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Whose carbon is burnable? Equity considerations in the allocation of a "right to extract"

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Abstract Carbon emissions—and hence fossil fuel combustion—must decline rapidly if warming is to be held below 1.5 or 2 °C. Yet fossil fuels are so deeply entrenched in the broader economy that a rapid transition poses the challenge of significant transitional disruption. Fossil fuels must be phased out even as access to energy services for basic needs and for economic development expands, particularly in developing countries. Nations, communities, and workers that are economically dependent on fossil fuel extraction will need to find a new foundation for livelihoods and revenue. These challenges are surmountable. In principle, societies could undertake a decarbonization transition in which they anticipate the transitional disruption, and cooperate and contribute fairly to minimize and alleviate it. Indeed, if societies do not work to avoid that disruption, a decarbonization transition may not be possible at all. Too many people may conclude they will suffer undue hardship, and thus undermine the political consensus required to undertake an ambitious transition. The principles and framework laid out here are offered as a contribution to understanding the nature of the potential impacts of a transition, principles for equitably sharing the costs of avoiding them, and guidance for prioritizing which fossil resources can still be extracted.

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1 Introduction

Under the Paris Agreement, Parties to the UNFCCC are now committed to "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" (Article 2.1(a)). These temperature limits imply that the remaining carbon budget is starkly limited. Only 200 $GtCO_2$ can be emitted if warming is to be kept below 1.5 °C, and 800 $GtCO_2$ if warming is to be kept below 2 °C, even if we accept a somewhat precarious 1-in-3 chance of failing. These budgets would be exceeded in a very few years—6 and 23 years respectively—at the current pace of extraction and combustion of fossil fuels.[1]

As pointed out by Muttitt (2016), the potential carbon emissions from burning the oil, gas, and coal in those fields and mines from which extraction is already underway is more than enough to exceed the 2 °C limit. Moreover, the oil and gas alone from these sources is enough to exceed the 1.5 °C threshold. An emerging body of research (Lazarus et al. 2015; Harstad 2012; Collier and Venables 2014; Seto et al. 2016; Green and Denniss 2018) argues that policies focused on emissions alone may not be sufficient, and that achieving the ambitious climate goals to which countries have committed themselves will require complementary policies to curb fossil fuel extraction and address carbon lock-in. Indeed, this is the common theme of the articles assembled in this Special Issue.

To neglect the equity ramifications of curbing emissions and extraction comes with serious risks. Clearly, it raises the moral risk of advancing pathways toward global decarbonization that are inequitable. It also risks advancing pathways that are simply unviable. Climate change is a commons problem, and an effective response requires global engagement and widespread cooperation that is robust enough to support and endure through a major global transformation. This engagement and cooperation is less likely to be forthcoming and to be robust if countries do not see the overall regime as being reasonably fair. In the understated phrasing of the Intergovernmental Panel on Climate Change (IPCC), an agreement that is "seen as equitable can lead to more effective cooperation" (IPCC 2014b).

Indeed, the historical inability to resolve issues of equity has arguably contributed to the slow rate of progress on climate action. At the global level, nations have been unable to address the question of how to equitably share the considerable effort that would match the climate change goals they have set, leading us to a regime based on nationally determined efforts that together fall short of those goals (UNFCCC 2016).

At the national level as well, equity questions have proven to be politically salient, and their neglect has led important constituencies to see climate change mitigation—more so than climate change itself—as a threat to their livelihoods, their access to energy, and their freedoms. These constituencies provide an audience readily disposed toward the anti-climate coalitions that have hindered ambitious action. Addressing these equity questions—on both the global and national stages—could make for a more forceful and enduring regime, and thus a more robust response to the climate challenge (Young 2013). Doing so could help increase confidence that there is more to gain than lose from an ambitious climate response, build trust

[1] NB: These figures are taken from Table 2.2 of the IPCC Synthesis Report, updated to account for the last 5 years (2012–2016) carbon emissions, as reported by the Global Carbon Project (Le Quéré et al. 2015) and estimated for 2016, as equal to ~ 200 Gt CO_2. The figures, in Gt CO_2 and years, thus correspond to the remaining budget or time for the period from 2017 onwards. Current fossil fuel combustion amounts to emissions of approximately 35 GtCO2 per year (neglecting additional emissions from land use change and cement production).

among parties, and establish a foundation for the deep cooperation and cohesion necessary for an effective global climate response.

