Extended Abstract

Selection and Scale in Carbon Offset Markets

Eduardo Azevedo[1] Susanna Berkouwer[1,4] Prakash Mishra[2]
Anna Russo[3] Arthur van Benthem[1,4] *

Abstract

Carbon offsets are intended to facilitate trade between suppliers of low-cost abatement and buyers who value emissions reductions. We show that offset markets suffer from failures on both sides of the market that interact to limit gains from trade and evaluate remedies. On the supply side, voluntary entry with imperfect measurement generates adverse selection: using data on more than 400 land-use projects, we find participating projects are over-credited by roughly an order of magnitude. On the demand side, we observe a standardized offset contract unravel: over-credited projects select in, prices fall, selection worsens, and trade collapses. At the same time, we estimate that buyers value true carbon reductions only modestly and exhibit preferences for nominal market scale independent of environmental impact. We embed these results in a model of land use and crediting to study how adverse selection impacts equilibrium trading outcomes. Under the status quo, over-crediting sustains trade at low prices and minimal (yet vastly overstated) environmental gains. At the other extreme, imposing unbiased crediting leads to market unraveling in both voluntary and compliance offset markets—even in high-price regulated markets—despite realizable welfare gains. Subsidies are required to preserve trade and environmental integrity while providing incentives to improve measurement.

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[1] University of Pennsylvania. [2] Dartmouth College. [3] Harvard University. [4] National Bureau of Economic Research.

Many sectors and geographies are not covered by carbon pricing schemes. Emissions may be avoided or removed in these non-covered sectors at lower costs per ton than other carbon abatement technologies (see, e.g. Jayachandran et al. (2017); Souza-Rodrigues (2019); Araujo et al. (2026); Assunção et al. (2026) for forestry and land use). Carbon offset markets are intended to address these missing markets through trade: emissions reductions and removals can be sold from low-cost, non-covered entities to higher-cost emitters. This theoretical appeal has generated substantial policy and market interest (see, e.g. Pande et al., 2025). Offset markets exist in a substantial voluntary carbon market serving 40% of Fortune 500 companies, in 40% of carbon pricing schemes that allow an offsetting mechanism (Macintosh et al., 2025), and are a longstanding, central component of international climate agreements.

Despite this appeal and prominence, carbon offset markets are controversial. It is challenging to accurately measure the emissions reductions represented by the offsets being traded. Ensuing concerns about the environmental integrity of offset markets have contributed to a broader loss of confidence in their viability (Macintosh et al., 2025). However, it remains unsettled whether offset markets are doomed to fail, or if they can be re-designed to yield socially-desirable gains from trade. Should they be banned for concerns of environmental integrity, are they fated to unravel, or could they be structured differently to tap the potential of low-cost carbon abatement? The answer depends on the scope for inefficiency on *both sides* of the trade: suppliers' selection into offset provision and buyers' offset purchase rules. In this paper, we introduce an equilibrium framework to assess the viability of offset trade, empirically investigate the choices on both sides of the market, and quantify implications for offset market performance and regulation.

We begin by developing a stylized equilibrium framework to highlight the scope for inefficiency. Offset credits are issued, given projects' estimated emissions reductions, which are subsequently sold to buyers. On the supply side, imperfect measurement of emissions reductions can introduce adverse selection: projects with estimated reductions overstating true reductions find entry most profitable (as documented in Aspelund and Russo (2026)). We demonstrate that equilibrium offset trade depends on the nature of offset *demand*, which we estimate directly. We show that offset markets may be stuck in either of two undesirable trading equilibria. Buyers — or a regulatory environment enforcing trading rules — may condition on the composition of available offsets and trade *expected emissions reductions*. While this ensures environmental integrity, it could limit or even unravel trade as the expected value of the offset will diverge from its value at the margin (Akerlof, 1970). Alternatively, buyers — or a regulatory environment failing to enforce trading rules — may

demand nominal offset credits, irrespective of expected emissions reductions. It is therefore possible for no trade to occur even when socially desirable (low-cost carbon abatement opportunities remain untapped), and for trade to occur even when socially undesirable (offset credits are issued and project costs are incurred when true emissions savings are minimal or absent).

To investigate the empirical relevance of this tension, we have assembled a new and comprehensive dataset covering forestry carbon offset credits traded in global markets. This dataset combines information about the supply of offset credits with prices and transactions to estimate demand and the equilibrium implications of offset trade. First, we combine hand-collected geographic boundaries of over 400 offset projects protecting and restoring tropical forests — over an order of magnitude more than prior studies (West et al., 2020; Guizar-Coutiño et al., 2022; West et al., 2023) — which we obtained from project registration documents. These records also include data on each project's issued offset credits by year. We link each project to rich data on land use from a new panel of satellite-derived tropical forest cover, agricultural productivity, transport costs, and measures of biomass. Second, we leverage a unique dataset recording carbon offset transactions on a leading trading platform (Xpansiv/CBL). This dataset records prices and quantities for over the counter (OTC) trades, including project identifiers, as well as the universe of trades and deliveries of a standardized, pooled exchange-traded offset product. The empirical analysis proceeds in three parts.

