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Unilateral Action on Climate Change and the Moral Obligation to Take Leadership

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ABSTRACT

We claim that a moral obligation to take climate leadership by means of unilateral mitigation depends on the existence of a plausible follow-the-leader mechanism whereby unilateral mitigation by some increases the probability of sufficient mitigation by others to avert catastrophic climate impacts. By understanding these mechanisms, we can better articulate the obligation for climate leadership across various sectors, from government to individual actors, in the fight against climate change.

1 | Introduction

The longstanding failure to achieve an adequate international climate change mitigation treaty and the urgent need to act quickly to stave off severe impacts suggest an obvious need for leadership in the form of unilateral mitigation. By *unilateral mitigation* we mean mitigation efforts taken in absence of any widespread agreement requiring others to do the same. For example, if California keeps its pledge to achieve 90% renewable electricity generation by 2035 and 100% by 2045, that would be unilateral mitigation. Many major recent climate change initiatives are unilateral mitigation in our sense, such as the United States' Inflation Reduction Act, China's efforts to increase its rate of renewable energy installation, and the European Union's commitment to be carbon neutral by 2050. Yet meeting climate change mitigation targets, such as keeping mean global heating to less than 2°C or no more than 1.5°C, requires mitigation worldwide. The concept of leadership, then, is crucial in suggesting that unilateral mitigation by some may induce others to follow. We can roughly say an act demonstrates leadership when it contributes to a collective goal and increases the likelihood of sufficient aggregate contributions by others to achieve it.

We claim that a moral obligation to take climate leadership by means of unilateral mitigation depends on the existence of a plausible follow-the-leader mechanism whereby unilateral mitigation by some increases the probability of sufficient mitigation by others to avert catastrophic climate impacts. While Shue (2011), Vanderheiden (2012a, 2012b), and Maltais (2014) have called for climate leadership, they have not adequately explained the basis for expecting a follow-the-leader mechanism when it comes to action on climate change. Addressing this issue, we suggest, requires emphasizing the central role that a transition from fossil fuels to renewable energy plays in climate change mitigation. Technology diffusion often involves self-reinforcing mechanisms whereby increased uptake of a technology results in lowered costs and improved performance, and hence to further adoption. Moreover, production responds to consumer demand as well as support and incentives provided by governments, but may generate political opposition from vested interests in incumbent technology. These aspects of technology diffusion suggest mechanisms whereby unilateral mitigation can make others more likely to follow suit. That in turn supports an argument for an obligation for climate leadership that can apply to a variety of governmental, institutional and sometimes individual actors.

Our discussion is organized as follows. Section 2 examines arguments advanced by philosophers for an obligation to take climate leadership, and claims that an adequate explanation for why unilateral mitigation should be expected to move others to act remains to be given. We take up this issue in Section 3. In Section 3.1, we propose sufficient conditions for a moral obligation to take leadership, which include the existence of a plausible follow-the-leader mechanism. In Section 3.2, we introduce three key self-reinforcing mechanisms of technology diffusion, and suggest that the energy transition be seen as a competition where feedback mechanisms favoring renewables must outpace those on the side of fossil fuels. In Section 3.3, we explain how the dynamics of technology diffusion disarm an economic argument that unilateral mitigation may be ineffectual or even counterproductive. In Section 4, we consider the relevance of our proposal for a decision by the Canadian government to approve a major offshore oil project. Section 5 concludes by discussing implications for climate ethics.

2 | Calls for Climate Leadership

Several climate ethicists have called for leadership and, while their work is valuable in many respects, we claim that their proposals have not adequately explained how mitigation by some would make others more likely to follow. Of course, a person may have a moral obligation to mitigate even when doing so has no influence upon others, say by eating less meat or biking to work. But we take *leadership* to refer to actions that promote a collective aim while increasing the probability that a sufficient number of others will come on board to achieve it. Thus, arguing that there is an obligation to *lead*, rather than simply to act regardless of what others do, requires some explanation of a pertinent follow-the-leader mechanism.[1]

Shue's discussion of climate leadership emphasizes an impasse arising from the bargaining positions of wealthy and less wealthy countries on mitigation (2011, 17). Less wealthy countries refuse to act if wealthier countries do not assist them in doing so, while wealthier countries refuse to provide assistance if the less wealthy countries do not take action; the end result is inaction by everyone (2011, 22). As Shue sees it, this bargaining is not done in the spirit of fairness, at least as far as the United States (and similarly positioned countries) are concerned. These wealthy countries are failing their minimum obligations—in particular, the obligation "to do at least one's own fair share, irrespective of whether one should ever do more than one's fair share to compensate for the noncompliance of others" (2011, 23). The refusal to do anything until a comprehensive decision is reached is, according to Shue, what results in a stalemate. Shue argues that leadership is required to initiate sufficient mitigation. Well-positioned countries should act first, and appeal to conditions of fairness later, changing the "after you" script to "I went first, so now you" (2011, 23). Thus, Shue suggests that wealthier countries should lead by reducing their own emissions and by providing financial support for mitigation to lower-income countries.