The focus of climate ethics (the study of ethical issues underlying climate change) has thus far predominantly been on the emissions side, addressing issues such as the fair allocation of rights to emit greenhouse gases or emission reduction targets, the distributional impacts of carbon taxes, and the extent of obligations to provide support for mitigation in poorer countries (Gardiner et al. 2010). Comparatively, little research has focused on the extraction side (Caney 2016; Kartha et al. 2016), with the assumption being that as demand for fossil fuels is curbed, markets will decide which sources of extraction persist, and which decline. However, leaving the allocation of "who may extract?" to market forces risks placing the greatest burden of transition on those least able to carry it. For example, McGlade and Ekins (2015) used a least-cost model to assess which of the world's fossil fuel reserves may be extracted in a 2C world: it found that 94% of remaining oil reserves could be extracted in the USA, but only 61% of those in Central and South America.

Yet, just as on the emissions side, countries cannot be expected to earnestly curb their own fossil fuel extraction if it is not seen as part of an effort that is reasonably fairly distributed overall, that is, if their own efforts will be undone by those countries seen as free-riders.

This raises several questions. One set of questions concerns which fossil fuels can ultimately be extracted and by whom? Whose fossil fuels must stay in the ground? On what basis should these decisions be made? A second, distinct but closely related, set of questions concerns who should bear the costs associated with curbing extraction to keep within climate limits, and who should enjoy the benefits of extracting the permissible fossil fuels? If a country or community is required not to extract, is compensation warranted? Who should be responsible for providing such support? If a country is permitted to extract fossil fuels, should it, in some circumstances, be required to pay for the privilege and share benefits with others?

Hence, there is a need for climate ethics to encompass the extraction side. That is not to say that the relevant ethics are entirely different than on the emissions side. In both the fossil fuel supply-side (or extraction-side) context and the demand-side (or emissions-side) context, the relevant principles are in many ways analogous, as we will discuss below. However, even though extraction-side and emissions-side policies represent two facets of a common equity problem, the ethical issues that arise will differ, and will have varying implications for different groups of people. An emissions-side policy such as a tax on fossil fuel diffusely affects people throughout an economy by raising energy prices (in the absence of readily available alternatives), whereas an extraction-side policy such as the shutting of a coal-mine will primarily affect those groups that earn the wages, who are largely concentrated near the mine, and those who capture the rents from that mine.

This article lays out a simple framework for thinking through the equity implications of extraction-side policies, and for considering how they might be addressed, with the aim of helping identify more implementable and effective climate policies.

2 Curbing extraction equitably: what are the costs and how might they be fairly shared?

In this section, we parse these matters into two distinct but overlapping issues. The first is: what set of impacts will a country confront when endeavoring to curb its fossil resource extraction? These impacts will weigh heavily as a country assesses how its contribution stacks

up relative to the efforts of other countries. The second is: what are the fundamental ethical principles that guide judgements about how those impacts and their costs might be equitably distributed among countries, among communities, and among citizens?

2.1 The developmental implications of curbing extraction

Reflecting a broader moral imperative, the United Nations Framework Convention on Climate Change (UNFCCC) recognizes "that economic and social development and poverty eradication are the first and overriding priorities of the developing country[ies]" (Article 4). It follows that, in order to be just, the overall effect of a collective response to climate change should enhance, and at a minimum, not impede the efforts of the world's poor to rise out of poverty and develop. However, the implications of a finite carbon budget pose undeniable challenges to developing countries already at low levels of energy use (Rao et al. 2014). Here, we focus on two dimensions of the challenge posed by possible limits on fossil fuel extraction: the implications for energy demands for development; and the impact on economies, communities, and workers dependent on the fossil fuel extraction industry.

