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The Voluntary Carbon Market: Managing the Private Provision of Public Goods

Atticus Maloney
Swarthmore College, cmalone1@swarthmore.edu

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Abstract

While much work has examined the large-scale compliance-based carbon offset programs associated with the Kyoto Protocol and Clean Development Mechanism, there has been far less focus on the voluntary purchasing of carbon offsets. This critical literature review will look at the formation and management of the demand for voluntary carbon offsets within the United States. It will frame carbon offsets as impure public goods and review possible explanations as to why private provision has been so active in the U.S. market. The paper will then survey the efficiency gains and other benefits associated with the voluntary market. It will highlight the informational asymmetries that undermine these benefits through moral hazard and adverse selection. To mitigate these concerns, it will examine the current regulatory environment for voluntary offsets and propose possible pathways to optimize the market through regulation in the future.

Keywords

Carbon Offsets, Public Economics, Moral Hazard, Public Goods, Environment

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The Voluntary Carbon Market: Managing the Private Provision of Public Goods - ***Atticus Maloney**, Swarthmore College*

Introduction: What Are Carbon Offsets?

The Intergovernmental Panel on Climate Change (IPCC) released a statement in 2018 that warned a "rapid and far-reaching" transition is needed by 2030 to limit the impact of climate change to 1.5 degrees Celsius and avoid pushing natural systems past a dangerous tipping point (Ahmed et al., 2020). To reach this goal it will be necessary for companies, organizations, and individuals, around the world to dramatically reduce their greenhouse gas (GHG) emissions. Yet, in the short term, some entities will be unable to meet their reduction goals while continuing to provide their product or service. Additionally, emissions reduction potential is not spread homogeneously among firms: some companies and organizations can reduce and sequester emissions much more cost effectively than others. Regardless of the origin of GHG emissions, they have an equal impact on the progression of climate change. Thus, to account for unavoidable short-term emissions, firms can pay to have their remaining emissions reduced or sequestered elsewhere. This action allows companies to more easily meet "carbon neutrality goals" and other green initiatives that respond consumer demand for climate action. Making payments to reduce or sequester emissions is called "carbon offsetting" with the equivalent of one ton of carbon dioxide (CO_2) emissions being referred to as a "carbon credit". The terms "carbon emissions" and "carbon offsets" often encompass other forms of GHGs such as methane (CH_4) and nitrous oxide (N_2O). These gases are given a "carbon equivalency" or quantity of CO_2 emissions that equal their warming potential. Carbon offset projects can take on a variety of forms including emissions capture, renewable energy investments, and nature-based sequestration (Seeberg-Elverfeldt, 2010).

Carbon offsetting was popularized by the Kyoto Protocol, an international attempt to save the climate through the commodification of carbon dioxide. This agreement established the Clean Development Mechanism (CDM), the world's largest compliance market for carbon credits. A compliance market creates demand for offsets via government enforced emissions caps while allowing these goals to be met through the purchase of

carbon credits. The United States refused to ratify the Kyoto Protocol and, as a result, compliance offsets do not play a large role in the domestic space. Instead, the majority of offsets traded in the United States go through the voluntary carbon offset market (Conte et al., 2010). Voluntary offsets differ from those for compliance purposes in that they are provided by companies without emissions caps or reduction targets. The majority of these credits are traded on a deal-by-deal basis in the unregulated over-the-counter (OTC) market (Corbera et al., 2009). This paper will focus specifically on the OTC market and refer to it by the general term: voluntary carbon market.

Offsetting the impacts of global climate change through carbon offsets can be characterized as the private provision of a public good, begging the question of why individuals and firms choose to participate in the voluntary market. This paper will outline several incentives, both on the individual and corporate level, that support this provision. While the compliance offset market is kept in line through strict guidelines and an extensive project approval process, the voluntary market faces no required regulations. This lack of oversight creates unique opportunities and challenges for offset purchasers and suppliers. One major opportunity is the financing of projects that support other sustainable development goals (such as poverty reduction or global health) besides emissions reductions referred to as "co-benefits." Many of these projects are unable to make it through the strict CDM approval process. One such example is agriculture and forestry-based offsets that are barred from the CDM yet are popular in the voluntary offset space due to their ample co-benefits. The reduced level of regulation in voluntary markets also exacerbates latent offsetting concerns that stem from an informational asymmetry between consumers and producers. To mitigate these concerns and take full advantage of the market's benefits, regulations are needed that ensure project quality while maintaining the freedoms that distinguish the voluntary market.