Vanderheiden (2012a, 2012b) further develops Shue's arguments in a pair of articles. Vanderheiden discusses conditions that underlie effective leadership, especially moral authority, which he characterizes as the ability to persuade reluctant parties to contribute to a fair solution for achieving a collective goal (2012b, 467–478). He suggests that establishing moral authority often depends on prior demonstrations of moral courage, such as being the first to contribute to a collective good even when it is uncertain whether sufficient cooperation from others will be forthcoming. Vanderheiden also recommends an international climate treaty centered on conditional mitigation commitments (2012a, 80–81).

Maltais claims that the urgent need for action creates an obligation for economically powerful states to take unilateral action on climate change, even if this means doing more than their fair share and there is no assurance that other states will reciprocate (2014, 618). Such leadership, Maltais argues, should be pursued in order to create conditions in which an equitable international agreement on climate change mitigation will be easier to achieve. Moreover, Maltais suggests a mechanism that is not discussed by either Shue or Vanderheiden. According to Maltais, "Developing, demonstrating and deploying low-carbon technologies and infrastructures on commercial and societal scales clearly sets the stage for others to do the same" (2014, 623). This suggests that climate leadership will reduce economic and technological barriers to mitigation thereby making a binding international climate treaty a more realistic possibility.

While we support calls for climate leadership, we also think the work described above has not provided an adequate explanation of how leadership by some would significantly increase the probability that others mitigate, too. The literature above suggests three types of mechanisms: (1) a moral example that inspires others to act, (2) an international agreement involving conditional mitigation commitments, and (3) climate leadership that reduces economic and technological barriers to mitigation.[2]

The first mechanism proposes that a moral example by an influential actor will cause others to follow. Shue seems to have this idea in mind when he writes, "We need one state to break the paralysis by unilaterally (if necessary) taking action in the hope that the others will respond to its example" (2011, 23). Vanderheiden's emphasis on leadership grounded in moral authority earned from deeds that exhibit moral courage expresses the same idea. While helpful, this suggestion is insufficient. If there are strong barriers to mitigation, like political opposition from vested fossil fuel interests and upfront economic costs, then merely setting an inspiring moral example may do little to move others to action. Climate leadership by moral example is also vulnerable to political polarization, in which action on climate change becomes associated with one side of a heated ideological divide (Brulle 2020; Fiorino 2022). Given polarization, climate leaders are unlikely to sway opinion among people whose political identity is linked to opposing action on climate change.

Turn, then, to the mechanism involving conditional commitments. Shue might be read as suggesting that lower-income countries have implicitly made conditional pledges to mitigate. However, such an assumption would be problematic. "You must go first" does not necessarily mean "I will follow if you do." After you go first, I might continue to produce reasons for my inaction. Vanderheiden recognizes this difficulty and proposes that world leaders seek an international treaty wherein each party commits to mitigate provided that a sufficient number of other countries have signed on (2012b, 475). However, Vanderheiden's proposal fails to confront the difficulty that motivated calls for leadership in the first place, namely, the inability to achieve a broad international treaty committing its parties to mitigate climate change. Consider the 2015 Paris Agreement, which at the time of writing is the most prominent and ambitious international climate treaty in force. The Paris Agreement aims to keep mean global heating well below 2°C and requires parties to formulate nationally determined contributions (NDCs) to this end. But the Paris Agreement does not require that the sum of NDCs be sufficient for the aim and, while the agreement creates reporting requirements relating to NDCs, their implementation is voluntary. The Paris Agreement might be seen as aiming to create a framework where unilateral mitigation increases the likelihood of mitigation by others. But this still requires a mechanism for that leadership effect, which remains to be explained.

Finally, consider Maltais' suggestion that leadership in the large-scale implementation of renewable energy will lower technological and economic obstacles to mitigation and consequently make an enforceable international climate treaty more likely. We regard this as the most promising of the three mechanisms. Yet Maltais does not elaborate it in any detail. For instance, he provides no discussion of scientific literature on the diffusion of renewable energy technologies. This is no trivial concern as there are well-known examples of policies to promote the transition to low-carbon technologies that failed to meet their targets, such as California's 1990 mandate that 5% of cars sold in the state by 2001 be zero-emission vehicles (Breetz, Mildenberger, and Stokes 2018, 506). Furthermore, some economists have developed models according to which unilateral mitigation reduces incentives for others to mitigate and may increase net emissions (Auerswald, Konrad, and Thum 2017, 269–287; Hoel 1991, 55). An argument for climate leadership founded on the idea that it will spur the diffusion of renewable energy technologies, therefore, must provide answers to challenges like these.

Shue, Vanderheiden, and Maltais, therefore, have not adequately explained why unilateral mitigation would increase the probability that others would follow. Yet arguments for a moral obligation to take leadership, rather than to simply act in isolation, should be supported by some reason to expect that action by the leader would increase the probability of sufficient action by others to achieve the goal. For convenience, we use the phrase *follow-the-leader mechanism* to refer to causal chains that have this effect, with the caveat that actions taken by others need not be of the same form as those taken by the leader. Mitigation can be pursued in a number of different ways, including transitioning to renewable energy, refraining from extracting fossil fuel reserves, and enhancing carbon sinks. So, let us consider when leadership is morally obligatory and whether there are plausible follow-the-leader mechanisms associated with unilateral mitigation.