First, extraction of domestic fossil fuel resources has historically provided a path to cheap and secure energy for development, and still serves as the mainstay of the energy economy. Current low levels of energy access constrain the meeting of essential household needs such as electrification, clean cooking, and water and sanitation (Rao and Pachauri 2017). A substantial literature now suggests that energy is strongly correlated with improvements in development indicators, whether that development is measured in terms of gross domestic product or, more saliently, in terms of improvements in the Human Development Index (HDI) or access to basic services. For example, cross-country evidence suggests that HDI and energy consumption increases in near lockstep until energy consumption levels of about 2 tons of oil equivalent per capita, which is a level considerably higher than average consumption in most developing countries today (Jess et al. 2011). If undertaken through fossil fuel use, achieving traditional development goals of higher life expectancy, access to basic needs and economic growth through traditional growth pathways are likely to absorb a large share of the remaining global carbon budget (Lamb and Rao 2015). For developing countries with limited technical and institutional capacities, the attractiveness of treading a well-worn path rather than a more experimental path should not be understated, especially in a context of the persistent reluctance of many wealthier countries to be early movers.

The extent to which limits on fossil fuel extraction have regressive equity consequences for development turns in part, on whether these energy resources can be adequately substituted by other sources of energy, such as renewables, which in turn depends on the relative costs of each, and how any incremental costs are distributed. In the next few years, this cost advantage of fossil fuels is likely to be challenged, particularly by solar and wind energy (IRENA and NEA 2015; BNEF 2017). At the same time, a more complete transition to renewable energy will require the development of complementary technologies such as battery storage and grid integration technologies and practices. While there are hopeful indications, there remain significant infrastructural and other challenges in building out a renewable-based energy system. Doing so at the pace necessary to address climate change while also enabling rapid development compounds these challenges.

Second, scaling back the fossil fuel supply industry can also bring transition costs insofar as fossil fuel extraction provides important opportunities for export revenue, employment, or wider economic contribution (Mehlum et al. 2006; Torvik 2009; Kurtz and Brooks 2011).

Economic diversification has long been an objective of oil-exporting countries, often with very little success (Amuzegar 2001). Some studies have indicated that across the whole supply chain, renewable energy delivers more jobs per unit of energy delivered, or per dollar invested, than fossil fuels (IRENA 2011; IRENA 2016; Blyth et al. 2014; Pollin et al. 2015). However, there is limited data comparing the quality of jobs, or whether they are matched with existing skills and locations in the fossil fuel industry. Extraction often occurs in geographically concentrated areas, meaning a large proportion of local jobs would be vulnerable, along with the broader communities in which those workers live. Even when the overall share of extraction-based employment in a national economy is small, or when a transition to alternative energy sources can in principle yield a net positive contribution to employment, the localized and short-run disruption can be severe (Andrews-Speed et al. 2005; Harfst 2015; Shimazaki 2015). In addition, the land-intensive nature of many renewable sources—particularly bioenergy—could pit them against other critical land uses such as food production and natural habitat (Haberl et al. 2010; Smith et al. 2016).

A specific, and controversial aspect of these transition costs are enshrined in the UNFCCC under an injunction to consider the impact of "response measures," on "… countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels" (Article 4). Many UNFCCC Parties and observers would find it objectionable if finance were allocated to help relatively wealthy oil exporting countries, in the face of inadequate resource being made available for adaptation in the most vulnerable countries, particularly if this approach were used as a blocking measures (Depledge 2008).

These tensions emphasize the importance of addressing the equity aspects of fossil fuel extraction. By analogy with equity on the emissions side, reasonable arguments can be made that poorer countries deserve support in curbing extraction and diversifying their economies, as part of a fairly and collectively shared global effort to address climate change by transitioning globally to a low-carbon economy. This, we suggest, is a more fruitful and morally compelling approach to extraction-side equity issues than one framed in terms of compensating countries for stranded fossil fuel assets.