First, we establish the empirical relevance of a market-wide wedge between (1) estimated and issued offset credits and (2) the associated underlying carbon reductions due to selection into offset trade. We use a standard matched event study design, leveraging the timing of each offset project's first issued credits. Our approach quantifies changes in tropical forest cover within project boundaries over time, relative to controls, translates these changes into carbon emissions reductions, and compares magnitudes to issued offset credits. Crucially, our estimation approach diverges from that of the market, which drives selection. We document that issued offset credits exceed our estimated emissions reductions by approximately an order of magnitude for both deforestation prevention and reforestation (tree-planting) projects, with substantial project-level heterogeneity. While striking, the existence of this supply-side wedge alone does not imply inefficiency in offset trade, nor does it directly reveal its source.

Therefore, we next investigate whether the equilibrium interaction of demand and adverse selection limits trade in offset markets. Our empirical approach leverages a natural experiment

to analyze this directly, exploiting the introduction of a standardized, *pooled*, exchange-traded offset contract alongside bilateral, project-specific OTC trades. The standardized contract trades at a single price, delivering buyers a random draw from credits whose sellers opt into settlement at that price. While initially trading at the average OTC price, we observe this pooled contract subsequently unravel. Prices drop, the set of offset credits selecting into trade becomes adversely selected, causing prices to further drop until the market for the pooled contract has unraveled to no trade.

Third, we quantitatively evaluate demand for offsets — shaped by the *status quo* regulatory environment — by assessing the empirical relevance of the two cases highlighted in the conceptual framework: willingness-to-pay for expected emissions reductions *versus* nominal offset credits. We exploit shocks that revealed widely publicized information about the wedge between estimated and issued offset credits and the underlying carbon reductions for a subset of offset projects. Using a hedonic triple-difference design, we estimate that a one tCO2e increase in expected reductions increases offset prices by approximately $5. Before or without such shocks, prices are orthogonal to estimated reductions. The magnitudes of these results indicate that both cases highlighted in the conceptual framework are quantitatively relevant: status quo offset buyers exhibit a positive willingness of approximately $6 to pay for credits irrespective of expected emissions reductions and a positive, but modest willingness to pay for estimated reductions. These choices shape equilibrium offset market outcomes, but are also endogenous to alternative offset market regulation.

We therefore extend our conceptual framework to an empirical model of offset trade that embeds and interprets our empirical facts and quantifies their implications for offset market regulation. An intermediary awards credits based on a noisy signal of emissions reductions relative to baseline. In the absence of an offset market, land-use decisions — agriculture vs forest — are made given observables and unobservable productivity shocks. A project enters the offset market and increases forest cover if expected revenue from credit sales exceeds land-use opportunity and transaction costs, where a project cannot sell more credits than those awarded by the intermediary. The intermediary may shade credit issuances downward to address a selection-driven wedge or upward to expand the supply of low-priced credits. Buyers choose credits differentiated by characteristics and expected effectiveness. We estimate supply using observed land-use choices (following Souza-Rodrigues (2019)) and offset prices, matching levels and heterogeneity in observed credit issuance and our event study estimates. We estimate demand using the variation provided by the information provision shocks.

Model estimates imply that credit issuances are unbiased estimates of emissions reductions *on average*, but diverge among market participants. In other words, the observed wedge between issued credits and carbon reductions is best rationalized by selection alone, without explicit shading above what is scientifically defensible. At low prices, entered projects are severely selected on optimistic credit awards; this is ameliorated as prices rise. Consistent with the hedonic estimates, *status quo* buyers of credits exhibit positive, but modest willingness to pay for expected reductions, positive willingness to pay for credits irrespective of expected emissions reductions, and are very price elastic. This is consistent with many buyers purchasing credits voluntarily in the unregulated Voluntary Carbon Market (VCM).

With these estimates, we return to our motivating question and assess the viability and social value of offset trade. Our counterfactual analyses contrast the two cases highlighted in the conceptual framework: (1) trade in nominal offset credits with modest willingness to pay for expected reductions (observed) *versus* (2) trade in expected emissions reductions (counterfactual). These two cases align with regulatory regimes in reality: (1) the weakly regulated Voluntary Carbon Market (VCM) *versus* (2) a heavily regulated compliance offset market, in which credits can offset tax or compliance obligations (see, e.g. Pande et al. (2025)). In the latter, we assume that a regulator is subject to the estimates provided by the intermediary, but can impose that transacted offset credits are unbiased in expectation so as to maintain the environmental integrity of trade. We benchmark performance against a global planner's socially-optimal prices.