3 | Strengthening the Case for Climate Leadership

In this section, we advance a strengthened argument for a moral obligation to undertake climate leadership by means of unilateral mitigation. In Section 3.1, we present three conditions for a moral obligation to take climate leadership, one of which is the existence of a plausible follow-the-leader mechanism. In Section 3.2, we propose that three self-reinforcing mechanisms—which we discuss under the broad heading of "technology diffusion"—are all potential follow-the-leader mechanisms underlying a moral obligation for climate leadership. We explain how technology diffusion often depends on government support early on and beating back political opposition from incumbent interests once underway. And in Section 3.3, we explain how an economic argument against unilateral mitigation relies on assumptions that are clearly false of the diffusion of renewable energy technologies.

3.1 | Moral Obligations to Lead

When does an agent—whether it be an individual, government, or other type of actor—have an obligation to take leadership on mitigating climate change? We propose three conditions relevant to answering this question. These conditions can be satisfied to a greater or lesser extent, and when all are satisfied to a high degree, we believe that this indicates a moral obligation to lead. An obligation to undertake climate leadership exists to the extent that an agent has an available act that:

1. Reduces greenhouse gas emissions or enhances their sinks.
2. Is linked to a plausible follow-the-leader mechanism that would reduce the probability of catastrophic climate impacts.
3. Does not incur severe countervailing costs.

The first condition simply means that it is *possible* for the agent to mitigate. Clearly, some agents have greater capacity to reduce emissions than others. For example, the government of the United States can do much more to mitigate climate change than the island micro-state of Tuvalu. Similarly, some individuals may have much greater capacity to mitigate climate change than others. Other things being equal, the greater the agent's capacity to mitigate, the stronger their obligation to take leadership.

The second condition is important because preventing climate catastrophe requires mitigation by multiple countries across the globe. Moreover, we take it to be clear that climate change poses catastrophic risks (Beard et al. 2021; Kemp et al. 2022; Steel, Tyler DesRoches, and Mintz-Woo 2022). Examples of catastrophic climate risks include the disintegration of the Greenland or West Antarctic ice sheets and destruction of the Amazon rainforest, which pose a widespread threat to survival of humans and other species (McKay et al. 2022; Lenton et al. 2019, 592–595). Another point of reference is the concept of planetary boundaries—the environmental limits within which humanity can safely operate (Rockström et al. 2009; Steffen et al. 2015). In this context, a plausible follow-the-leader mechanism is a credible causal mechanism whereby unilateral mitigation makes it more likely that a sufficient number of others will join in to prevent catastrophic climate impacts.

Similar to the first consideration, agents often differ significantly in their ability to stimulate or accelerate a plausible follow-the-leader mechanism, and governments that regulate larger economies often have a greater potential to bring others along behind them. For example, if governments of the world's three largest automobile markets—China, the United States, and the European Union—each decided to prohibit the sale of new internal combustion engine vehicles after 2035, then major auto manufacturers everywhere would have little choice but to shift production accordingly (Sharpe 2023, 248–281). That in turn would significantly limit the availability of internal combustion vehicles in all auto markets, no matter the preferences of other governments and individual drivers. In contrast, Norway's decision to phase out the sale of new internal combustion engine vehicles by 2025, while important, would be unlikely to have as large an impact on global auto production. Again, other things being equal, the greater an agent's capacity to stimulate a follow-the-leader mechanism, the stronger their obligation to lead.

Finally, *severe countervailing costs* include adverse economic, social, or environmental impacts resulting from mitigation efforts. The severity of cost associated with mitigation is often linked to wealth: major investments required to transition from fossil fuels, such as expanding and modernizing electricity grids, are more easily borne by wealthier countries. Indeed, one leadership obligation for wealthy countries is to provide financing for renewable energy infrastructure in lower-income countries. Justice concerns, for instance related to mining minerals needed for renewable technologies, are also relevant to the severity of costs. For example, a transition to renewable energy should not be pursued in a manner that tramples rights of Indigenous Peoples.

Other considerations besides the three we have discussed, such as an agent's past emissions, may be relevant to obligations for climate leadership. However, we limit our attention here to the three above because they are most directly tied to the follow-the-leader mechanisms we discuss in Section 3.2, which emphasize self-reinforcing mechanisms whereby mitigation by some can make mitigation more directly beneficial for others. Moreover, we think that past emissions often coincide with the three conditions for leadership articulated above, since those conditions are often most strongly fulfilled by countries whose current wealth is tied to a history of significant fossil fuel use.

Taken together, our three conditions suggest that agents who can reduce emissions at relatively low cost and whose actions are likely to increase the probability of further mitigation by others have a strong moral obligation to take the lead on mitigation. If there is more than one such action available, our argument aims only to establish that one act of leadership should be taken. However, even an agent who is already showing leadership on mitigation should compare the effectiveness of their existing actions to new alternatives as they become available (Tank and Baatz 2023).

This situation suggests a straightforward consequentialist argument for a moral obligation for leadership for agents that can, with modest or even negative cost, significantly reduce emissions and increase the probability of emissions reductions by others. Several researchers find that net costs of mitigation are often very low due to co-benefits like reduced air pollution (Shindell and Smith 2019, 408; Karlsson, Alfredsson, and Westling 2020, 292–316). Falling prices of renewables can also reduce costs of mitigation. For example, Jacobson et al. estimate the payback times for a complete transition from fossil fuels to wind, water, and solar energy by 2050 for 145 countries, and find that mean payback times on renewable energy investment from energy costs savings alone (i.e., not counting health and environmental benefits) is 5.5 years (2022, 3343). This suggests that, for many countries, net economic costs of aggressive mitigation are not merely low but are in fact negative in the relatively near term. If a government has substantial capacity to mitigate and increase the probability of mitigation by others, then low mitigation costs generate a strong moral obligation for it to take climate leadership.