This approach is also fully consistent with the recognition that the pursuit of development imperatives through a fossil fuel first strategy has mixed consequences. For fossil fuel producers and exporters, a turn away from fossil fuels could also signal a move away from the problems of dispossession of local communities and other human rights violations with which these energy forms are often associated (Watts 2006; Obi 2010; Lahiri-Dutt et al. 2012), decreased exposure to macroeconomic instability through the "Dutch disease" (Ross 1999, 2013; Weidner 2011), and a decreased enmeshment with geopolitical instability (Moran et al. 2008; Yergin 2011). Limits on fossil fuels and a shift to renewable alternatives also bring a range of "co-benefits" for development, for example, in terms of energy security and air pollution (Ürge-Vorsatz et al. 2014; Von Stechow et al. 2015; McCollum et al. 2011).

In addition, even if fossil fuels provide a lower cost form of energy today, or provide an export revenue windfall, declining renewable energy costs and slackening fossil fuel markets could mean that investments today in a fossil-based infrastructure could lock-in a higher cost fossil energy path and/or lead to stranded fossil fuel infrastructure assets (Fouquet 2016; IEA 2014). In a rapidly changing energy technology environment, it may also condemn poor countries to technological backwardness. Since many long-lived energy assets in developing countries are only now being created, a long-term perspective may not argue for locking into the lowest cost short-term option, but rather for initiating a turn toward a renewable energy future.

The costs of a shift from fossil fuel extraction and their distribution will inevitably be strongly country-dependent. For example, the results will depend on the natural resource base of the country—fossil fuel rich or poor, and the availability of other clean energy resources such as wind and solar—and the prospects for economic diversification away from fossil extraction. An important consideration is the costs—both tangible and intangible—of expanding renewable energy at a pace sufficient to provide all the incremental energy and economic needs. How, in practice, energy access and socio-economic benefits that are forgone as a consequence of curbing extraction can be provided without imposing a drag on the development process, is a country-specific empirical question. The answer will depend strongly on the choice of institutions and mechanisms put in place to limit disruption, and how the attendant costs are shared.

2.2 Ethical principles for sharing responsibilities, burdens and benefits

In this context, the salient policy question turns on how the costs of the transition away from fossil fuel extraction can be eased, and how they can be equitably shared. Before discussing in Section 3 how those costs might be eased, we examine in this section some fundamental ethical principles that can guide us in considering how they can be shared.

As these costs are incurred for common good—for the purpose of preserving the global atmospheric commons—we argue that they should be shared fairly, rather than allowed to fall on whoever is unfortunate enough bear them directly in the form of compromised energy access or other socio-economic sacrifices of curbing their own extraction. Indeed, we contend that if they are not shared fairly, it will be unlikely that fossil-producing countries will earnestly endeavor to limit extraction.

The principle of common but differentiated responsibilities and respective capabilities (CBDRRC), which was reflected in both the Rio Declaration (Article 7) and the UNFCCC (Article 3), concisely expressed two widely held ethical principles for considering justice in the context of climate change. The first is the principle of "historical responsibility." Just as this principle is applied to the consumption of fossil fuels and the emission of greenhouse gases as a "polluter pays principle," it can likewise be applied to the extraction of fossil fuels. This "extractor pays principle" would posit that those who have extracted fossil fuels have a greater obligation to contribute to a transition away from extraction. There is, after all, a finite total available "extraction budget," which humanity must honor to keep warming below any specified level (IPCC 2014b), and different agents (where this might include companies (see Ekwurzel et al. 2017) and political elites as well as other actors) have extremely disparate levels of historical responsibility for having depleted it so far. A greater obligation to curb extraction, and to provide support to others who must curb extraction, should be borne by those who have been responsible for the extraction of fossil fuels in the past.

Certain objections are often raised against such notions of historical responsibility. First, some object that current generations cannot be held responsible for the extraction undertaken by previous generations (the past generations argument). However, one may counter that the wealth of some who are currently alive arose because of this history of extraction, and if they have received a large share of the benefits of this extraction then they should also accept the corresponding costs. Specifically, they should bear a larger share than others of the costs of transitioning away from extraction and supporting developing countries to curb their extraction, enable diversification, and avoid socio-economic disruption. This parallels a response

often made in the context of historical emissions (Gosseries 2004: 41–42; Caney 2010; Shue 2014: 182–186).