Our results imply that offset markets face a stark tension in implementation. Under observed trading, trade is *sustained* by a willingness to pay for nominal carbon reductions. This serves as an implicit subsidy for offset projects, facilitating trade at low prices even while the pool of entrants is highly selected on low underlying carbon reductions. Despite large quantities of traded offset credits, we estimate that the market achieves limited environmental impact and therefore may yield a net social welfare loss from investing resources in ineffective projects and buyers over-claiming carbon reductions at the expense of alternative abatement investments (though we do not model the latter cost directly).

By contrast, trade in expected emissions reductions (a regulated compliance offset market) *unravels* — even at high valuations of expected emissions reductions (e.g., at allowance prices in the EU Emissions Trading System (EU ETS)) — as the effects of adverse selection are exacerbated. The expected value of an offset falls below its price at every possible price level, driven by selection on over-optimistic credit assignments at low prices. At any given price, conditioning on the *expected* value of the pool of entrants makes the *marginally*

supplied offset credit unprofitable, despite the fact that the social value of this marginally supplied offset credit exceeds its cost. It is therefore socially-valuable for trade to occur, but offset trade alone will not deliver it. Our estimates therefore imply a direct tension between maintaining the environmental integrity of trade and the existence of trade at all.

We conclude by investigating potential remedies. We focus on solutions that both support trade and align incentives for improved measurement of emissions reductions. Compliance offset markets must be *explicitly* subsidized — in contrast to the implicit subsidization in *status quo* markets that undermines environmental integrity — to support trade at socially-valuable levels. For example, the EU has recently approved the use of 5% reductions (relative to 1990 levels of $\sim$ 5 billion tCO_2e) through the use of international offsets. We estimate that at current EU ETS prices ($83), this goal requires a $16 per ton subsidy to achieve this stated additional reduction while maintaining environmental integrity. If, instead, offsets were allowed into the EU ETS at face value, they would trade at very low prices (below $10 per ton). No subsidies would be required to support this trade, but the offsets would overstate true emissions reductions by a factor of five.

Importantly, realizing offset markets' promised gains from trade requires *both* regulatory oversight *and* a public subsidy. This combination is required: without subsidies trade would not exist, and without strong regulatory oversight (the *status quo*), participants *benefit* from the cheap credits afforded by poor measurement and the ensuing adverse selection. In contrast to the *status quo*, combining regulatory oversight with a public subsidy provides strong incentives to invest in improved measurement, which in turn may limit the extent of adverse selection and the magnitude of the required subsidy. Therefore, while offset markets can address missing markets for abatement, this gain from trade does not come for free. Beyond offset markets, our results have broader implications for the limits and challenges to voluntary climate action.

Related Literature. Our primary contribution is to provide evidence of and a framework to assess the equilibrium implications of adverse selection in voluntary and compliance carbon offset trading mechanisms. We build on and complement prior work studying supply-side selection in payments for ecosystem services (Aspelund and Russo, 2026), energy efficiency (Chen et al., 2025), and renewable energy investments (Calel et al., 2025) by studying implications for the viability and design of trading mechanisms. The central challenge of imperfect measurement is a common theme across offset market designs (Groom and Venmans, 2023; Aronoff and Rafey, 2025) and incomplete regulation (Montero, 1999).

Our focus on tropical forest preservation and reforestation builds on a large literature documenting low abatement costs of forest preservation and restoration in the tropics (Jayachandran et al., 2017; Souza-Rodrigues, 2019; Araujo et al., 2026; Assunção et al., 2026; Mishra, 2026). Our model builds directly on this literature and documents similar opportunities. We then investigate whether these gains can be realized through trade.

Our revealed preference estimates of willingness to pay for offset credits contributes to a literature on private contributions to public goods (Andreoni, 1990; Kotchen, 2006; Bénabou and Tirole, 2010) as offsets are frequently voluntarily purchased by corporations. Our results quantitatively evaluate the scope for and limits to voluntary environmental action.

Finally, we build on and contribute to a large literature studying adverse selection and limits to trade (Akerlof, 1970; Cutler and Reber, 1998; Einav et al., 2010; Hendren, 2013; Wang and Xing, 2023) and information intermediaries (e.g., Bolton et al. (2012)). Our empirical results document new and direct empirical evidence of market unraveling and apply this logic to explain a long-standing puzzle in offset market implementation. When observed, offset trade is almost invariably characterized by a compromise of environmental integrity (Macintosh et al., 2025), or trade in credits divorced from their underlying environmental or social value. Our results indicate that this may be a fundamental consequence of the market design: (unsupported) trade may only exist when environmentally compromised.

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