Carbon Offsets as a Public Good

Global climate change brings with it many adverse conditions that will negatively impact human wellbeing. The productive capacity of the land, livable ambient temperatures, and stable weather conditions will all be diminished through the progression of climate change. Each of these can be referred to as "public goods"

as they are both non-rival (one person's enjoyment of them does not diminish another person's ability to enjoy them) and non-excludable (it is nearly impossible to restrict one's access to these things). Reduction or offsetting emissions to mitigate climate change can provide greater levels of these goods to everyone. In this way, the mitigation of climate change is also a non-rival and non-excludable public good. Basic economic theory hypothesizes on the basis of the free rider problem that the private sector will tend to under-provide other public goods such as infrastructure or education (Gruber, 2019). In the case of climate change, the logic of the free rider problem suggests that since one company's enjoyment of favorable environmental conditions is not solely dependent on its own emissions offsetting, it will purchase fewer carbon credits than is socially optimal.

Compliance-based carbon markets make use of government regulation to correct for this under-provision. They build on the work of Ronald Coase whose theorem states when there are well-defined property rights and costless bargaining, negotiations between the party generating the externality (GHG emissions) and the party affected can bring about the socially optimal market quantity (Gruber, 2019). This idea of property rights informs the basis of cap-and-trade programs like those highly active in the European Union. Here a regulator will set an aggregate cap on the use of a public good (GHG emissions) and allocate property rights to companies so that the quantity of use is not exceeded. Under this system, firms that reduce their emissions more cost-effectively, can trade their property rights with less sustainable firms (Dormady et al., 2015). This trading scheme greatly lowers the overall regulatory cost relative to a flat mandate while meeting the same emissions reduction target (Gruber, 2019). The Kyoto Protocol goes beyond this localized version of cap-and-trade through the introduction of compliance carbon offsets. This policy allows institutions to source their offsets from approved projects globally, effectively extending the jurisdictional boundaries of cap-and-trade to the global scale. These compliance offsets further reduce the cost of meeting emissions reduction targets while providing funds for environmentally conscious projects worldwide. Due to the government incentive to purchase compliance offsets, the size of the voluntary market is far smaller in comparison. However, it is quite a bit larger than would be suggested by the traditional model for the private provision of a public good.

Private Provision of Carbon Offsets

The Kyoto Protocol and other policies have worked to overcome the free rider problem through the assignment of property rights. Yet, even in sectors without required emission reductions, the provision of climate change mitigation in the form of offsets is surprisingly high. A United Nations task force recently estimated that the voluntary market for carbon credits could be worth upward of $50 billion by 2030 (Blaufelder et al., 2021). This growth is fueled by the interest and investments of large corporations as demonstrated by the popularity of offsets among the 100 most capitalized companies on the UK stock exchange (Corbera et al., 2009). The observed level of offset consumption is surprising given a traditional understanding of public goods: if people can enjoy the benefits of pleasant environmental quality without purchasing offsets themselves, they should have little incentive to contribute and make these purchases. However, this free rider problem is reduced in the case of imperfect public goods that provide both public and private benefits.

The purchase of carbon offsets not only mitigates the level of global climate change but also provides significant personal benefits. Purchasing carbon offsets can provide people with a sense of joy and satisfaction for "doing their part" to advert the climate crisis. This emotional response is described as "warm glow" and can lead to greater provision of a public good than would be expected in the free market (Gruber, 2019). Voluntary carbon offset purchases are also associated strongly with the alleviation of guilt. The literature often compares the purchase of carbon offsets to indulgences that are paid to the church to account for one's sins (Kotchen, "Offsetting Green Guilt," 2009). Professor of economics at Yale School of the Environment, Matthew J. Kotchen, looks at the impact of guilt on individual consumption behavior. He envisions a model of private-public goods provision that accounts for individuals offsetting activities that hurt the available level of a public good. With the addition of this offsetting behavior, the model comes far closer to reflecting the empirical evidence on public goods provision in carbon offset markets (Kotchen, "Voluntary Provision of," 2009). These individual motivations for the purchase of carbon offsets compound at the firm level affect institutional purchasing decisions.