A second objection that might be pressed against the historical responsibility argument is that it is not fair to hold people responsible for the social costs of extracting fossil fuels when they could not have been expected to know what these would be (the "reasonable ignorance" argument). This objection does not apply, however, to the extraction of fossil fuels for at least the last 30 years or so, which is the era during which more than half of all fossil fuels have been extracted. Furthermore, even if one could not be held responsible for social costs that they could not reasonably be expected to foresee, this does not mean that those who enjoy a high standard of living precisely because of the historically high levels of extraction in the past should not be expected to bear some burden. Otherwise, they are enjoying the benefits of past extraction while passing on the associated costs to others. Again, an analogy can be made to arguments about historical responsibility for past emissions (Gosseries 2004, 40–41; Caney 2010; Shue 2014: 186).

A third point is worth noting. To say that an agent's history of extraction is morally relevant is not to say that it is the only relevant factor when determining ethical obligations. It has been argued, for example, that it would be unfair to apportion responsibilities for the past without taking into account an extractor's standard of living. To ignore this would result in ascribing responsibilities to those for whom extraction is helping to reach a decent minimum standard of living. In the same way that it has been argued that the "polluter pays principle" only applies to those with a decent standard of living (Caney 2010), one might also argue that the "extractor pays principle" only applies to people once a certain standard of living is reached.

This last point brings us to the second principle of CBDRRC—the principle of capabilities—which holds that a just transition must take into account societies' respective capacities to bear any burdens involved in curbing extraction and transitioning to a low carbon world. This "capacity principle" should be interpreted to include both the capacity to bear the costs of curbing extraction in its own society and the capacity to provide support to others coping with their transitional costs.

Capacity should also be understood to include factors such as economic capacity, physical capacity, and institutional capacity. Economic capacity refers to the wealth and non-fossil fuel income to cope with the transitional costs of curbing fossil fuel extraction and provide support to other countries. Physical capacity refers to societies which have other energy sources available to ease the costs of transition. Institutional capacity refers to the ability to plan ahead and implement policies that can cope with the transition from extraction (although it should be added that where political systems lack this capacity, members may have a responsibility to create effective institutions, and not treat the status quo as given).

The fundamental ethical principle is that with greater capacity come greater ethical obligations to contribute to the global transition (Caney 2014). This matters for two reasons. First, an effective response to climate change requires an enormous political effort, and is thus dependent on those with the greatest capacity to take a lead. Second, it is only fair to expect more of those with a greater capacity to play a leadership role, rather than place the burdens on those with less capacity.

To summarize, then, the question of who can extract fossil fuels must be answered in a way that takes its starting point as the legitimate claims of the world's least advantaged to develop, recognizing any adverse local impacts of fossil fuel extraction (see Section 2.1). In addition, any allocation of the burdens (and benefits) arising from the allocation of rights to extract to some but not others should take into account both the relevance of historical responsibility and the extent to which different societies enjoy different capacities. In the next section, we turn

from this formulation of ethical principles to explore their implications in practice in the context of a transition away from fossil fuel extraction.

3 Toward an equitably managed decline in fossil fuel extraction

If the objective, from the standpoint of effective climate action, is to curb fossil fuel extraction at a rate that is consistent with our agreed climate goals, then the objective from the standpoint of equity is (i) to bring about a managed decline in fossil fuel extraction in a manner that minimizes the disruption to key developmental priorities, and (ii) to distribute the costs of doing so in a fair manner. Here, we discuss in broad terms what minimizing the disruption to a number of key developmental priorities would entail, and what a fair distribution of the costs might look like in practice. We draw on the earlier principles and consider their practical implications.

3.1 Minimizing disruption to key developmental priorities

Provision of energy services First, to the extent that fossil fuel extraction is for the sake of domestic energy consumption (as opposed to export markets), it is critical that countries maintain access to energy services even while their extraction declines. Provision of basic energy services (cooking fuel, household lighting, etc.) are so indisputably associated with progress in poverty eradication and human development that any disruption to basic energy services would be intolerable from the equity standpoint. And certainly, if any temporary or permanent energy scarcities arise, basic energy services should trump energy for "luxury" consumption.

