The Evolving Role of Greenhouse Gas Emission Offsets in Combating Climate Change

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Abstract

Governments, firms, and universities adopting ambitious greenhouse gas emission goals – including net-zero emission targets – stimulate demand for emission offsets. Suppliers of emission offsets undertake projects that reduce or remove emissions relative to what they would have been otherwise. However, there are concerns about permanence, double-counting, whether an offset will actually reduce emissions relative to the status quo, and whether the emissions will simply shift somewhere else. We review the roles of offsets in regulatory compliance, as incentives for early action, and when implementing voluntary emission goals. The rules and institutions governing offsets result in large variations in the prices of offsets and in the types of projects. Entities in one region may not know about the prices and environmental integrity of offset project activities in other places. An array of financial and technological innovations could enhance offsets' environmental integrity and promote liquidity in offset markets. Unresolved questions about the future of policy will influence the evolution of voluntary markets for emission offsets.

Keywords: climate change, certified emission reductions, offsets, cap-and-trade, corporate social responsibility

JEL Codes: Q54, Q52, Q58, H23

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In recent years, governments, major corporations, and universities have issued ambitious pledges regarding greenhouse gas emissions. For example, the European Union (2021) enshrined into law a goal of net-zero emissions by 2050, Microsoft has a goal to be carbon-*negative* by 2030, and Harvard University aims to be fossil fuel-neutral by 2026 (EU 2021, Smith 2020, Harvard University 2018). Meeting these goals will require the purchase of emission offsets – emission reductions that occur beyond a government's jurisdiction or the footprint of a company or university. These emission offsets could make up for any difficult-to-eliminate residual emissions created by the entity in question. For an entity to attain net-zero emissions, it needs offsets that at least equal its residual emissions.

An emission offset represents a greenhouse gas reduction or removal relative to what would have otherwise happened. For example, a new wind farm may be evaluated for emissions reduction relative to a 'no-project' counterfactual baseline. If the project developer demonstrates that a coal-fired power plant would otherwise have been constructed, then the emission offsets associated with the wind farm will reflect the avoided carbon dioxide (CO_2) emissions from burning coal at that counterfactual power plant. Similarly, sequestration efforts, such as tree-planting projects, may be evaluated for their net impact in removing CO_2 from the atmosphere and storing it in biomass. The resulting offsets would be determined by the estimated incremental afforestation and its translation into tons of CO_2 stored biologically.

Emission offsets can help firms comply with government regulations, including emission cap-and-trade programs, in which companies must acquire emission allowances to cover their emissions. They may also help a business or university demonstrate progress in attaining a voluntary emission goal. In both the regulatory and the voluntary contexts, the economic and environmental characteristics of offsets will depend on institutional details and policy design. Such design details will influence the evolution of the market for offsets because they affect both the supply and demand for emission offsets, as well as the prospects of financial innovations to improve the liquidity and efficiency of such markets.

The promise of emission offsets as a climate mitigation strategy is that it can promote cost-effective abatement of emissions and broaden participation in decarbonization activities. The incentive to buy an offset occurs when the costs of reducing emissions at the offset project are lower than the costs that the firm buying the offset would incur through its own attempts to reduce emissions.

Offsets can help deliver the net-negative global emissions of greenhouse gases necessary to limit warming to 1.5 or 2°C relative to pre-industrial levels. The possibility of earning revenue from offsets can encourage unregulated sectors, such as forestry and agriculture, as well as economies without emission regulations, to adopt technologies that reduce emissions. In turn, this can enable the future expansion of ambitious mitigation policies.

Several challenges, however, characterize the estimation of, and market for, emission offsets. Voluntary offsets can become green indulgences: a form of greenwashing that allows a business to appear to be taking action to address climate change, despite it providing little material benefit to the environment (Dalsgaard 2022). Where buyers lack sufficient information to distinguish low-quality from high-quality offset projects, uncertainty about the environmental integrity of offsets could cause the market to unravel. This risk has prompted an array of potential policy fixes, but these have increased the costs in doing business in the offsets markets. These increased transaction costs may have a chilling effect.

To better understand the economic, environmental, financial, and policy implications of using offsets to mitigate greenhouse gas emissions, we turn next to the lessons from their use as a regulatory compliance strategy. We then focus on the growing voluntary market for offsets and examine its key drivers. The evolving regulatory institutions, as well as emerging voluntary institutions governing offsets, form the foundation for an assessment of the challenges to estimating offsets and demonstrating their environmental benefits. In particular, we examine the threats to environmental integrity associated with offsets projects, drawing from policy experience with offsets markets and ex post evaluations of their environmental performance. We explore opportunities for financial and technological innovation to enhance the integrity and robustness of markets for offsets. We conclude with a discussion of the policy implications of the growing voluntary-offsets market.

Offsets as a Regulatory Compliance Strategy

Emission offsets emerged as a way to reduce regulatory compliance burdens by providing more cost-effective options for attaining environmental goals. For example, under the U.S. Clean Air Act, the Environmental Protection Agency (EPA) sets national ambient air quality standards and designates "non-attainment areas" that fail to meet a given standard. While the initial version of the law prevented firms from building emitting facilities in such areas, the 1977 amendments enabled firms to construct new facilities if they offset these new sources' emissions by cutting emissions at existing nearby sources (Hahn 1989; Schmalensee and Stavins 2019; Shapiro and Walker 2020). Such emission offset transactions typically require regulator certification and approval of "permanent" emission reductions.

Such a compliance option can deliver environmental, economic, and political benefits. In some cases, to accelerate progress toward the desired air quality standard, a regulator has required firms to finance emission cuts at nearby facilities that exceed their own new facility's expected emissions. Enabling a firm to seek out lower-cost emission reduction opportunities improves the cost-effectiveness of regulatory compliance and delivers marginal benefits in excess of marginal costs in most local offsets markets (Shapiro and Walker 2020). Permitting such flexibility in implementation can also enhance the political durability of air quality policy (Carlson and Burtraw 2019).

The fundamental challenge with offsets lies in demonstrating that the emission-reduction project would not otherwise have happened (Hahn 1989). The environmental benefits depend on the “additionality” of the activity: evidence that the investment and associated emission reductions would not have happened without the offsets transaction. Failure to demonstrate “additional” emission reductions could produce “paper tons,” defined as emission reductions that are recorded in a transaction, but that do not reduce net emissions in practice (Butler 1984, Dudek and Palmisano 1988). In an effort to address the threat of paper tons that would undermine the environmental integrity of offsets, environmental regulators have developed project-specific review and verification methods, but these imposed higher transaction costs.

These early Clean Air Act experiences informed policy experimentation in various forms of emissions trading, including greenhouse gas emission offset programs. The 1992 United Nations (U.N.) Framework Convention on Climate Change established non-binding emission goals for developed countries and a voluntary offsets program, often referred to as “joint implementation.” Under joint implementation, one country could invest in an emission-reducing project in another country. However, a decision at the 1995 U.N. climate talks prevented a national government from investing in a joint implementation project in another country and using the estimated emissions reductions to show progress toward its own voluntary goal. As a result, only a few developed countries invested in pilot projects of joint implementation. These early, modest efforts set the stage for the expanding role of offsets in subsequent international negotiations (Wiener 1998).