Beyond the personal drives of their employees, firms are also motivated to increase their level of voluntary offset consumption by strategic incentives. Notable companies such as IBM, Microsoft, Unilever, Coca-Cola, and Uber to name a few, have gone beyond cursory offset purchasing to commit to carbon neutrality. This "carbon norm" signifies that these companies are required to produce net zero GHG emissions. Firms meet this goal through a combination of emission reductions and the purchase of offsets. It seems to contradict basic microeconomic theory for a private firm to voluntarily impose restrictions on its operations to provide a greater level of a public good. Yet, companies are incentivized by the influence of their stakeholders and the benefits of strategic positioning to self-regulate their emissions. The growing trend of conscious consumption has led the biggest corporate stakeholder, the consumer, to more kindly view firms that take part in widely recognized environmental efforts such as carbon neutrality (Pinkse, 2013). As a result, corporations often see increases in stock prices and sales associated with commitment to climate initiatives. Other stakeholders, such as NGOs and government agencies also pressure corporations to further their movement towards sustainability (Pinkse, 2013). Long-term corporate strategy is supported via neutrality goals, allowing firms to differentiate their capabilities from competitors, adapt to rising energy prices, and profit from emissions trading (Corbera et al., 2009). Corporations that view sustainability as a future norm for their industry can take immediate action to establish leadership in environmental efforts moving forward.

Voluntary carbon offsets behave as an impure public good as there are many private reasons, both on the individual and corporate level, that encourage their consumption. As the market for this offset type is large and growing, it is necessary to ask whether or not the purchase of voluntary carbon offsets truly contributes to the sustainable development of planet earth.

Benefits of Voluntary Carbon Offsets

Voluntary Carbon Offsets not only reduce GHG emission levels but also provide multiple "co-benefits" that support the other sustainable development goals (SDGs) established by the United Nations. The lack of

regulation in the voluntary space lowers barrier to entry for projects, enabling greater innovation, efficiency, and the entrance of small-scale projects.

Meeting the quality standard for compliance-based offsets involves a lengthy five-step process with high transaction costs, especially for projects that break from the traditional structure. These bureaucratic constraints prevent many smaller projects from benefiting from the sale of their offsets in the compliance market. As a result, a survey of offset projects shows that the number of small-scale projects and their contribution to carbon credit volumes in the voluntary markets is far higher than in the compliance market. This is a considerable benefit of the voluntary market given that small-scale projects also generally provide better social and economic benefits than large ones (Corbera et al., 2009). The lower barrier to entry to the voluntary market also increases overall market efficiency (removing bureaucratic overhead) and reduces the price of offsets (voluntary offsets tend to sell for about 30% less than those approved by the CDM) (Conte et al., 2010). The latter point is essential to maintaining levels of private provision. Since corporations in the voluntary space are not required to purchase offsets, they likely have a high demand elasticity and be very responsive to changes in price. Even a small price increase could dramatically reduce voluntary offset consumption. Finally, lowering the barrier to entry for unconventional projects induces greater levels of innovation in the voluntary market, allowing it to adapt quickly to new technologies and novel offset methods (Lovell, 2010).

Compliance-based offset markets not only put projects through a lengthy approval process but also prevent certain project types from entering the market at all. Significantly, agriculture and forestry-based projects are not commonly accepted into the compliance market. The provision of this project type is a major benefit to the voluntary offset market as agricultural offsets are both low cost and provide multiple co-benefits. A 2019 report by the National Academies of Sciences, Engineering, and Medicine found that agricultural carbon sequestration was one of the most cost-effective means of reducing GHG emissions (U.S. Library of Congress, 2019). Many of the practices used to reduce emissions through agriculture also improve the well-being of the land and people involved in the process of food production.