When upfront costs of mitigation are not low, a consequentialist argument for leadership based on our three conditions might be inconclusive due to uncertainty about the follow the leader mechanism. In such circumstances, arguments for an obligation for leadership might be supported by the precautionary principle (PP). Here we underscore the reference to *catastrophic* climate impacts in our second condition. In general, PP recommends taking precautionary measures that prevent a catastrophic outcome, provided there is credible evidence that the catastrophe may occur (Hartzell-Nichols 2017; McKinnon 2009, 190; Resnik 2022, 111). Some formulations incorporate the requirement that the precautionary measures should be proportionate to the plausibility and severity of the threat (Steel 2015, 197). This entails that the recommended measures should not themselves produce unduly harmful, let alone catastrophic, consequences. Our three conditions, therefore, support a precautionary argument for climate leadership. Roughly, if the costs of an act of leadership are not overly high, and there is a plausible mechanism whereby that act could reduce the likelihood of a catastrophic outcome, then the act of leadership is mandated on precautionary grounds. Where more than one possible act of leadership is available, PP mandates the option perceived to be most effective in reducing the probability of catastrophe. While precautionary arguments for climate leadership are less sensitive to uncertainty about follow-the-leader mechanisms than consequentialist arguments, they agree that the strength of obligation to lead can vary according to the extent to which the three conditions are satisfied.

Arguing for an obligation for climate leadership, then, requires some account of the mechanisms that might produce follow-the-leader effects. We now consider what those mechanisms might be.

3.2 | Technology Diffusion and the Energy Transition

Since the majority of greenhouse gas emissions stem from burning fossil fuels like coal, oil and gas, a transition to renewable energy lies at the heart of mitigation. In this subsection, we claim that three self-reinforcing processes of technology diffusion, in which uptake of a new technology by some increases the probability of uptake by others, provide a basis for follow-the-leader mechanisms relevant to climate leadership. These three self-reinforcing processes are price, product performance, and policy diffusion. We explain how each of these processes is self-reinforcing in the sense that one agent's action reduces costs of similar actions by others. The agents we consider are collective actors like governments and advocacy groups, while costs are interpreted broadly to include such things as monetary expenses, safety risks, and failed policy initiatives.

Technology diffusion is the adoption of a technology by a population over time. According to diffusion of innovations theory (Rogers 1962), adoption of a new technology often yields the classic S-shaped curve: slow at first, faster in the middle, and slowing down again as the technology reaches market saturation. For example, photovoltaic electricity generation increased slowly from 2000 to 2010 but accelerated dramatically in the following decade, suggesting that solar power is currently approaching the midsection of the S-shaped curve (Nemet 2019). But it would be a mistake to view technology diffusion solely as a techno-economic process. Major shifts in technology usually evolve with new government policies and broader social and legal changes, something that is especially true of energy transitions (Newell 2021).

The first self-reinforcing mechanism related to climate leadership arises from the “experience curve,” in which prices decline as production increases. These price reductions can result from increased workforce experience, streamlined production methods, economies of scale, and the development of complementary technologies that make production more efficient (Breetz, Mildenberger, and Stokes 2018, 496; Wagner 2014). For example, due to technology diffusion and production increases involving the United States, Germany, and China among other countries, photovoltaic solar electricity generation has become more than 10,000 times cheaper since the mid-1950s (Elshurafa et al. 2018, 122; Nemet 2019; Yu, van Sark, and Alsema 2011, 324). Moreover, these falling prices have coincided with steep and persistent increases in the rates of newly installed solar capacity (Al-Shetwi 2022). The experience curve suggests a feedback mechanism: since production responds to demand, increased adoption of the new technology can stimulate production and investment, resulting in reduced prices and increased incentives for further uptake (Kemp and Volpi 2008). Policies that promote adoption of renewable energy technologies through mandates, subsidies or institutional arrangements like net energy metering (which allows consumers to sell home-generated solar power back to the grid) consequently have the potential to accelerate this feedback loop (Sharpe and Lenton 2021, 422). Similar processes can also operate for fossil fuel technologies, however. For example, the experience curve and associated reductions in price have also been documented in connection with hydraulic fracturing, which like photovoltaic solar had existed for many years but only became commercially attractive due to innovations prompted by government subsidies (Counts and Block 2016, 933–941; Fukui et al. 2017, 263).

Like price, improved performance of new technologies is also a typical feature of technology diffusion that occurs with increased production volume (Grübler, Nakićenović, and Victor 1999, 250; Wagner 2014, 48). Performance is an important determinant of uptake of a novel technology. For instance, in the case of lithium-ion batteries for grid-scale energy storage, consumers and utility companies may have concerns about safety, longevity, and reliability. Moreover, there is a plausible feedback mechanism centered on investment whereby rising demand for the new technology can stimulate improved product performance by increasing incentives for investment in the novel technology while drawing investment away from the incumbent (Barrett 2021, 7; Sharpe and Lenton 2021, 421). Improved product performance is often linked to the development and implementation of complementary technologies and infrastructure, a point illustrated by utility-scale electricity storage and charging networks for electric vehicles (Geels et al. 2017, 473). Policies that promote uptake of the new technology or support the development of complementary technologies or infrastructure can therefore result in improved performance, which stimulates further uptake, and so on. Again, similar product performance mechanisms operate for fossil fuels: co-technologies like jet engines, and their improvement over time, make fossil fuels more useful as do public investments in supporting infrastructure, such as highways, airports, and pipelines.