The 1997 Kyoto Protocol established the first, legally-binding emission targets for industrialized nations and enabled these countries to employ an array of market-based approaches – including emissions trading and the Clean Development Mechanism (CDM) – as a part of their implementation strategies. The CDM institutionalized a process where an emission-reduction project in a developing country could be registered, evaluated, and issued credits – offsets, referred to as Certified Emission Reductions (CERs) – that could be sold to a developed country for its use in complying with its Kyoto target (Lecocq and Ambrosi 2007).

CDM projects face questions of additionality much like the risk of paper tons that faced Clean Air Act project-based offsets. If a project in a developing country that would have happened anyway receives emission reduction credits that offset efforts to cut emissions elsewhere, then these could result in “tropical hot air” – a net increase in emissions (Meyers 1999, Philibert 2000). The CDM Executive Board, created under the Kyoto Protocol, developed rules to govern this new offset market with an objective to minimize the risk of such tropical hot air. These market rules covered project eligibility criteria; methods for estimating emission reductions and monitoring emission-related outcomes; registration of specific CDM projects; issuance of offsets that may be sold by registered projects; and certification of project auditors.

CDM offsets offered more than a low-cost way for developed countries to satisfy their Kyoto targets. A robust international offsets market could also enable greater global cost-effectiveness by indirectly linking country-specific mitigation programs via the offsets market. For example, if developed country A bought CDM offsets and developed country B bought CDM offsets, then a liquid offsets market should result in global convergence of carbon prices between countries A and B (Jaffe et al. 2009).

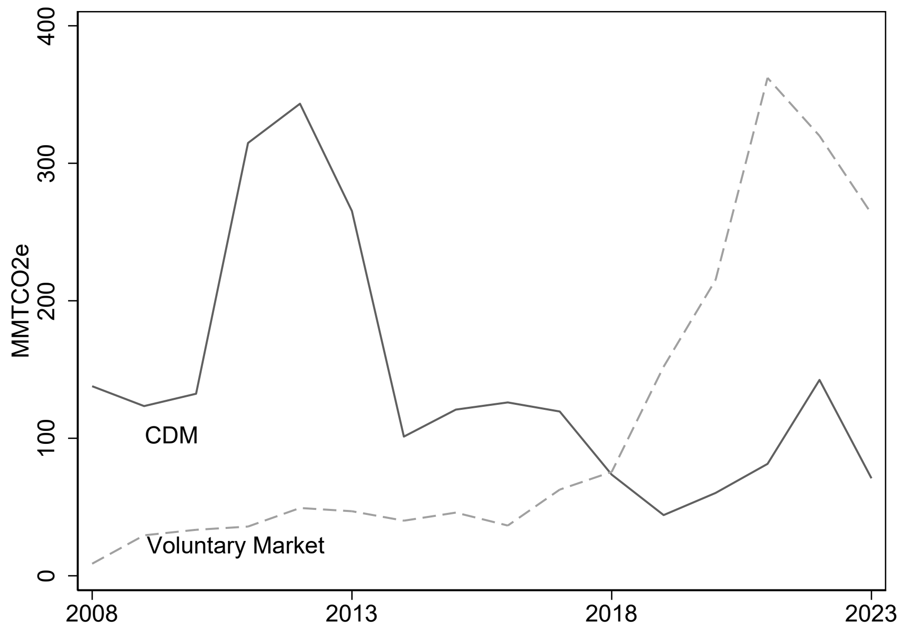
While the Kyoto Protocol allowed national governments to buy and use CDM offsets to demonstrate compliance with their emission targets, the largest driver of demand for such offsets came from European firms regulated by the EU Emission Trading System (ETS). As a cap-and-trade program, the EU ETS allowed firms to buy and sell emission allowances such that they held allowances sufficient to cover their emissions. The ETS program rules also allowed firms to demonstrate their compliance by acquiring and submitting CDM credits in lieu of ETS emission allowances. Doing so effectively converted the offsets into a commodity on par with allowances, enhancing demand for offsets among firms and improving market liquidity. CDM credits traded at prices fairly consistent with, but at a modest discount to, ETS emission allowances through 2011 (Ellerman et al. 2016).

The resulting demand catalyzed substantial growth in the offsets market: in 2012, developing countries' projects generated nearly 350 million metric tons of credits (Figure 1). For the post-2012 period, the EU set qualitative and quantitative limits on the use of CDM credits, reflecting concerns about the environmental integrity of CDM projects. For example, the EU prohibited the use of CERs from projects that destroyed industrial gases, such as HFC-23 and nitrous oxide, because so many did not deliver additional emission reductions. The EU also began to limit CDM credits from country of origin – allowing post-2012 credits only from projects registered in least-developed countries – and set maximum limits on the use of CDM credits for compliance purposes by emission sources covered by the ETS (European Commission n.d.). These restrictions depressed demand for CDM credits, and offsets issued through the CDM declined more than 80 percent between 2012 and 2023.

Building on the EU ETS experience with offsets, several sub-national carbon pricing policies have integrated offsets into their design. For example, California and the Regional Greenhouse Gas Initiative (RGGI) cap-and-trade programs have included offsets as a compliance strategy for covered firms. However, in both of these cap-and-trade markets, a regulated firm can use offsets to satisfy only a specified percentage of its emission compliance obligation (these percentages vary over time). In addition, the RGGI market has precluded the use of offsets when emission allowance prices are below a specified level. Thus, offsets in RGGI are available for compliance only in high-allowance price states of the world.

In 2016, the member countries of the International Civil Aviation Organization agreed on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which established the goal of "carbon-neutral growth" in emissions in the international aviation sector starting in 2020. After an initial voluntary compliance period, the goal becomes mandatory after 2027 (Larsson et al. 2019). Given the challenges of large-scale commercialization of low-carbon aviation fuels, emission offsets from beyond the aviation sector will play a critical role in determining whether the international aviation sector can sustain carbon-neutrality. CORSIA could represent the single largest policy driver for demand for emission offsets – on the order of 100 to 250 $MMTCO_2$ per year – between 2021 and 2035 (Warnecke et al. 2019).

Figure 1. CDM and Voluntary Market Offset Volumes (Issued Credits), million metric tons of CO_2-equivalent, 2008-2023



Sources: Voluntary Carbon Market Dashboard, Climate Focus, available at https://climatefocus.com/initiatives/voluntary-carbon-market-dashboard/ (accessed January 16, 2024), and UNFCCC Clean Development Mechanism database, available at: https://cdm.unfccc.int/Statistics/Public/files/202312/cershpnum.xls (accessed January 16, 2024).