Empirical studies have shown that agricultural and reforestation carbon offsets provide co-benefits that include improved soil, animal, and ecosystem health. Kurkalova et al. showed in their study on Iowa conversation tillage that paying farmers for reductions in carbon output also reduces nitrogen runoff, wind erosion, and water erosion[97] (González-Ramírez et al., 2012). Many of the methods used to reduce emissions on farms also provide benefits to the water, soil, and farm animals. Fertilizer and land-use changes not only reduce emissions and nitrogen leakage to waterways but also improve soil health. Improved animal health monitoring and illness prevention minimizes emissions from enteric fermentation and increases animal well-being (Ahmed et al., 2020). Agricultural carbon offsets not only mitigate climate change but also increase the sustainability of food systems by supporting the health of the land and animals involved in the food production process.

Another significant co-benefit of agricultural offsets is greater financial security to farmers. Out of 25 measures identified by McKinsey and Company as reducing total CO_2 emissions on the farm, 15 are cost-saving or cost-neutral for the farmer (Ahmed et al., 2020). These changes have primarily been constrained from implementation by capital constraints, limited technology access, and commitment to traditional farming practices. However, the provision of carbon credits can help to overcome these initial capital barriers and create the incentive necessary to cause farmers to take up these new practices. A study by Feng et al. shows that carbon offsetting provides immediate financial support to farmers through an income support benefit and pricing co-benefit. The first benefit is the improvement to financial stability from offset payments, reducing farmers' vulnerability to perennial price and weather shocks. The second pricing benefit comes from the additional revenue stream that carbon offsetting provides, allowing farmers to charge higher prices for agricultural commodities (Gonzalez-Remirez et al., 2012). The sale of agricultural carbon credits improves the financial security of farmers in both the short and long term, supporting the people most intimately involved in food production to generate the long term co-benefit of food system security.

[97] the full citation for the Kurkalova et al. piece cited by Gonzáles-Ramírez et al., 2012 is Kurkalova et al., 2004.

The voluntary carbon offsets market provides several unique benefits that cannot be found in the compliance market. These advantages stem from a flexible regulatory environment that lowers the barrier to entry for offset approval. Lower regulation increases efficiency through reduced administrative costs and allows for the permeation of innovative projects. It also provides a venue for projects, such as those in agriculture and forestry, that have been excluded from the compliance market. Agricultural projects provide a particular example of a low-cost project with many co-benefits that could not be traded outside the voluntary market. The lack of mandated regulation enables the voluntary market to provide offsets with a variety of additional benefits beyond GHG mitigation.

Limitations of The Voluntary Offset Market

While voluntary carbon offsets have enormous potential as a low-cost, innovative solution for climate change mitigation, they are subject to implementation challenges that can undermine their positive effects. These challenges stem from offsets being both intangible (there is no immediate physical result of your purchase) and reductive (where payments are made to reduce a certain activity). Both qualities exacerbate the informational asymmetry between offset producers and consumers: the supplier knows far more about the quality of the offset project than the purchaser does. As in insurance markets, this asymmetry leads to market failures that can undermine the offset's overall environmental impact.

Additionality

The central talking point in the debate over carbon offset regulation is additionality. To be specific, additionality is an emissions reduction or sequestration that results in a lower level of net greenhouse gas emissions or atmospheric concentration than would occur in the absence of an offset project (Bushnell, 2011). This complex definition begs the simple question: Does the added revenue from selling greenhouse gas credits enable a project's implementation or does it just line the pockets of someone who would have implemented the project anyway? In practice, additionality is observed by comparing the impact of reduction activities to a baseline

emissions level. This is a difficult challenge in any carbon market given that baseline measurement is the product of a ‘what if’ exercise.

The problem of additionality is effectively illustrated by the example of the farmer who can sequester carbon in her land via no-till operations (the process of tilling releases CO_2 stored in the soil). For the farmer to generate credible offsets, these no-till operations must be induced solely by the potential financial gain from the offset market. If no-till farming was part of normal operations before a gain could be made by offsetting, then the project would fail the additionality test. Many farmers that have been using this novel technique for years have just recently started receiving offset compensation. This is a straightforward instance of a non-additional offset. The example above highlights the complexity of judging whether an offset is additional. This process is difficult enough in the compliance market and is exacerbated by the flexibility of regulation in the voluntary space. The voluntary market lacks a common credible procedure to compare and select emissions reduction projects, making it difficult for the consumer to deduce project quality and rule out non-additional projects. The offset literature often blindly focuses on additionality without examining the mechanisms that contribute to a non-additional project. As in insurance markets, informational asymmetry in the carbon market creates problems of moral hazard and adverse selection. Together, these mechanisms account for the uncertainty surrounding project additionality in the voluntary offset market.