The third self-reinforcing mechanism we consider is policy diffusion. There is now an active literature exploring factors that make countries more or less likely to adopt renewable energy policies of other countries (Baldwin, Carley, and Nicholson-Crotty 2019; Zhou et al. 2019). We interpret policy diffusion broadly to cover influence among strategies pursued by non-governmental organizations, such as environmental groups. For example, lawsuits against governments whose policies or approved fossil fuel projects conflict with their officially stated climate commitments are a recent trend in climate litigation (Peel and Osofsky 2020; Setzer et al. 2021). The Bay du Nord case, discussed below, is an example of this pattern. Policy diffusion can be self-reinforcing in at least two ways. First, a successful policy in one place can act as a template for similar policies elsewhere, thus reducing costs of policy development. Second, the precedent set by a successful policy improves the chances that similar initiatives will be adopted. This reduces the risk of failure, and hence of costs associated with resources being devoted to a policy that is ultimately rejected. As for the other two mechanisms, policy diffusion can also operate on the side of fossil fuels, as policies aimed at supporting fossil fuel extraction, such as hydraulic fracturing projects, can also be imitated (Millar 2021, 50).

To recap, we have described three mechanisms whereby unilateral mitigation by some can increase the probability of further mitigation by others: *price* (increased uptake reduces prices, incentivizing further uptake), *performance* (increased uptake leads to performance improvement, incentivizing further uptake), and *policy diffusion* (uptake of policies reduces costs of policy development and risks of failure, leading to further uptake). These three mechanisms should be viewed as interacting, rather than as working in isolation from one another. Thus, a successful policy aimed at expanding wind and solar power might exert effects through all three mechanisms: price, product improvement, and policy diffusion. While these mechanisms provide some basis for optimism about increased uptake of renewable energy, they also face several complexities in practice. One complication is that the effectiveness of a renewable energy policy often depends on the technical, economic, and political context, while a second is that successful climate change mitigation requires not merely that renewable energy technologies diffuse but that they supplant fossil fuels.

Consider technical, economic, and political contexts. Breetz et al. argue that different policies are more likely to be effective at different points along the experience curve. They distinguish three stages of the experience curve: top, middle, and bottom (Breetz, Mildenberger, and Stokes 2018, 499). At the top, the new technology is in its early development phase, is significantly more expensive than the incumbent, and faces serious performance limitations. In the middle, the new technology is approaching the incumbent in terms of performance and cost, but still has not caught up in one or both of these categories. Finally, at the bottom of the curve, the new technology matches or exceeds its predecessor in performance at a lower cost. These distinctions suggest ways that efforts to promote renewable energy technologies can fail to achieve their objectives. Policies might jump the gun by mandating use of the new technology when it is still near the top of the experience curve. In addition, reactionary policies promoted by political constituencies tied to the incumbent technology may obstruct the transition. Fossil fuel corporations are unlikely to sit idly by as renewable energy technologies threaten their markets. They have strong incentives to promote subsidies for the fossil fuel industry and policies that obstruct implementation of renewables, for instance, by supporting politicians and political parties that advocate these positions (Darian-Smith 2022, 403; Jacobsson and Lauber 2006, 256). Reactionary politics of this sort are likely to become more intense in the middle and bottom of the experience curve, when the novel technology becomes a serious threat to the incumbent. The emergence of political constituencies to support the new technology, therefore, play an important role in counteracting reactionary policies supported by vested interests of the incumbent.

Consequently, Breetz et al. recommend different policies according to the location of the new technology on the experience curve. At the top of the curve, policies should focus on funding for research and development along with subsidies for implementation in niche markets. In the middle, market carve-outs supported by subsidies can move the new technology into the mainstream, but here it is important to accompany these with support for complementary technologies and infrastructure, like utility-scale electricity storage and an expanded electrical grid. Moreover, it is important to cultivate constituencies that can provide political support for the new technology, including renewable energy companies, workers, and consumers. At the bottom of the experience curve, economics is on the side of the new technology, which no longer needs support by subsidies. But its diffusion can still be delayed by policies promoted by incumbent technology interests.

Let us turn, then, to the second complication, namely, that achieving climate goals requires not only that renewable energy technologies diffuse but also that they (almost) entirely replace fossil fuels within the next 30–50 years. One challenge to this transition arises from the fact that diffusion mechanisms can operate for fossil fuels as well as renewable energy: innovations may reduce costs of fossil fuel production and improve their performance, while reactionary policies and litigation pursued by fossil fuel interests can be imitated. As noted above, government support and technical innovations played an important role in the hydraulic fracturing boom of the 2000s (Counts and Block 2016, 933–941; Fukui et al. 2017, 263). A similar future scenario—for instance, involving new technologies and government subsidies that reduce costs of deep-sea oil drilling—would clearly not be a positive from the perspective of climate change. Consequently, actions that thwart the development of innovations related to fossil fuel technologies are crucial to the energy transition. The costs and performance of renewables in absolute terms are less important to the transition than their *relative* costs and performance in comparison to fossil fuels.

