted materials, including natural gas serving as the transition fuel that replaces coal (Safari et al. 2018). But this does not necessarily mean rising or stable prices on which to tax upstream production.

There remain many uncertainties that are associated with the metals and hydrocarbon mix that will be thrown up by the evolving energy transition. For example, how long might it take before cobalt becomes less significant in battery technologies; or will ways be found how to reduce our dependence on copper? The broad conclusion is that the imperative for conventional upstream fiscal regimes in the producing countries is that they be designed flexibly so that they can deal with price and other uncertainties as and when they arise. But it is just as important to reflect on fiscal and other policies more broadly, not least to recognize what opportunities the transition could deliver, including in relation to investing in the conservation and the restoration of natural capital. For example, global efforts should deliver new revenue streams that low-income countries can tap into, including payments for ecosystem services.

Yet, there remain unresolved questions about the use of land. Invariably, producing energy from renewable natural resources requires land. In low-income countries, clashes between formal and informal rights to land are a common source of tensions and conflicts. Harvesting solar, wind, or hydro power to generate electricity is poised to increase the value of land and other space-related assets, triggering the risk that those with the political means will seek to grab these assets for their private gain. But land (and what grows on it) is also a renewable common pool resource, and it is not easy to strike a sound balance between using land to produce inputs for low-carbon technologies (e.g., biofuels, wood, and other 'green' materials) and conserving land for natural habitats that sustain biodiversity and air, soil, and water quality.

Several organizations have underlined that the global transition to a low-carbon economy will require changes in how land is used (IPCC 2019), and also that much of the world's land resources remains (and possibly should continue to be) held and/or managed by communities, including those considered to be indigenous. For example, there is the proposition that assuring that communities gain formal rights in communally managed land and supporting them to provide ecosystem services would offer cheaper solutions to containing CO_2 emissions compared with betting on subsidizing efforts to find expensive technical solutions, such as certain proposed forms of carbon capture and storage (Ding et al. 2016). This points squarely to the critical issue of nation-states backing the legal and regulatory systems that guarantee private property rights over

[30] Author's observation.

renewable common pool resources and it opens up a new set of questions on the role of fiscal policies and taxation supporting the low-carbon transition in low-income producer countries.

5 Conclusion

This paper set out to explore the potential impacts of the transition to a low-carbon future for the taxation of extractive resources. It started the global debate on climate change having firmly moved on from the question of *whether* countries ought to shift towards such a future to that of *how* they are going to achieve this future. Global efforts to price carbon emissions are, at best, at an early stage. The implicit average global carbon price of US$2 lies well below the benchmark of the US$30–70 bandwidth that scientists suggest is necessary. Fewer than 20 countries had applied schemes in 2018, although several pronouncements on introducing schemes have since been made. There is merely the hope that at some point in the future the sum of all national climate policies might add up to a reduction in the global demand for fossil fuels and that this reduction be large enough to contain global warming.

Section 2 set off by laying out the policy imperative for the global low-carbon transition and the policy options that individual countries have been contemplating. These options are underpinned by the logic of internalizing the negative externalities of emissions with focus on the downstream end of the fossil fuels value chain. Much less, if any, consideration has been given to the upstream end of exploiting fossil fuels as a particular type of 'common pool resource'. Instead, the carbon pricing debate touches many vested interests who fear immediate losses more than they appreciate potential future gains. A key concern is the political and social acceptability of carbon pricing options, especially in those countries where carbon consumption is high.

What gets taxed is critical also for the question of who gets the revenues from the policy measures aimed at furthering the low-carbon transition and, also, what those revenues should be spent on. Section 3 reflected on extractive resources taxation, raising some fundamental issues about the future of revenues collected on the back of exploiting extractive natural resources. Drawing on the basic concept of taxing economic rent, it focused on the rising cost of capital for high-carbon industries and financial resources moving towards other sectors, thus, eroding the basis of taxing upstream production. Nationally granted private property rights to extractive resources are critical for that tax base. It is also those very same rights that grant a right to pollute, although rather implicitly. This right is then passed on to the purchaser of the produced fossil fuels, shifting downstream the problem of internalizing the externalities of excess emissions. Environmental taxation, preferably in the form of pricing carbon, is then expected to pick up the issue (imperfectly) at the other end of the value chain. This may seem a neat solution, but humankind still holds a collective responsibility for ensuring that the organized use of monopolized power granting exclusive rights to common pool resources is put towards the sustainable governance of these resources. It is not conceivable, therefore, that at some point in the (not-so-distant) future a major institutional shift of the scale that brought about the Industrial Revolution might have to happen.

Section 4 focused on the concerns of low-income producer countries. The voluntary commitments that sovereign national governments have so far delivered on are neither comprehensive nor inclusive and they have targeted those sectors that are least controversial. Moreover, the more advanced countries that have progressed the furthest on pricing carbon have viewed the revenues raised from downstream environmental taxation as income that can be spent to compensate national constituencies most exposed to the downsides of ending the high-carbon era. But low-income producer countries are also exposed. And this begs the question why, in principle, it should

not be possible to pay for the right to pollute at the upstream end of the fossil fuel value chain. It may seem far-fetched, but low-income producer countries should perhaps consider more seriously if there are potential options for internalizing the globally negative externalities of emissions at the upstream end, for example, in the form of conserving, restoring, and growing natural capital as a global ecosystem service. In any case, looking forward there does not seem to be much space left for producer countries to bank on increased revenues from the extractives sectors. Broadening their tax bases will require that governments focus more closely and in a much more joined-up manner at the legal, regulatory, fiscal, and other policy areas that affect *all* of their natural resources endowments.

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