Moral Hazard

Moral hazard is the threat of detrimental behavior inspired by informational asymmetry and flexible regulation of the voluntary offset market. Emission baselines are often the private information of offset suppliers and can also be readily influenced by those suppliers. These firms face an adverse incentive to actively invest in high carbon sources only to reduce those investments in exchange for offset payments. An example of this occurred with compliance market payments for the mitigation of HFC-23 emissions. These payments were large enough that their value exceeded that of the product whose production emitted HFC-23. As a result, firms expanded and maintained production to capture more HFC-23 and qualify for the payments (Bushnell, 2011).

Moral hazard is intensified by the low level of regulation in the voluntary carbon offset market. Due to the lack of a centralized monitoring agency, projects rely on multiple third-party regulators with heterogeneous standards for approval. There is no legal regulation for the enforcement of contracts, enabling two parties to sell the same reduction or a single party to sell a reduction to multiple buyers (Gillenwater et al., 2007). This, combined with inconsistent project monitoring methods, contributes to hesitancy about the *permanence* of a voluntary carbon offset. Permanence is defined by the CDM as the length of carbon storage provided by the offset and the risk of releasing that carbon back into the atmosphere (Seeberg-Elverfeldlt, 2010). For example, if a farmer that uses no-till techniques to sequester carbon in the soil reverts to old practices, all that stored carbon will be released and contribute to warming levels. This is a threat for voluntary offsets because unstable contracts and lack of consistent monitoring leave few barriers to prevent offset suppliers from reverting to baseline emissions. Inconsistent standards, monitoring, and enforcement in the voluntary offset market make it vulnerable to the impacts of moral hazard.

Adverse Selection

Adverse selection is the danger that offset projects providing less environmental benefit face a greater incentive to join the market. This can be seen in the case of providers whose true emissions baselines are lower than regulators estimate. They essentially earn a "free lunch" by joining the offset market, getting an extra paycheck for their business-as-usual (BAU) operations. Another example of adverse selection is the supply of voluntary offset projects that involve *leakage*. Leakage is defined by the CDM as the unplanned and indirect GHG emissions from project activities (Seeberg-Elverfeldlt, 2010). If an offset supplier can easily lower the emissions of one part of her operations by increasing the emissions of another part, she may be motivated to sell offsets for the first operational change. In both these scenarios, offset money is spent to incite behavior that does not decrease atmospheric GHG concentrations on net. These examples demonstrate that the provision of a less additional offset often provides greater rewards to the offset supplier. In the first case, the supplier makes no changes to BAU operations and can earn an extra paycheck. In the second case, instead of making fundamental changes to her operations, the offset supplier simply shifts emissions from one part of the production to another. Compared to

offsets that provide real additional decreases to atmospheric GHG concentrations, these low-quality offsets incur far fewer costs on their suppliers. The cost-benefit ratio of low-quality offset projects could create a perverse incentive leading to a high proliferation of these projects on the voluntary market. This danger is heightened by the voluntary market often acting as a "backup option" for projects that cannot qualify for compliance markets such as the CDM. Lacking the regulation to offset adverse selection, the voluntary market is exposed to a growing proliferation of low-quality offsets that may not result in real emissions reductions.

As both intangible and subtractive goods, carbon offsets create a high degree of informational asymmetry between producers and consumers. The offset supplier faces numerous perverse incentives, supported by this asymmetry, to produce low-quality and non-additional offsets. Through a strict project approval process, compliance markets like the CDM attempt to reduce the dangers resulting from this asymmetry. Facing little to no regulation in the voluntary offsets market, these concerns of adverse selection and moral hazard can run rampant. They call into question the additionality of offsets purchased on the market, making it clear that government regulation is necessary to ensure offset quality.