Since the three self-reinforcing mechanisms can operate for both fossil fuel related technologies and renewables, the energy transition should be understood as a competition between renewables and fossil fuels (Sharpe and Lenton 2021, 424).[3] In this competition, vested fossil fuel interests possess political and economic incumbent advantages that can be exerted to obstruct the transition. However, cost reductions from innovations are permanent for renewables, while economic gains from technical advances in fossil fuel extraction, like hydraulic fracturing, ultimately diminish as reserves are exhausted (Way et al. 2022). This difference means that renewables, but *not* fossil fuels, enjoy long-term price reductions as a result of the experience curve. Despite enormous technical innovations in fossil fuel extraction in the past 140 years, prices of fossil fuels show no downward trend over that period (Way et al. 2022). In contrast, costs of solar, wind, and batteries have demonstrated decades-long price declines of approximately 10% per year (Way et al. 2022). Since energy costs are something that virtually everyone cares about, regardless of culture or political persuasion, this suggests that price will emerge as a persistent asymmetry favoring renewables over fossil fuels in the 21st century. Accentuating this advantage should be a major goal of climate mitigation policy.

But could technology diffusion spurred by a few major actors significantly reduce the risks of catastrophic climate impacts? An analysis by Barrett (2021) suggests that the answer to this question is *yes*. Barrett uses a multi-region integrated assessment model to examine a scenario in which OECD Europe and China but no other countries implement a policy of net zero by 2050, a scenario chosen not for realism but simply to explore the question of whether diffusion effects make a substantial difference to mean global warming. Barrett considers this scenario both with and without international technology diffusion spillover effects, finding that global mean temperature peaks below a 3°C increase in the spillover condition, compared to around 7°C with no technology diffusion. The specific scenario and numerical results of Barrett's modeling exercise are less important than what it suggests about the qualitative significance of diffusion effects. As Barrett puts it, "the difference between the cases with and without international technological diffusion is qualitatively huge: the former is a future where the planet likely becomes uninhabitable towards the end of this century; the latter is one where climate change is painful but manageable" (2021, 3).

3.3 | Answering the Crowding Out Objection

Some economic models suggest that unilateral mitigation by one country creates an incentive for other countries to increase emissions and may result in higher emissions overall (Auerswald, Konrad, and Thum 2017; Hoel 1991, 55). This is commonly referred to as the *crowding out effect*, and it poses an obvious challenge to our argument. In this section, we explain why economic crowding out models are entirely unsuitable for representing technology diffusion.

Hoel provided the earliest discussion of the crowding out effect in relation to climate change, and we limit our attention to his analysis as subsequent work builds on his model while retaining its basic assumptions (Auerswald, Konrad, and Thum 2017). Hoel's model considers two countries, labeled 1 and 2, with emissions represented by the variables X_1 and X_2, respectively. Each country has a benefit function $B_i(X_1 + X_2)$, representing the global public good of climate protection. Hoel assumes that each country has a cost function $C_i(X_i)$ that depends only on its own decisions about emissions. For convenience, call this assumption *cost independence*. Finally, Hoel makes three assumptions about the shape of the benefit and cost functions: $B_i'' < 0$ (*decreasing marginal benefits*), $C_i' > 0$ (*increasing costs*), and $C_i'' > 0$ (*increasing marginal costs*). The first of these, decreasing marginal benefits, states that the greater the sum of the two countries' prior mitigation, the smaller the benefit from further mitigation.

Suppose, then, that country 1 has unilaterally increased its mitigation. Given decreasing marginal benefits, the benefit to country 2 of a further unit of mitigation is then reduced, yet by cost independence, the cost of mitigation for country 2 is unchanged. Thus, Hoel's model entails that unilateral mitigation by country 1 reduces country 2's incentive to mitigate. In fact, in a non-cooperative setting, it creates an incentive for country 2 to increase emissions. Given this starting point, Hoel considers various scenarios in which unilateral mitigation by one country increases or decreases the total amount of mitigation. On the basis of his analysis, Hoel concludes: "whatever good intentions lie behind a policy of unilateral emissions reductions, the consequences may differ from what one hoped and expected" (1991, 70).

However, if mitigation is largely a matter of an energy transition involving the diffusion of renewable energy and a phase out of fossil fuels, then the cost independence assumption of Hoel's model is untenable. As discussed in Section 3.2, the experience curve states that increased production of a new technology is associated with reduced cost. For example, prices of solar panels have fallen dramatically in the past two decades in stride with increased production. And since production responds to demand, this means unilateral mitigation in the form of transitioning from fossil fuel to solar electricity generation by one country can bring down costs of the transition for others. So, *cost interdependence* is a central feature of technology diffusion. Moreover, as discussed in Section 3.2, performance of new technologies typically improves with the quantity of production due to technological innovations and the appearance of co-technologies. Since Hoel's benefit function only counts climate effects, benefits from improved renewable energy technologies would also enter his model as reductions in cost.