Market Drivers for Supply and Demand of Voluntary Offsets

In the 1990s and 2000s, voluntary efforts to reduce emissions often reflected expectations about future regulatory policy and the signals from policymakers that first-movers would receive credit for early action. For example, in his 1999 State of the Union address, President Clinton called for legislation to “reward companies that take early, voluntary action to reduce greenhouse gases”. Some firms registered emission reductions through a Department of Energy voluntary greenhouse gas reduction registry (Government Accountability Office 2008), while others began to participate in a voluntary emission reduction market organized through the Chicago Climate Exchange. The California Global Warming Solutions Act of 2006, which launched the state's CO_2 cap-and-trade program, required regulators to provide "appropriate credit for early voluntary reductions"[1]. The American Clean Energy and Security Act of 2009 would have exchanged emission allowances for offsets that represented voluntary early action to reduce emissions[2]. However, after the failure of federal cap-and-trade legislation in 2010, private firms reformulated their expectations of policy-driven demand for offsets.

Universities and firms have increased demand for offsets to demonstrate progress on their own voluntary emission goals. Colleges and universities have adopted such targets in response to advocacy from students, faculty, and donors (Barron et al. 2021). Some firms have adopted ambitious emission goals in response to investor, consumer, and employee pressures, as well as the leadership of managers (Lyon and Maxwell 2008; MSCI n.d.). Consumer demand for emission offsets – such as for airline travel – also emerged as a driver for emission reductions (Segerstedt and Grote 2016).

The supply of offsets to the voluntary market has grown with the spillover from regulated markets. The developers of offset-eligible projects under cap-and-trade programs and the CDM have likewise generated emission offsets for the voluntary market. The evolution of remote sensing has enabled growth in nature-based solutions that use satellite imagery of biomass to estimate carbon sequestration (Lubowksi and Rose 2020). The institutional development of third-party verification, and independent audits in these public programs, have facilitated the emergence of firms and trained workers who can assess the environmental integrity of voluntary offset projects. The active engagement of civil society with the business community in crafting standards for what is effectively self-regulation in

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[1] §38562(b)(3) of Assembly Bill 32, State of California, September 27, 2006: http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf, (accessed January 20, 2024).
[2] §795, Exchange for early action offset credits, HR 2454, 111th Congress: https://www.govinfo.gov/content/pkg/BILLS-111hr2454eh/pdf/BILLS-111hr2454eh.pdf, (accessed January 20, 2024).

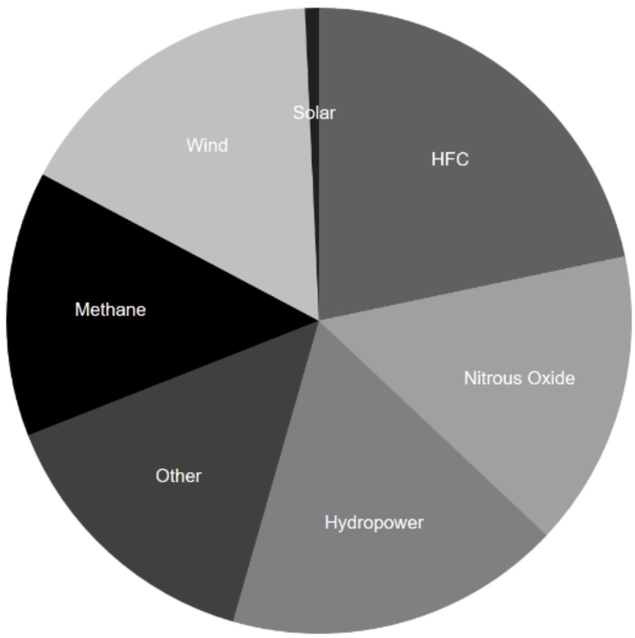
the voluntary carbon market replicates conventional regulatory standard development. For example, the Integrity Council for the Voluntary Carbon Market (ICVCM) – governed by a board consisting of representatives from environmental NGOs, sustainable finance, academia, indigenous peoples, and other stakeholders – published a 2022 draft assessment framework on which it solicited public comment. The process was akin to that which a regulatory agency would follow when proposing a regulation.[3] The voluntary offsets market grew to more than 360 $MMTCO_2$ in volume in 2021, well in excess of the 210 $MMTCO_2$ average annual CDM volume during the Kyoto Protocol's first commitment period. The volume of the voluntary carbon market, however, fell in 2022 and 2023 (Figure 1).

The variation in the composition of offset projects among voluntary markets, the CDM, and the California cap-and-trade offsets program provides suggestive evidence of the impacts of different market drivers and institutional designs. The CDM verified more than half of its offsets volume in projects that reduced emissions of methane, nitrous oxide, and hydrofluorocarbons. Clean energy projects – such as installation of wind and solar power – represented a much smaller fraction of offsets, and the CDM did not issue offsets for afforestation and reforestation (Figure 2, Panel A). In contrast, forest projects that capture CO_2 represent more than four-fifths of offsets in the California offset registry (Figure 2, Panel B). There are no renewable energy-based California offset projects. In contrast, renewable energy represents more than half of the voluntary offsets market in 2020 and about one-third of projects since 2008 (Figure 2, Panel C). Determining project eligibility under emerging voluntary standards and public policies will play a critical role in the growth in offsets over time.

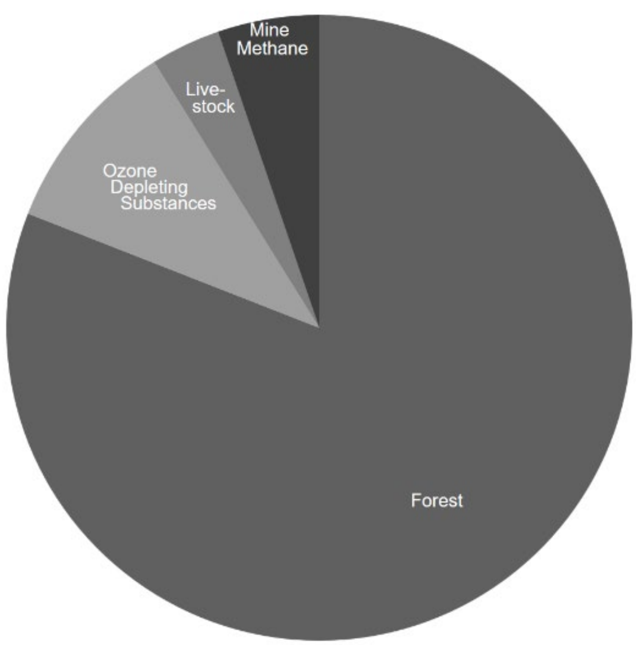
[3] Refer to the public consultation at https://icvcm.org/public-consultation/ (accessed January 20, 2024).

