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The market for carbon offsets: insights from US stock exchanges

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Abstract

Carbon offsets are a critical factor in addressing the harmful effects of climate change. The recent growth in voluntary carbon offsets is a welcome development in a setting dominated by compliance-oriented carbon markets driven by government emissions targets. However, fragmentation, volatile pricing, and low quality offsets have been problematic indications of inefficiency in this market. We argue that the underlying economic theory for compliance-oriented markets is different from that of voluntary offsets. Coase's (1960) Problem of Social Cost lays the groundwork for the former while Akerlof's (1970) Market for Lemons underpins the latter. We propose a literature on successful responses to the lemons problem, which employ a two-sided market structure (or multi-sided platform, MSP). We suggest that the value chain in the voluntary offset market could be reconfigured using this structure, as one possible response to the lemons problem. This structure has the added advantage of driving innovation and adoption in accounting and other market standards that would be tailored to support the carbon offset market.

Keywords Carbon market · Emissions trading · Carbon offset · Lemons problem · Stock exchange

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1 Introduction

A voluntary market for carbon offsets has emerged recently as a potentially important tool for mitigating climate change. A cause for optimism about the growth of such a market is the decades-long success of carbon credit and emissions trading schemes around the world. The Kyoto Protocol, adopted in 1997, led to the development of a world-wide system of carbon targets and mitigation projects (Michaelowa et al., 2019). Meanwhile, in the United States, which signed but did not ratify the Kyoto agreement, pollution mitigation efforts at a local level rely on a system of emissions allowances (Ahonen et al., 2023).

The theoretical basis for these systems, including cap-and-trade, emissions trading, and pollution taxes, rests on the economic insight of Coase's (1960) "The Problem of Social Cost". Using the example of a cattle ranch that abuts a farm, in which cattle stray onto the farm's land and damage its crops, Coase argued that, in the absence of transaction costs, the farmer and rancher would be able to privately negotiate the economically optimal level of crop damage. All that was needed was for the government to allocate a clear right, either to undamaged crops or to damage a neighbor's crops. This logic underpins the successful environmental protection mechanisms designed over the decades since Coase's (1960) Nobel-prize-winning paper. As Goulder (2013) notes, "[t]rading rights to pollute—which was just an idea in the minds of a few economists 45 years ago—has…largely lived up to its basic promises… environmental targets have largely been met…for local pollutants…as well as for carbon dioxide…."

More recently, *voluntary* demand for carbon credits has arisen, especially from large firms whose customers and shareholders have environmental concerns (MacDonagh & Williams, 2024; Twidale & Mcfarlane, 2023). Thus, firms voluntarily purchased about $1 billion of carbon offsets in 2021 (Zelljadt, 2022) and an estimated $2 billion in 2022 (MacDonagh & Williams, 2024). Are voluntary markets, which seem poised to grow, the natural successors of the earlier government-backed schemes built on Coasean logic?

Several events—and theory—suggest the answer to this question is not so straightforward. Observers note that the market could grow substantially but only if credibility problems are addressed (BloombergNEF, 2023; Reuters, 2023; Blaufelder et al., 2021; Forest Trends 2023). A scandal at Verra, which "manages the world's leading voluntary carbon markets program" (Verra, 2024), cast significant doubt on the quality of carbon credits. A recent investigation of the organization found that "more than 90% of their rainforest offset credits do not represent genuine carbon reductions" (Greenfield, 2023). Firms like Gucci and Nestle have stopped buying carbon credits and the market overall fell 6% in the first half of 2023 (Twidale & Mcfarlane, 2023).

We propose that the economic problem for a *voluntary* market is fundamentally different from that of a market driven by government targets, i.e., a *compliance-driven* market. In a voluntary market, buyers of a good or service face information asymmetry with sellers, such that they cannot assess quality knowing that sellers have an incentive to overstate quality. This causes buyers to distrust the market. In the extreme, this "lemons problem", which Akerlof (1970) described in the context of

bad used cars, can cause buyers to abandon the market, resulting in market collapse. Such a market failure might unfold in the nascent global market for carbon offsets.

Given this theoretical basis for voluntary carbon markets, we argue that a literature on how institutions mitigate the lemons problem can inform solutions. For example, an analysis of the lemons-mitigating mechanisms of the New York Stock Exchange (NYSE) indicates that ownership drove incentives to improve quality and trust in stock investing (Diamond & Kuan, 2018). Two insights are applicable to a voluntary carbon market. First, mechanisms can draw upon a burgeoning literature on two-sided markets (e.g., Rochet & Tirole, 2003, 2006) to address such open issues as defining and standardizing carbon credits, where progress in carbon accounting (Kaplan et al., 2023a; Roston et al., 2023) and standards (Ahonen et al., 2023) is being made. Second, because ownership is critical to incentivizing quality, the owners of a high-quality carbon market will be the main beneficiaries of the market. Thus, large buyers of carbon offsets might collectively create a high-quality market for their own use (Stanford Law School, 2022) or, following the NYSE example, their agents might do so.

This study contributes to the literature on carbon markets, expanding its focus beyond government policy to include a private ordering solution. We argue that the underlying economic problem for voluntary markets is different from that of compliance-based carbon markets and therefore must employ the literature on lemons markets, including two-sided markets.

2 Context

In the context of carbon markets, the literature discusses compliance-driven markets and voluntary markets. Compliance-driven markets are built upon a theory by Coase (1960) that gives government a key role in assigning property rights and, in practice, also designing and implementing the market. Voluntary carbon markets have arisen more recently and involve autonomous demand for carbon offsets. They therefore must address a lemons problem, described in the Nobel-prize-winning theory by Akerlof (1970). The lemons problem is very much in evidence in the growing market for voluntary offsets, so a literature on markets that overcome the lemons problem provides insights.