Similarly, although perhaps secondarily, it would be important to ensure the continued (and, especially in developing countries, the growing) provision of energy for broader domestic economic purposes, such as industrialization, urbanization, transportation, etc., which are closely related to supporting and expanding access to livelihoods.

As pointed out above, there is reason for optimism that these energy services need not be compromised even as fossil fuel extraction is being aggressively phased out. From the techno-economic perspective, there is strong evidence (IPCC 2014a) that global energy services can be met with non-fossil energy sources and efficiency technologies, given their increasing availability, improving performance, and declining costs, especially in view of their co-benefits. The equity challenge here relates to ensuring that these alternatives are available, affordable, and can expand at the necessary pace and in a sustainable manner, and that deployment costs are fairly shared.

For this to occur, many pieces will need to fall in place. It will require access to the relevant technologies and know-how, establishment of the required institutional frameworks, the creation of the needed human capital, the laying of upstream and downstream market linkages, and, not least, the availability of the needed financial and technological support. All of these issues arise similarly with the other dimensions of equity below.

Availability of secure livelihoods and stable communities An abiding concern is the loss of jobs linked to fossil fuel extraction. Addressing this issue equitably has come to be referred to as providing a "just transition" (UNFCCC Secretariat 2016c). While the details of ensuring a just transition are highly localized, the fundamental tenets are fairly well defined and widely

shared. First, where jobs are at stake, decent and feasible alternative jobs must be made available. Second, workers must have access to the necessary retraining and skills building to shift into the alternative positions. Third, social protection must be ensured for those whose jobs are affected. And finally, communities dependent on extraction-based jobs, directly or indirectly, must receive the necessary investments to ensure the sustainability of the local economy. Measures to achieve each of the above must engage and remain accountable to the affected workforce and communities (ILO 2010; Rosemberg 2017; UNFCCC Secretariat 2016a; ILO 2015).

Diversification of extraction-dependent economies The diversification of economies highly dependent on a single or small number of commodities has long been recognized as an important and difficult challenge. The UNFCCC Secretariat's technical paper on economic diversification (UNFCCC Secretariat 2016b: 25) points out that "[t]here is no clear consensus on the measures that are necessary to achieve economic diversification." It is clear that the fundamentals are important: maintaining macroeconomic stability, transparency, good governance, counter-cyclical fiscal policy, good infrastructure, etc. However, as countries have started to contend specifically with the challenge of diversifying away from heavy fossil fuel (especially oil) dependence, examples are emerging and lessons are being learned that will help manage the impacts of reduced extraction (Hvidt 2013).

3.2 Equitably allocating the remaining extraction and sharing the costs of foregoing extraction

The above suggests that a wide range of ameliorative measures are required if we are to deal with the potential adverse impacts of a global decline in fossil fuel extraction so as to keep within the scarce remaining carbon budget. And the smaller that carbon budget is deemed to be, the more rapid that decline must be, the more disruptive the potential consequences, and the more important that they be managed equitably. The small size of the remaining carbon budget to limit temperature rise to 1.5 °C or well below 2 °C implies that a path to development that relies on expanding fossil fuel extraction is no longer available.

To manage the implications equitably means two things. First, it demands an answer to the question "how rapidly must each country curb its extraction" that attends explicitly to equity issues, allowing for a slower ramping down in those countries where the rapid transition away from extraction would cause the greatest disruption that have the least viable alternatives for meeting their developmental needs, and least capacity to the transition to those alternatives.

Clearly, this allocation of fossil resource extraction may differ quite substantially from a de facto allocation by market forces, which is typically assumed to mean (e.g., McGlade and Ekins 2015) that "economic efficiency" dictates which fossil fuel assets should be extracted, i.e., those available at lowest marginal production cost. However, from the equity standpoint, there are socio-economic costs associated with curbing extraction while avoiding transitional disruption that go far beyond the marginal production costs, especially given how rapidly global extraction must be ramped down. Some of these socio-economic costs might be particularly difficult to mitigate; consider the impacts of the loss of a large portion of livelihoods in a community where there are scant opportunities for alternative livelihoods in the near term, in a poor nation that is hard-pressed to ensure a basic social safety net.