Figure 2. Distribution of Offsets by Project Type, 2008-2023

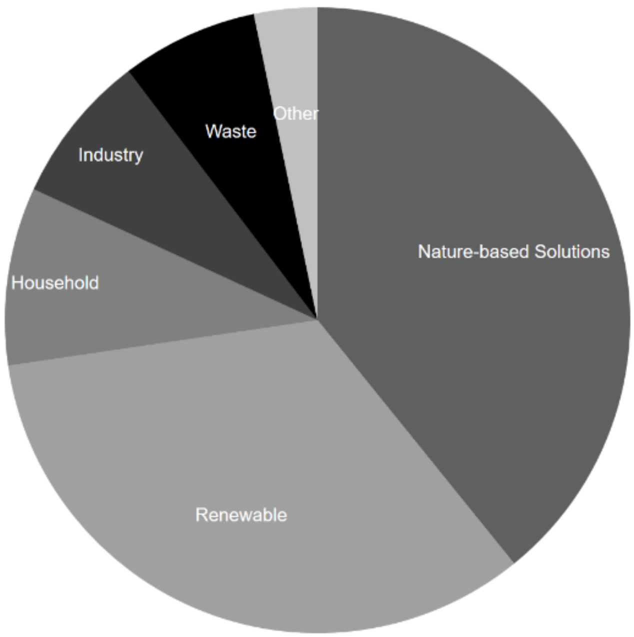
A. Clean Development Mechanism



B. California Offsets Registry



C. Voluntary Carbon Market Registries



Notes: The CDM did not issue certified emission reduction offsets to biomass projects. The California program recognizes urban forest and rice cultivation projects for emission offsets, but has not issued offset credits for these categories.
Sources: Panel A: UNFCCC Clean Development Mechanism database, available at: https://cdm.unfccc.int/Statistics/Public/files/202312/cerstypenum.xls (accessed January 16, 2024). Panel B: California Registry of offset credits issued by the California Air Resources Board, available at: https://ww2.arb.ca.gov/resources/documents/arb-offset-credit-issuance-table (accessed January 16, 2024). Panel C: Voluntary Carbon Markets data sourced from Voluntary Carbon Market Dashboard, Climate Focus, available at https://climatefocus.com/initiatives/voluntary-carbon-market-dashboard/ (accessed January 16, 2024).

Private sector forecasts of voluntary offsets highlight the potential for a fast-growing market. The Taskforce on Scaling Voluntary Carbon Markets (2021) projected an order of magnitude increase in the annual value of the voluntary offsets market, reaching $50 billion in 2030. Bloomberg New Energy Finance (2022) published three offset market scenarios, with a 2030 market value of $190 billion for the most bullish of these. The future of voluntary emission offsets may be uncertain, but it could prove a significant means to finance decarbonization efforts.

Comparing the Environmental Risks of Offsets to Other Policy Instruments

The growth in offsets markets will depend, in large part, on the environmental integrity of offsets projects. If offsets do not result in meaningful emission reductions or removals, then the advocates for rapid decarbonization – both investors in publicly-traded firms and key stakeholders weighing in on public policy – may oppose their use in voluntary and regulatory compliance strategies. Emission offsets share some similarities with clean energy subsidies – from the perspective of offset suppliers – and with some carbon pricing policies – from the perspective of offset purchasers. Comparing offsets with subsidy and carbon pricing policies can illustrate their potential environmental consequences.

An offset project produces a stream of emission reductions and an associated stream of offset revenues similar to production subsidies such as the U.S. production tax credits and other jurisdictions' feed-in tariffs, which fix long-term, above-market prices for renewable power. Clean energy subsidies, like public subsidies more generally, often suffer from a targeting challenge. Specifically, a subsidy available for an investment or output may reward both projects that would have happened anyway and the intended projects that would only proceed as a direct result of the subsidy. Projects that would have happened anyway are "inframarginal," while projects that would proceed only as a direct result of the subsidy provide marginal (additional) benefits. Large fractions of inframarginal claimants – often referred to as "free-riders" on the subsidy program – can reduce the cost-effectiveness of clean energy subsidies (e.g., Houde and Aldy 2017), but such poor targeting would not increase emissions. In contrast, an offsets program with inframarginal (non-additional) projects could increase net emissions; the buyers of the offset credits from the projects would not undertake emission mitigation within its own footprint or finance an alternative project that would have been marginal (additional). Granting offset credits for non-additional or inframarginal projects could crowd out marginal emission reduction efforts. The additionality problem creates more cost (public expenditure) risk under the subsidy approach, and more emission quantity risk under the offsets approach.[4]

In some emission trading programs, covered firms can use offsets in the same way as emission allowances. This is similar to a voluntary opt-in to a cap-and-trade program, such as how Phase II generating units could opt into Phase I regulation under the U.S. sulfur dioxide (SO_2) cap-and-trade program in the 1990s (Montero 1999). However, such opt-in policies can result in adverse selection, in which enterprises that already are able to reduce their emissions at low or zero cost (i.e., inframarginal emission-reduction projects) could opt into the market and sell allowances (in the past SO_2 market case) or offsets (in the current CO_2 cap-and-trade program context). In either case, the emission cap effectively grows by either the allowances allocated to the firms opting in, or the offsets supplied by each offsets project. Indeed, the concern that an offsets project may not be "additional" often reflects this adverse selection.

While economic efficiency should benefit from offset trading, such transactions may raise distributional concerns. Both an emission offset transaction and an emission allowance transaction represent the relocation of emission-reducing activity from the buyer to the seller of the offsets or allowances. One prospect that such transactions may prolong the economic lifetimes of fossil fuel-based facilities – which may impose disparate public health risks on nearby low-income communities and communities of color. Another possibility is a shift of emission-cutting projects from the Global North to the Global South, despite pledges by developed countries that they would undertake more ambitious emission reductions than developing countries. These possibilities have elicited criticism among environmental justice advocates (Farber 2012, Amazon Watch 2021).

Does the emerging voluntary offsets market resemble the current allowance market, in which allowances are interchangeable at a uniform price? Recent evidence suggests that it doesn't; there is

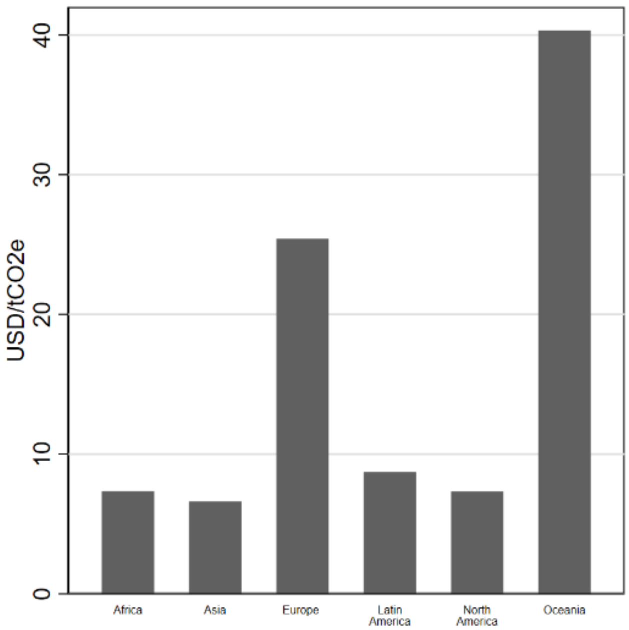
[4] Thanks to an anonymous referee for this insightful distinction.

significant price variation in the offsets market. Prices of offsets in Asia are about one-seventh of their equivalents in Oceania, and offset prices in Europe are triple those in Latin America and Africa (Figure 3, Panel A). Different verification standards – the rules determining the quantity of offsets for a given project – can yield average offset prices that vary by an order of magnitude (Figure 3, Panel B). Offset prices vary by a factor of three across project types (Figure 3, Panel C). In 2020, the average price for offsets paid by buyers differed significantly across major sectors of the economy; airlines bought offsets at one-quarter the prices that other transportation companies paid (Forest Trends' Ecosystem Marketplace 2021b). CORSIA-eligible offsets averaged nearly $5 per ton of ($tCO_2$), with a spread between minimum and maximum prices of nearly $50/$tCO_2$ (Forest Trends' Ecosystem Marketplace 2021a).