Approaching Regulations

The potential limitations of voluntary carbon offsets present a significant market failure that requires government regulation to increase efficiency. A market failure results from problems that cause a market economy to deliver an outcome that does not maximize efficiency (Gruber, 2019). One classic market failure is that of a negative externality. The current operations of the voluntary carbon market present a severe negative externality in the form of reduced environmental quality. Neither the suppliers nor the purchasers of low-quality voluntary offsets feel the immediate negative impacts of the transaction, instead, the global population feels its indirect effects in the form of aggravated climate change. The regulations to correct this externality will need to strike a balance between the strict project review process of the CDM and the current laissez-faire nature of the voluntary market. It will be essential to consider the benefits that result from this market flexibility as well as understand the private market context in which these regulations will be established. In general, three key strategies can be

used to reduce the fear of non-additionality while maintaining freedoms in the voluntary offset market: programmatic review of offsets, market consolidation, and overestimation using a government-defined carbon norm.

The voluntary offset market suffers not from a lack of regulation, but a lack of standardized regulation that prioritizes the reduction of GHG emissions. Over 98% of voluntary offsets were verified by some third-party standard in 2015 ("VCS Again Voted", 2016). Yet, the voluntary market makes use of over 17 different standards for project certification each with its own protocols and approval process. The most popular standards include the Climate Action Reserve (CAR), American Carbon Registry (ACR), Verified Carbon Standard (VCS), and Gold Standard (GS). Of these standards, the VCS is the most prominent, claiming nearly 50% of the total market share (Lovell, 2010). The VCS and other third-party offset standards work to strike the balance between flexibility and additionality in the market. They are trusted by many companies and, as a result, attempts to impose government regulations on the voluntary space will need to take these regulators into account. This was a lesson learned by the UK government in 2009 when they established a centralized accreditation program for voluntary offsets that would only certify those approved by the CDM market. Offset suppliers simply bypassed the government accreditation completely as the leading voluntary standards of VCS and GS were excluded. This regulation aimed to be too strict, robbing the voluntary market of its freedoms by imposing the same standards applied to compliance offsets. It demonstrated that the UK government was out of touch with the voluntary offset space and showed the importance of considering existing market players when imposing new regulations (Lovell, 2010). It will be essential to build from the self-regulatory methods currently established in the voluntary market when creating policy solutions.

Programmatic Review

While keeping in mind the current standards that have been self-imposed by the voluntary market, there are a few ways that policy can centralize regulation to reduce concerns in the voluntary offset space. The CDM makes use of a review process to estimate baselines that has been criticized as too onerous and inadequate in

weeding out non-additional projects (Bushnell, 2011). One way to mitigate the resources spent on baseline estimation is grouping offsets by sector and undertaking a programmatic review of projects. According to Bushnell, if the baseline emissions of offset suppliers in a given sector are highly correlated, a regulator can estimate what emissions should be under a BAU scenario (Bushnell, 2011). If firms can reduce or sequester emissions to move below that level, they are awarded payments for their offsets. While there will be suppliers that receive payment despite already being under the offset cutoff, Bushnell calls this type of adverse selection "coincidental" and dismisses its negative impact as these firms' lower emissions still mitigate the effects of climate change (Bushnell, 2011). This approach of programmatic review also enables easier evaluation of the agriculture and deforestation projects that have been barred from compliance markets (Bushnell, 2011). Another application of programmatic review is the use of randomized trials to gauge voluntary offset effectiveness. To accomplish this, one population of project applications would be chosen to supply offsets while the other would be used as a control group against which to judge the additionality of offset payments. If the treatment group's emissions did not decrease by more than the control group, the offset payments would be ruled non-additional. Through the programmatic review of project baselines, a centralized regulator can reduce the barriers to entry for project approval while mitigating additionality concerns.

Market Consolidation

As discussed above, programmatic review greatly increases the efficiency of project approval. This kind of review process is enabled by high project volumes that allow for ample data collection and the formation of experiment and control groups. This process would be greatly benefited by a consolidation of the market for 3rd party offset verification. Similarly, the current problem of credit quality heterogeneity could be minimized through a centralized approval process that establishes shared principles for the description of voluntary offsets. A unified, transparent online project tracking system would reduce concerns surrounding the permanence of offsets. Each of these changes benefit from a centralized authority taking charge of voluntary offset market regulation. With the cautionary tale of the UK government's attempt at regulation in mind, the US government could select an already popular private sector entity to manage this centralized standard. Effectively, this would