Second, it means that as countries curb their extraction, the cost of ameliorative measures to deal with transitional disruption should not necessarily be theirs alone to bear. Rather, the costs should be distributed in accordance with principles of equity. The two fundamental principles outlined in Section 2 would govern such an equitable distribution of the costs. Historical responsibility suggests that, all else being equal, greater past extraction should imply greater contribution to bearing the costs. And, likewise, respective capabilities suggest that all else being equal, greater capabilities should imply a greater contribution to bearing the costs.

Some might argue that it would be more efficient to allow markets to determine the allocation of extraction, and to address any equity concerns through separate international financial transfers; the claimed efficiency benefits would derive from the lower fossil fuel production costs and more rational price signals to investors in fossil fuel production. Two points may be raised in response.

First, we stress that production costs are but one component of the total costs, which must include the transitional costs which—given the rapidity of the necessary transition—could even turn out to be the predominant cost. Moreover, with regard to needing markets to send rational price signals to investors, the tightly limited remaining carbon budget implies that all future investment in fossil resource development should be curtailed, which can equally be unambiguously signaled through strong fossil supply-side policy. Given these points, the primary rationale for allowing market prices determined by marginal production cost does not seem determinative.

Second, and equally important, it would not be equitable to expect poorer countries to curb extraction and wait for transfers that may never materialize. While we argue that the remaining budget should be allocated to those countries which most need it to minimize transitional disruption; we would also agree that a country could choose to speed up its transition in exchange for more transitional support, on its own terms and with a level and type of support that it finds sufficient. In other words, the default should not be that the market allocates extraction to those countries with lowest production cost, with a subsequent transfer occurring at their discretion and on their terms. After all, there is little guarantee that international transfers at the requisite scale will materialize; follow-through on promises of financial transfers has historically been a sticking point in climate negotiations. This is not to suggest that financial transfers are not a critical part of an equitable solution, but rather that both a differential pace of transition (slower where disruption is greatest and capacity to bear to least) and an equitable sharing of residual transition costs are necessary.

In any event, this points toward the crucial role of international cooperation, especially between those countries with the technological capacity and financial resources to provide support, and those countries, regions, or communities with the most pressing transitional needs. It also suggests that the areas that would have the most justifiable claims to some future extraction would be those for which a transition away from extraction without major, unavoidable, immitigable disruption is simply impossible, or where claims to support are warranted but none is forthcoming.

4 Summary

Carbon emissions—and hence fossil fuel combustion—must decline rapidly if warming is to be held below 1.5 °C or well below 2 °C. Yet fossil fuels are so deeply entrenched in the broader economy that a rapid transition poses the challenge of significant transitional

disruption. Fossil fuels must be phased out even as access to energy services for basic needs and for economic development expands, particularly in developing countries. Nations, communities, and workers that are economically dependent on fossil fuel extraction will need to find a new foundation for livelihoods and revenue.

Much more needs to be understood about the nature of the disruption that could occur, and the exact measures, institutions, and agreements needed to minimize it. Of course, there are empirical questions to be answered (such as, what would be the economic impacts of foregoing fossil fuel extraction in a given region? what would a comprehensive just transition program in this region look like?), as well as normative questions (how exactly should the remaining extraction be allocated? what is the relative moral weight of historic responsibility versus respective capabilities in equitably distributing costs?).

These questions are answerable, and the challenges are surmountable. In principle, societies could undertake a decarbonization transition in which they anticipate, prepare, cooperate, and contribute fairly to minimize and alleviate the transitional disruption. Indeed, if societies do not work to avoid the disruption, a decarbonization transition may not be possible at all. Too many people may conclude they will suffer undue hardship, and thus undermine the political consensus required to undertake an ambitious transition.

The principles and framework laid out here are offered a contribution to understanding the nature of the potential impacts of a transition, principles for equitably sharing the costs of avoiding those impacts and guidance for prioritizing which fossil resources can still be extracted.

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