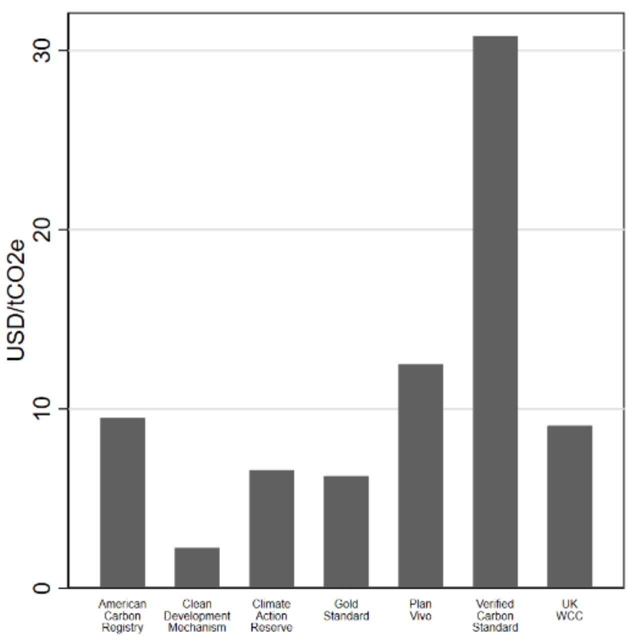
Such price dispersion could, in theory, reflect the costs of searching for information. However, search costs probably are modest, given the availability of such information online and through subscription services. Price variation across verification standards illustrates the importance of the rules for project evaluation: what counts as an emission offset in one standard may not count in another. To be fair, some standards differ in the types of projects on which they focus, and the differences in costs among project types could explain some of this variation. The correlation among specific project types and geographies may also explain some of the price variation across countries. The absence of price convergence among buyers, however, signals differences in the procedures that individual companies employ to identify appropriate offsets for acquisition. These price data are consistent with a segmented market, in which some firms purchase offsets with lower environmental integrity or greater environmental uncertainty than others. The variation in prices also may reflect fundamental differences among corporate decision-makers in terms of the highest prices they are willing to pay for offsets when implementing their voluntary emission goals.

Figure 3. Variation in Offset Prices, 2023

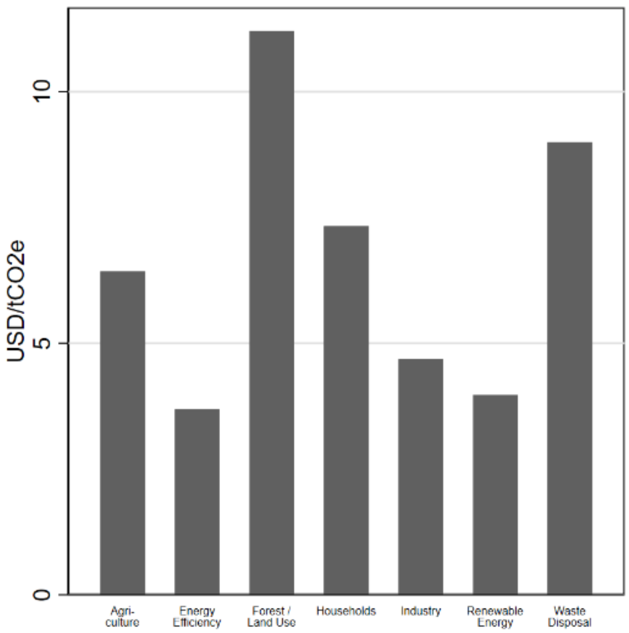
A. by Region



B. by Verification Standard



C. by Project Type



Source: Forest Trends' Ecosystem Marketplace 2023, Tables 3, 7, and 11.

Challenges in Evaluating Emission Impacts of Offsets

While conceptually appealing as a low-cost way to reduce emissions, implementing offsets in practice raises a number of challenging issues (Aldy and Stavins 2012). The potential for offsets to undermine the environmental integrity of regulatory and voluntary schemes has motivated regulators, civil society, and the private sector to develop rigorous project rules. However, demonstrating that a project delivers emission benefits is daunting, especially since the comparison must be made relative to an unobserved counterfactual scenario. Carbon taxes, cap-and-trade programs, and performance standards measure compliance using monitored and measured emissions. In contrast, offsets use estimated emission reductions or removals.

There are a number of threats to the environmental integrity of offsets; these inform the development of the rules – private and regulatory – needed for liquid, high-integrity offsets markets.

First, systematic biases in estimating baseline counterfactual scenarios could result in over-estimates of emission reductions. For example, voluntary projects to reduce deforestation and forest degradation in the Brazilian Amazon used baselines that assumed higher rates of deforestation than were evident through after-the-fact, statistically rigorous estimates of deforestation (West et al. 2020). A key factor in this analysis, to which we return below, is the failure to account for national policies that may change baseline activities after the start of an offset project. If the government implements new policies to reduce deforestation nationwide, than an individual project reducing deforestation would not deliver as many tons of emission removals as it would in the absence of the policy reform.

For example, a recent analysis of CDM wind farm projects in India found that more than half of those certified were “blatantly inframarginal projects” (Calel et al. 2022). They found that these CDM-qualifying projects were more profitable than non-CDM projects that came online in the same state and year. Since the CDM offsets were not financially necessary for these profitable companies to build wind farms, the resulting emissions offsets were unlikely to have been additional to what would have happened anyway.

Related to this, offsets may create incentives for firms to manipulate the baseline. One-fifth of CDM credits over 2008-2023 reflected reductions in hydrofluorocarbons (HFCs; Figure 2). In the early implementation of the CDM, Chinese manufacturers built excess capacity for producing a specific HFC so that they could shut this down to generate CDM credits (Wara 2007). In effect, the HFC-based CDM offsets were inducing firms to inflate their baselines by expanding HFC capacity that they could then destroy to generate ‘paper’ emission reductions.