be the creation of a government-sponsored monopoly. Often this occurs in the case of natural monopolies that produce large efficiency benefits through economies of scale allowing a single firm to better serve the market at a lower cost than any combination of smaller firms. Railway infrastructure, electricity grids, and national broadband networks are all common examples of natural, government-sponsored, monopolies. The natural monopoly case also applies to government sponsorship of carbon market regulation. Monopoly verification would take advantage of the high volumes necessary to conduct programmatic review and reduce project approval costs. It would also establish the common standards and monitoring methods necessary to reduce market heterogeneity. Given that the government will only have to enforce regulations on a single firm, it will more easily be able to track contract disputes. The current market leader in the voluntary space is the Verified Carbon Standard (VCS) with a significant market share. In order to avoid "reinventing the wheel," it would be reasonable for the government to contract with this group to form a monopoly over voluntary offset verification.

Overestimation

While programmatic review and consolidation can reduce the limitations of voluntary carbon offsets, there remains a good deal of uncertainty as to whether they can provide a similar benefit to direct emissions reductions. This is a major concern given that the level of global warming is quickly nearing tipping points that will have drastic impacts on life on planet Earth. In addition to implementing the policies outlined above, the government will need to control this uncertainty in the voluntary market. One way to do this in the compliance market is by tightening the emissions cap on offset purchasers (Bushnell, 2011). This solution assumes some abatement loss due to adverse selection and moral hazard tries to account for both by overestimating the total abatement necessary. While there is no government-mandated "cap" in the voluntary market, there are corporate norms such as carbon neutrality that establish best practices for environmentally concerned companies. The government could standardize requirements for neutrality claims, mandating that carbon credits be purchased in excess of emissions levels to qualify for carbon neutrality. There is precedent for this kind of intervention in the USDA's certified organic label that appears only on foods that meet specific production guidelines. In the same way, the government's carbon neutrality label would put strict standards on what it means to be carbon neutral.

Informational asymmetry makes the carbon market vulnerable to the problems of adverse selection and moral hazard, putting into question the additionality of offsets. The voluntary market is especially vulnerable to these issues given its fragmented and inconsistent regulatory environment. These troubles represent fundamental market failures in the voluntary market and signal a need for government intervention. The government will need to balance regulation with the benefits that the market currently reaps from a great degree of freedom. It will also need to consider the self-regulatory mechanisms that are already in place. Three possible avenues exist to maintain this balance while mitigating market failures. The first is a programmatic review of offsets, evaluating them by sector or group rather than individually. The second is a consolidation of market ideals and reporting strategies. Both aims could be met through the establishment of a government-regulated monopoly on offset verification. The third acts as a catch-all for possible oversights in the former solutions. It establishes a government standard for carbon neutrality that requires offset purchases to be made in excess of remaining emissions. This assumes some remaining loss of emissions reduction due to adverse selection and moral hazard and controls for it via a net negative emissions mandate. Together, these solutions could mitigate the negative consequences of informational asymmetry while enabling the voluntary offset market to provide its considerable benefits.

Conclusion

In order to avoid the worst impacts of climate change, individuals, companies, and organizations need to take drastic action to reduce their emissions of GHGs. In the short-term, some entities cannot make the necessary reductions while continuing to supply their product or service. Carbon offsets provide the opportunity for these individuals and firms to pay someone else to reduce or sequester those unavoidable short-term emissions. As the urgency of climate change increases, the demand for carbon offsets is expected to skyrocket. By some estimates this could result in an increase in the voluntary market's size by a factor of 15 over the next decade (Blaufelder et al., 2021). As the market blossoms, it will be more important than ever to have the proper regulations in place to counteract the moral hazard and adverse selection concerns involved in the provision of voluntary offsets. Throughout my research on this topic, it became clear that offsets are one small part of transitioning firms towards greater sustainability. They are a useful band-aid that can buy companies and organizations the time necessary to

make more fundamental and long-lasting changes that result in lower emissions. In future research I am interested in focusing on the mechanisms involved in these long-term changes. I would like to take a closer look at the incentives, such as carbon taxes or consumer pressure, necessary to initiate fundamental change and the most cost-effective pathways for implementation, such as a circular economic framework or traditional efficiency measures. In this way I hope to expand my scope to cover the full range of opportunities available to incentivize and implement a sustainable transition.

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