Cost independence, then, is far removed from what has already been occurring in the diffusion of renewable energy. As such, a model founded on this assumption is of little use for understanding or predicting the consequences of unilateral mitigation. Not surprisingly, then, a recent study finds no evidence of the crowding out effect in connection with policies that promote renewable energy (Grafström and Poudineh 2023).

4 | Bay du Nord

Our argument in Section 3 suggests that governments of wealthy states often have an obligation to enact policies that promote the uptake of renewable energy, even without an international climate agreement binding other countries to do so as well. Such actions reduce greenhouse gas emissions and lower costs of renewables and policies that promote them, thus increasing the probability of mitigation by others. Upfront costs of such policies, furthermore, can be small compared to the budgets of wealthier nations, and can generate economic savings and other benefits within less than a decade (Jacobson et al. 2022). But our argument also emphasizes that the energy transition should be seen as a competition between renewables and fossil fuels, in which mechanisms supporting the diffusion of the former should be accelerated while those of the latter inhibited. This raises the question of whether there are also obligations to take leadership in opposing fossil fuel projects. In this section, we explore this idea by means of an example concerning deep sea oil drilling.

Bay du Nord is located within the Flemish Pass, a deep-water basin located off the coast of Canadian province Newfoundland and Labrador. Between 2013 and 2020, the Flemish Pass was discovered to be rich in oil, leading the Norway-based company Equinor to propose a drilling project there. Canada's Federal Minister of the Environment and Climate Change, Steven Guilbeault, approved the Bay du Nord project in April 2022 (CBC News 2022), a decision supported by the provincial government (Drummond and Lévesque 2021). However, the decision appears to contradict Canada's climate pledge to be a net-zero emitter by 2050. While the project is expected to bring in around $3.5bn CAD, it is also estimated to generate approximately 400 million tonnes of carbon over the lifetime of the project—the equivalent of the emissions produced by 100 coal factories in a year (Roberts 2024). While advocates predict the Bay du Nord project will be carbon-neutral by 2050 (Singh 2022), critics point out that the "net zero" categorization fails to account for the *downstream* emissions of the project, those 400 million tonnes (Ecojustice 2023).[4]

The Bay du Nord project has faced significant headwinds since its approval. In 2022, a lawsuit was filed against the project by a coalition of Indigenous First Nations and environmental groups (Ecojustice 2023), and in May 2023 Equinor announced that it would postpone the Bay du Nord project for 3 years (Nickel 2023). However, since then fortunes of the Bay du Nord project have improved somewhat. The lawsuit was dismissed in June 2023, a decision that is being appealed at the time of this writing (Ecojustice 2023). And in January 2024, Equinor announced that it was seeking partners to help it bring down development costs so that the project could restart (Roberts 2024).

Consider the obligations of the Canadian government in this example from the perspective our proposal. In Section 3.1, we argued that a moral obligation for leadership arises for agents who have an available act that satisfies the following conditions: (1) the act reduces greenhouse gas emissions or enhances their sinks, (2) is linked to a plausible follow-the-leader mechanism that would reduce the probability of catastrophic climate impacts, and (3) does not incur severe countervailing costs. Given this framework, we consider whether the Canadian government had an obligation not to approve the Bay du Nord project.

Refusal of the Bay du Nord project would have been mitigation insofar as reducing the total quantity of fossil fuels that can be extracted and burned. Less supply of oil would put an upward pressure on its price, thereby making alternative energy sources more attractive by comparison. Proponents of the Bay du Nord project counter that halting the project would simply transfer market share to a producer unconstrained by Canada's strict environmental regulations, thereby resulting in a net increase of emissions (King 2022). However, even if fossil fuel extraction in Canada had lower operations emissions than elsewhere, that would be of minor importance as operations emissions are negligible by comparison to downstream emissions, which are largely unavoidable. Spillover effects of not moving forward with fossil fuel projects like the Bay du Nord project are also an important component of mitigation (Barrett 2021). This takes us to our second condition for an obligation for leadership, namely, a follow-the-leader mechanism.

Follow-the-leader mechanisms are causal processes whereby action by some increases the probability of sufficient action by others to achieve a collective goal. The follow-the-leader mechanisms we have focused on are self-reinforcing processes in which actions taken by some reduce costs of similar actions for others. Section 3.2 discussed three such mechanisms related to the emergence of new technologies: price, performance, and policy diffusion. Since these mechanisms are general, they can operate for both renewable and fossil fuel related technologies. Consequently, reducing greenhouse gas emissions involves accelerating them for renewable energy while dampening them for fossil fuels. Consider these ideas in connection with the Bay du Nord example.

Begin by considering the price and product performance mechanisms. Investments in fossil fuel technologies can lead to innovations that lower prices, as illustrated by the boom of hydraulic fracturing in the past two decades (Fukui et al. 2017). Consequently, since the energy transition depends on the price and performance of renewables in comparison to fossil fuels, it can be accelerated by events that divert investment from the latter (Barrett 2021, 3; Otto et al. 2020, 2360). Sharpe and Lenton identify cheaper financing for renewables than fossil fuels as a key tipping point in the energy transition (2021, 427). And, according to Barrett, innovations that *do not happen* for fossil fuels due to diversion of investment are a crucial driver of the diffusion of renewable energy technologies and consequently of emissions reductions (2021, 3). Refusing to approve the Bay du Nord project would have signaled to investors that major fossil fuel extraction projects are risky due to regulatory challenges. That would make financing for these projects more difficult to secure, thereby improving the accessibility of renewable financing in comparison to fossil fuel financing.