To understand whether a project would have occurred in the absence of offsets, an assessment of the underlying project finances is needed. The challenge lies in the fact that many offset projects, especially in the energy sector, are associated with an activity that has market value. A wind farm that displaces carbon-intensive power generation produces both electricity and emission offsets. Installing an efficient industrial boiler can both reduce emissions and increase the value-added per unit of energy at a manufacturing plant. There may be some exceptions; for example, a carbon capture and storage project may yield no revenue other than through its emission-reduction activity. However, if such a project receives substantial subsidies from other policies (e.g., the U.S. Section 45Q tax credit [Jones and Sherlock 2021]), there may still be a question of whether the firm would have undertaken the investment without the offsets revenue stream.

Second, the design of offsets rules could induce adverse selection into the market. The resulting errors in crediting offsets can undermine environmental integrity. For example, estimating the emission reduction potential in improved forest management (IFM) projects typically requires forest data to be combined across species and geographies. Assigning an average CO_2 sequestration rate to IFM projects may create an incentive for worse-than-average projects to opt in; in this case, projects in low-carbon density forests receive credit for high-carbon density forests that share the same region. The program's rules facilitate adverse selection: by employing regional averages when estimating biological sequestration, landowners can select the low-density parcels in their forests with specific below-average sequestration for participation in the offsets program. Such a bias resulted in the over-crediting of 29 percent of offsets issued in the California cap-and-trade market's forest offsets program (Badgley et al. 2022). This represented about 30 $MMTCO_2$, valued at more than $400 million. In effect, the environmental integrity of the program was undermined by efforts to reduce the administrative burden and transaction costs for offsets .

Third, there is a risk of double-counting emission reductions from offset projects. Much of the concern is due to the lack of standardization of offset registries and incomplete disclosure in the use of emission offsets. If the construction of a facility or the implementation of a project enables compliance with that jurisdiction's regulations or policies, then such a project should not be eligible for emission offsets, because it would happen anyway to comply with the law. For instance, an electricity generation company might build a wind farm to meet a renewable portfolio standard (a regulation that requires a certain percentage of electricity to come from renewable sources). If the wind farm allows the company to exceed the standard, it might then sell a “credit” to another electricity producer that is short on its quota. However, if the wind-producing company also sold emission offsets, it would be guilty of double-counting.

Fourth, emission-offsetting investments could have wider impacts that undermine the environmental integrity of any given project. Securing one forest parcel for sequestration may increase the profitability of clearing another forest parcel, and thus reduce some of the net environmental benefit of the offset project (Monge et al. 2016). Building a wind farm to displace a coal-fired power plant may reduce demand for and price of coal, , and thus make it more attractive for another firm to build or maintain a coal-fired power plant that they might not have otherwise considered. The relocation of emitting activity from a project to another place or activity is known as leakage. This example represents a form of emission leakage from the offsets market. It could become substantial if the voluntary market grows faster than regulatory schemes covering emission sources. For example, using offsets to subsidize the deployment of new zero-carbon power projects may increase the supply of electricity, thereby reducing the price of electricity; lower electricity prices could undermine incentives for conservation and energy efficiency. In one global energy-economic modeling analysis, such energy system impacts of clean energy offset programs diminished the emission reduction benefits of offsets by more than half (Calvin et al 2015).

Fifth, the environmental benefit from the offset – especially in the case of afforestation and reduced deforestation activities – may depend not only on investment today, but on the preservation of the biomass for decades into the future. This is the idea of permanence. A forest fire, or future decision to clear the land, effectively eliminates the estimated stream of offsets. Growing wildfire risk across the globe could undermine good-faith efforts to remove carbon from the atmosphere.

These environmental risks associated with emission offsets can prompt – and have prompted – rules and policies to reduce the risks[5]. At the project development stage, project assessment and verification protocols can address, to some extent, baseline bias and baseline manipulation risk. Such protocols can also serve as bases for after-the-fact audits of projects to ensure that they satisfy the standards they have set. While verification and auditing may be sufficient to demonstrate compliance with standards, experience indicates that they do not eliminate the possibility that offsets will deliver less than their verified emission reductions.

Recent efforts in performance evaluation could aid in the development of program evaluation techniques to confirm the environmental value of offsets projects. Establishing protocols for performance evaluations, and committing to undertake them, could add credibility to evaluations. The design of such protocols would also give the public and experts opportunities for feedback on evaluation methods. Such protocol revisions could draw from the emerging literature, from policy practice in program evaluation, and from reviews of how well regulations functioned in practice (Aldy 2014, 2022).

Building a Robust Offsets Market

Financial innovation can enhance the liquidity, integrity, and robustness of emission offsets markets. First, however, it is important to address the fundamental financial characteristics of an offset. Is it more similar to a commodity or to a bond, and thus, does the buyer bear any liability for the environmental integrity of the offset project?

[5] For recent examples, refer to (1) the REDD+ Environmental Excellence Standard developed by the Architecture for REDD+ Transactions at https://www.artredd.org/trees/, which has been employed to assess proposals to the LEAF Coalition, a public-private partnership financing reduced deforestation; and, (2) the Core Carbon Principles developed by the ICVCM at https://icvcm.org/public-consultation/, (accessed January 20, 2024).

If offsets are interchangeable with allowances, the buyer of the offsets bears no environmental risk. An offset would have the same compliance properties as an allowance; each offset gives the holder the right to emit, say, one ton of CO_2 under a cap-and-trade program, or is deemed on par with a one-ton reduction in its emissions.

If, in contrast, the buyer is liable for the emissions outcomes on which the offset was based, then the offset has properties more akin to a bond, since the returns are a function of the environmental integrity of the project. For example, if a firm acquires offsets from a forest preservation project, and the protected land subsequently burns in a wildfire – releasing much of the stored carbon that generated the offsets – is the buying firm liable for the environmental damage? What legal or institutional constraint could compel such liability in the context of a firm using offsets to meet a voluntary emission goal? Would bad publicity for having purchased a failed offset be sufficient to cause firms to acquire new offsets to make up for the lost environmental benefits?

Recent private sector proposals and initial public policy efforts illustrate the various ways of addressing these questions. For example, the Taskforce on Scaling Voluntary Carbon Markets (TSVCM) (2021) recommended standardized futures and spot benchmark contracts to facilitate a liquid market in offsets. Such benchmark contracts would be analogous to standardized futures contracts for crude oil, such as the CME NYMEX crude oil futures contract, which specifies the volume, grade, delivery location, pricing, and timing. Standardized contracts for emission offsets would effectively commodify offsets and could deliver two benefits: they would enable price discovery, reducing price dispersion in the market, and they would provide quality screening of offsets. The recent work of the ICVCM has focused on establishing a high environmental-quality, standardized benchmark that could serve as the basis for futures and spot contracts.

The private financial sector is playing a growing role. For instance, CBL, a market-maker in energy and environmental financial products, established the Global Emissions Offset (GEO) spot contract, and the CME Group (a financial services company) offers a futures contract based on the GEO standard (CBL 2021, CME 2021). The GEO spot contract specifies the volume (one metric ton of carbon reduced), the quality as determined by an approved verification protocol (American Carbon Registry, Climate Action Reserve, and Verified Carbon Standard), pricing (U.S. dollars per metric ton), and delivery and timing (immediate via electronic registry account). The GEO contract is designed to satisfy the requirements of the CORSIA program under the International Civil Aviation Organization. Buyers of GEO contracts could use them to demonstrate CORSIA compliance or to represent progress toward their own voluntary emission goals.