Consider our third mechanism, policy diffusion. Suppose Canada's Minister of the Environment and Climate Change had decided that downstream emissions, not just operations emissions, must be considered when evaluating the environmental impact of the Bay du Nord project. Establishing this precedent in Canada's environmental regulatory system would create a challenge for new fossil fuel projects in Canada, which would be significant given Canada's status as a major exporting country. Given international diffusion of climate change policies, there is the potential for influence beyond Canada's borders (Baldwin, Carley, and Nicholson-Crotty 2019; Zhou et al. 2019). Like the price and product improvement mechanisms, policy diffusion involves a self-reinforcing mechanism where action by some reduces costs of similar actions by others. A precedent in the Bay du Nord case would provide a template for justifying similar decisions in the future, so that those making similar decisions in the future would not have to bear the costs of developing the policy from scratch. And at least within Canada, the precedent would increase the probability that such decisions would withstand legal challenges, thus reducing risks of failure.

Our third condition is that taking leadership does not incur severe countervailing costs. Rejecting the Bay du Nord project would cause Canada, and the province of Newfoundland and Labrador, to forgo royalties paid by Equinor, and would mean lost employment opportunities for inhabitants of Newfoundland. But Canada is among the top 10 global economies by GDP, calling into question whether these effects should be considered "severe" (World Bank 2021). In contrast, an argument that severe societal costs would result from foregoing fossil fuel revenues would be more plausible for lower income oil exporting countries, such as Guyana (Bhattacharya 2022). In addition, Newfoundland and Labrador has also begun investing in renewable energy (Newfoundland and Labrador Department of Industry, Energy and Technology 2021), while projects that produce high-cost oil risk becoming stranded assets due to decreasing oil demand as the energy transition progresses (IEA 2023). Indeed, the International Energy Agency (IEA 2023) forecasts that global oil demand will peak before 2030 given currently stated policies. Peak oil demand, therefore, might arrive before the Bay du Nord project begins producing oil. Opportunity costs to Canada from not approving the Bay du Nord project, then, appear manageable and a focus on investment in renewable energy may be the best economic path forward.

Finally, while the federal government of Canada arguably had a moral obligation not to approve the Bay du Nord project, it did so anyway. The lawsuit brought against the project therefore illustrates the importance of climate leadership by a diversity of actors. When national governments fail to follow through on climate commitments, leadership by individuals, non-governmental organizations, and others can play a crucial role (Ostrom 2012). The mechanisms discussed above—price, product improvement, and policy diffusion—interact in similar ways for climate lawsuits as for regulatory decisions made by governments.

5 | Conclusions

We have argued that the dynamics of technology diffusion, which encompass political, policy, and legal issues along with economic and technical matters, support a moral obligation to take climate leadership. The strength of this obligation can vary depending on the probability that an agent will influence others and on whether there are severe costs associated with acting. However, for many governments, organizations and individuals, a moral obligation for climate leadership exists.

Our argument suggests that achieving an enforceable international climate treaty at some future Conference of Parties to the United Nations Framework Convention on Climate Change is not the only game in town. Self-reinforcing mechanisms relating to the diffusion of renewable energy technology are another means by which mitigation may propagate across the globe. Of course, technology diffusion and international climate agreements are not mutually exclusive, and agreements may become easier to achieve as the renewable transition progresses. However, our arguments do suggest that ethical issues relating to unilateral actions that accelerate the energy transition, such as those surrounding just transition, are important and may be more fruitful than hand wringing over an international agreement that is unlikely to happen under current circumstances.

Author Contributions

Daniel Steel: conceptualization (lead), writing – original draft preparation, writing – review & editing. **Rachel Cripps:** conceptualization (supporting), writing – original draft preparation, writing – review & editing. **C. Tyler DesRoches:** conceptualization (supporting), writing – original draft preparation, writing – review & editing. **Paul Bartha:** conceptualization (supporting), writing – original draft preparation, writing – review & editing. **Kian Mintz-Woo:** conceptualization (supporting), writing – original draft preparation, writing – review & editing, compiled the manuscript as corresponding author.

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Endnotes

[1] For instance, in a recent book on the philosophy of leadership (Marturano 2024), "leadership" involves influencing others to act in such a way that they promote collective aims, but there is no discussion of it requiring understanding or endorsement of a mechanism which facilitates this influence.

[2] These three mechanisms fall under the categories of directional, instrumental, and structural leadership, respectively, distinguished by Gupta and Grubb (2011, 23).

[3] It is worth noting that the competition is not on a level playing field, since there are explicit and implicit subsidies for fossil fuels, especially since carbon externalities are not priced in by carbon prices (Mintz-Woo 2022; Mintz-Woo 2024).

[4] Downstream emissions are often called "Scope 3" emissions: neither those generated by an entity's own property (e.g., emissions generated in heating an office) ("Scope 1"), nor those that are generated by demand needed for production processes (e.g., emissions generated by oil burned elsewhere for electricity used in production) ("Scope 2"). Of course, when producing fossil fuels, the main emissions are from consumer combustion after the production or extraction processes are complete, which is why Scope 3 emissions are the bulk of emissions in the Bay du Nord case.

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