Despite recent financial product development, there exist several limitations to structuring offsets as commodities. First, commodities markets require a high degree of liquidity to function in a robust manner and facilitate price discovery. Ongoing debate about the role of carbon offsets in corporate net-zero pledges, as well as the future form and ambition of climate change policies, cast a shadow of uncertainty on long-run private demand for offsets.

Second, benchmark contracts need to dominate market share in order to be effective. A key underlying assumption in commodifying offsets is that there exists a (near) uniformity of firm preference toward high-quality offsets that would meet the benchmark contract standards. If market segmentation emerges – with a cohort of firms opting for low-environmental quality, low-cost offsets (which can often trade at $1-2 per metric ton of CO_2) and another cohort opting for higher-quality, higher-cost offsets – there would be difficulty in establishing a benchmark contract with sufficient market demand. As illustrated in Figure 3, the absence of price convergence among regions, verification standards, project types, and buyers provide illustrative evidence of market segmentation.

Third, the variety of carbon offset project types may complicate standardization and pose challenges to implementing feasible and environmentally adequate quality screening criteria. For example, removing CO_2 from the atmosphere through industrial direct air capture and storing it underground may be measurable and likely considered permanent. CO_2 removal through nature-based solutions may be more uncertain – requiring estimation models based on remote sensing data – and subject to the risk of impermanence. And a CO_2-avoidance project, such as building a wind farm instead of a presumed counterfactual coal-fired power plant, likewise relies on estimation and key assumptions about the counterfactual and emission leakage. How to compare a metric ton of CO_2 under each of these three projects through verification protocols will play a key role in determining the potential to commodify offsets project outcomes through spot and futures contracts.

In contrast, offsets could be securitized into bonds. These would condition investor coupon payments on the emission outcome of the carbon-offsetting project. If a project does not deliver the stated emissions reduction, avoidance, or removal, the bond buyer bears the liability, and is exposed to contractual risk. Rating agencies could evaluate specific projects, or a portfolio of projects reflected in a bond, and provide information on likely environmental outcomes.[6] Groom and Venmans (2023) present a method for calculating the social value of offsets that accounts for permanence and additionality concerns. Such quantification could inform bond pricing as well as offset project insurance pricing. Such an approach could address concerns about the permanence of emission offsets and, to the extent that independent evaluation could account for the additionality and leakage impacts of offsets, a broader set of emission risks to these projects.

Under the Securities and Exchange Commission proposed climate-related disclosure regulations publicly traded companies would need to identify the financial risks associated with nature-based offsets that may need to be written off or replaced in the event of a wildfire or other factors reducing their emission-removal benefit.[7] This implied buyer liability differs from the implicit seller liability

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[6] For example, the firms BeZero and Calyx Global provide risk ratings on offsets used in voluntary carbon markets in a manner analogous to conventional credit rating agencies (refer to https://bezerocarbon.com/ratings/ and https://calyxglobal.com/approach, accessed January 20, 2024).
[7] 87 Federal Register 21334, April 11, 2022.

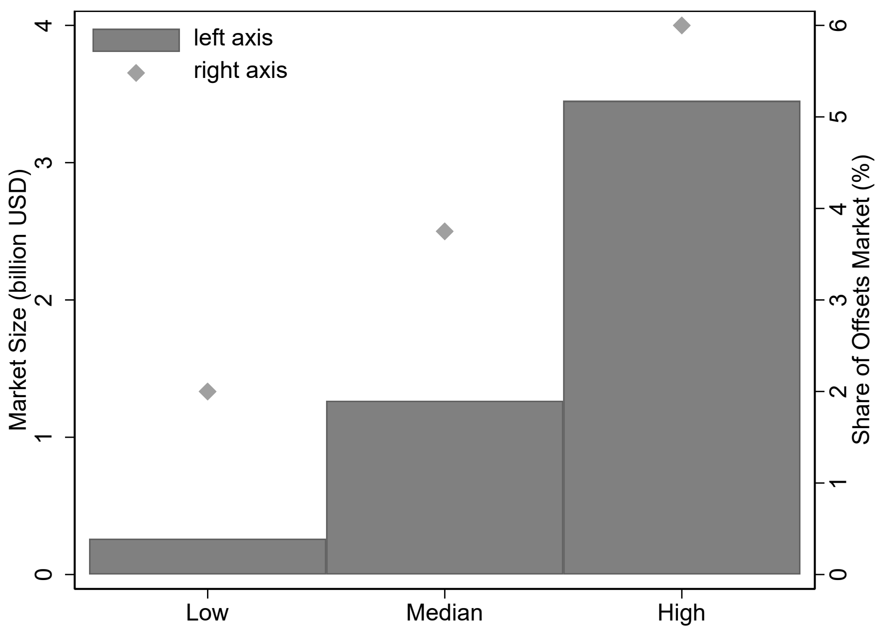
characterizing cap-and-trade program transactions, which has enabled many allowance trading markets to be fairly liquid (e.g., the EU ETS, U.S. SO_2 cap-and-trade program).

The experience of policy-created markets illustrates some pitfalls with a buyer liability approach. For example, the EPA implemented the Renewable Fuel Standard (RFS2) through a system of tradable credits (referred to as RINs). Biorefineries generate RINs as a function of the volume and carbon intensity of their biofuel output. Under RFS2, refineries, fuel blenders, and importers are required to purchase these RINs to satisfy their renewable volume obligations. These buyers bear liability if they acquire fraudulently-created RINs. After several cases of fraud emerged, RIN market liquidity fell, because the buyers had to undertake additional diligence to assess the quality and validity of any given set of RINs. Eventually, the EPA implemented a Quality Assurance Program to verify RINs, effectively eliminating the buyer liability on such QAP-audited RINs (Aldy 2019).

The California cap-and-trade program allows regulated firms to use emission offsets for compliance subject to a buyer liability standard. Initially, some offset project developers expressed reservations about the buyer liability scheme because of the uncertainty it would introduce to a new market. Advocates of offset buyer liability have emphasized the low rate of offset invalidation – about 0.3 percent over the first seven years of the program – as evidence that it is a market for high-environmental integrity offsets (Roedner Sutter 2020). It is difficult, however, to square this low rate of invalidation with the 29 percent estimated over-crediting in California's forestry offsets programs mentioned earlier (Badgley et al. 2022). The conditions that would trigger liability for a buyer may be a small sub-set of the factors contributing to less-than-expected emission reductions or removals by projects.

The emergence of verification protocols highlights the importance of information that enables buyers to differentiate low-quality from high-quality offsets. To signal the quality of offsets and improve the liquidity of offsets markets, a variety of financial instruments could be deployed. For example, bonding and insurance could reduce the financial risk associated with nature-based offsets. If the global voluntary offsets market grows to at least $50 billion by 2030, then an associated insurance market could be worth billions of dollars (Figure 4). Existing insurable physical risks emanating from natural disasters and causes could be synthesized with adjacent market-specific risks in the crop and timber fields. Howden, a global insurance broker, launched Parhelion, to issue an offset invalidation insurance product, which covers the replacement cost for offsets under California's cap-and-trade program.

Figure 4. Projections of the Voluntary Carbon-linked Insurance Market in 2030



Notes: The low, median, and high scenarios reflect variation in assumptions of overall offset market size, share of market covered by insurance, and premiums as a share of nominal offset values.
Source: Carr et al. 2021.

Further, to address leakage, a new insurance instrument could be offered or required. This insurance instrument could pay out in the event that leakage is later identified. Such an approach would likely require monitoring and evaluation methods to ascertain the scope of the emissions loss that could occur through threats to permanence or leakage.

Creating securities backed by portfolios of offsets projects could reduce the risk that buyers face of project-specific environmental failures and could maximize material impact through diversification of project types (Climate-Related Market Risk Subcommittee 2020). Such instruments could also lower reduce cost of financing the supply of offsets. Trading in derivative products could facilitate price discovery in offsets markets and encourage investment in high-integrity offsets projects.

There are already some markets for such environmental derivatives in relation to regulated emission trading schemes. For example, the Intercontinental Exchange provides a platform for trading futures and options in carbon offsets associated with the EU ETS, California's cap-and-trade program, and the UK's emissions trading scheme (ISDA 2021). Swaps are also commonly employed (ISDA 2021). In December 2023, the Commodity Futures Trading Commission (2023) proposed factors that contract markets should consider in the listing and trading of carbon credit derivative contracts.

Achieving the potential of financial markets in emission offsets will require the development of standards that can be used to evaluate the financial and environmental risks of offset projects. Transparency, and convergence on common standards, would encourage liquidity and enhance the environmental integrity of markets in offsets. Standards should address reporting and disclosure on projects, the parameters of standard derivatives contracts, and the role of financial regulatory oversight. The past decade has seen remarkable experimentation in the rules and guidelines governing third-party verification protocols, spot and futures contracts, regulatory approval of offsets, and firm-specific offset acquisition processes.

Policy Implications of Growing Voluntary Offsets Markets

The growth in markets for voluntary offsets reflects, in part, the gap between governments' goals and governments' mitigation policies. Many of the universities and businesses driving the offsets markets are doing so as part of their "Paris-aligned" emission goals. Achieving these goals require more ambitious emission reductions than the national policies of virtually any government participating in the Paris Agreement, as reflected in the “gaps in both mitigation ambition and implementation” identified in the recent UN global stocktaking at the Dubai climate talks (UNFCCC 2023, paragraph 17). When and how government policies will catch up with governments’ emission goals will have important implications for the voluntary offsets markets.

The potential interactions between voluntary offsets markets and climate change policies raise a number of questions.

First, would a growing voluntary offsets market increase business support for a national carbon pricing policy? Engaging more and more businesses in decarbonization, through the supply and acquisition of offsets, might encourage the broader business community to support a national emission mitigation policy. Moreover, the price per ton for an offset – if offset prices converge in voluntary markets – could inform the setting of a carbon tax or the design of regulatory approaches, such as cap-and-trade programs or clean electricity standards (e.g., Aldy 2012). Firms already participating in voluntary carbon markets would tend to support new climate policies that provide concrete rewards for early action. On the other hand, early voluntary efforts could lock in offset markets and deter the development of national climate policies.

Second, how does the evolution of public policy influence the eligibility of offset projects and the counterfactuals used to estimate them? Consider the case of a wind farm that generates emission offsets relative to a counterfactual coal-fired power plant, operating in a jurisdiction without any renewable power regulations or other related policies. Various potential policies could reduce the marginal value of this project’s estimated emission offsets. Such policies, ranging from standards that would phase out coal-fired power plants, to renewable power mandates, to tax credits for wind farm output, would result in the same emissions reductions that are claimed as additional reductions by the offset project. The possibility that future policies and regulations could reduce the offset revenues of clean energy projects may have a chilling effect on offsets investment. For firms that already supply offsets to the voluntary market, this may affect how they would engage with – and potentially oppose – future climate change policy. Future regulatory policies that include offsets as a compliance strategy may give civil society and the business community incentives to influence the design of regulatory standards and verification processes for offsets. This may reflect policy innovations at the state level (e.g., California), national level, and international level, such as the agreement at the 2021 Glasgow climate talks on rules for cross-border trading of emission reduction efforts and the public-private partnership for an Energy Transition Accelerator (UNFCCC 2021; U.S. State Department et al. 2023). The first instance of a cross-border offset credit exchange under Article 6.2 of the Paris Agreement occurred in late 2023 between Switzerland and Thailand (Spring 2024).. This could catalyze increased interest in international bilateral offset deals as well as more stringent regulation governing such transactions.

Third, how would limitations or prohibitions of emission offsets influence the ambition of corporate voluntary emission goals or government-established emission targets? Where emission offsets reduce the cost of attaining a given emission goal, they enable more stringent emission limits to be adopted with greater political acceptability. If offsets are unavailable, then firms may set more modest emission goals and national governments may establish less-ambitious nationally determined contributions under the Paris Agreement.

Fourth, how would climate-related disclosure regulations influence the evolution of the voluntary offsets market? Disclosure requirements imply greater transparency in the standards for verifying and auditing emission offsets, and might help establish a common standard for environmental integrity. Such disclosure regulations may also clarify emissions accounting rules, such as for emissions beyond the boundary of the firm (e.g., the emissions embedded in a company's supply chain, often referred to as scope 3 emissions in a firm's supply chain). This would reduce the likelihood of double-counting. Transparency about a firm's use of internal carbon pricing in the acquisition of emission offsets may also send more information to potential offset suppliers and enhance market liquidity.

Fifth, how could innovation in the data and methods for after-the-fact evaluation inform the assessment of environmental integrity and the development of risk management instruments in the financial sector? More precise monitoring and measurement data, in order to enable broader application of statistical tools that test causal inference, would allow more rigorous program evaluation of individual projects and broader offset programs. Such rigorous evidence could assist in the design of instruments that are premised on buyer liability, the pricing of insurance policies, or the accounting of progress toward emission goals.

Finally, given recent political interest in carbon border adjustments, could an importer reduce its carbon tariff obligations through offsets? Under a carbon border adjustment mechanism, the tariff on a covered imported good would be based on its carbon intensity. Emission offsets could enable the producer of the imported good to claim that its emissions are lower than estimated for that class of good. Alternatively, the producer could argue that it acquired offsets at a carbon price that would be on par with the price that domestic firms in the importing market face, thus ensuring a level playing field and precluding potential emissions leakage. Allowing such an exemption or modification to the carbon tariff could enable a carbon border adjustment mechanism to spur the offsets market in jurisdictions around the world that currently have weak regulations on carbon emissions. Doing so could then create positive policy feedbacks for more ambitious decarbonization policies in those exporting countries.

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