2.1 Compliance-oriented carbon markets

The idea that markets could achieve efficient levels of pollution originates with Coase (1960), who argued that an upstream polluter and a downstream party could implement a solution of payments and pollution levels, simply by granting one party the right to pollute (upstream firm) or to clean water (downstream firm). A key insight is that while government has a role to play, in allocating a property right, the market, i.e., the two parties, autonomously determines the price and level of pollution.

Coase's theory informs an approximation of this market via emissions trading systems, in which a government confers upon certain firms the right to pollute up to a limit and to trade emissions allowances. The cap is chosen by the government to

achieve a level of pollution, but trading and prices vary according to the market. A cap-and-trade system grants tradable carbon credits to firms that have reduced carbon beyond a target (Ahonen et al., 2023).

An extensive international infrastructure has been built since the Kyoto Protocol was adopted in 1997 to support national greenhouse gas (GHG) emissions targets for signatory countries. Michaelowa et al. (2019) detail the ups and downs of the international market for carbon credits over four epochs in the history of carbon targets and markets. Countries had to agree on a number of issues in order to implement carbon-reduction projects, measure them accurately, and assess progress against national targets. A number of criteria are now widely agreed upon (Stubbs et al., 2021; Ahonen et al., 2023; Broekhoff et al., 2019), including those listed in Table 1.

The United States failed to ratify the Kyoto Protocol and therefore has been a latecomer to the international market for carbon offsets. It thus provides a separate context in which to assess a Coasean market. In the United States, Coase's theory was implemented to reduce pollution at a *subnational* level, such as the city of Los Angeles and the state of California. These schemes have largely worked as theorized, achieving pollution targets and autonomous pricing (Goulder, 2013; Stavins, 2022). But recent scandals in California's cap-and-trade program demonstrate that government-run markets are vulnerable to regulatory capture and self-dealing, even in large, established markets (Nowicki, 2021; Halper, 2021).

2.2 Voluntary carbon markets

Voluntary demand for carbon offsets (Dhanda and Hartman, 2011) is not fully addressed by Coase's model of social cost. Incentives are one key difference between voluntary and compliance buyers of carbon credits. Compliance buyers follow a host of rules in meeting their carbon obligations and are answerable to regulators. By contrast, voluntary buyers are responding to demand from shareholders or customers and are therefore free to offset their carbon emissions in whatever manner satisfies those stakeholders. However, stakeholder scrutiny is severe, so voluntary buyers are strongly motivated to buy only high-quality offsets (MacDonagh & Williams, 2024).

This need for high quality suggests the need for a different approach, Akerlof's (1970) theory of lemons, in which buyers do not know the quality of a used car and sellers have an incentive to overstate the quality of their used car. In the extreme, the market fails because buyer bids are depressed by information asymmetry, which in turn causes high-quality sellers to withdraw.

Table 1 Criteria for Projects to Qualify as Carbon Credits

Criteria	Description
Realness	Promised GHG impact does happen
Additionality	GHG impact happens because of this offset sale
Leakage	Project increases GHG emissions outside the project area
Permanence	Stored carbon duration as promised
Verification	Offset impact quantified accurately
No double counting	Project can only be sold once
Do no harm	Project should not generate other harms

Recent investigations suggest that the lemons problem is very much in evidence. Verra is the dominant registry for GHG projects; its Verified Carbon Standard (VCS) program was responsible for 76% of credits traded globally in 2021 (Ecosystem Marketplace, 2022). But a study of 18 forestation projects certified under Verra's VCS program found problems with additionality (the carbon would have been reduced without the project) and double counting. The study concluded that only

> 6.2% of the 89 million *ex-ante* offsets from the…projects would likely be associated with additional carbon emission reductions…these projects have already been used to offset almost three times more carbon emissions than their actual contributions to climate change mitigation – with another 47.4 million carbon offsets being readily available in the market. (West et al., 2023)

A joint investigation of this and other data by the newspapers *The Guardian* and *Die Zeit* together with SourceMaterial, an independent investigative journalism organization, concluded that these kinds of problems "are rife in an industry whose claims to mitigate climate change are significantly at odds with reality," (SourceMaterial, 2023).

A few months after the release of this study of the "sell side" of the carbon offset market, *Climate Home News*, a leading journalistic effort focused on climate change, published a detailed report of mismanagement on the "buy side." It found that a large climate offset project developed by oil giant Shell was "riddled with accounting loopholes and questionable integrity claims," (Civillini, 2023a). The project was developed in a partnership with Verra to generate credits for Shell's own use and to be brokered to other buyers. Verra has now put all projects using the same methodology on hold while it carries out an internal investigation. While Verra "strongly disputed" some of the data presented by *The Guardian*, its CEO announced he was stepping down in the wake of the publication of both reports (Civillini, 2023b).

This problem of lemons in the voluntary market for carbon offsets is existential, according to Akerlof's theory (1970). Indeed, big firms have begun to exit the offset market, citing problems at Verra. The voluntary offsets market has declined for the first time in seven years (Twidale & Mcfarlane, 2023).

3 Institutions for mitigating lemons: insights from the NYSE

Given how recent a phenomenon voluntary carbon markets are, aspects of an efficient market are still being addressed piecemeal. The role of private carbon credit registries, which perform a listing function, is still being discussed by policymakers (Ahonen et al., 2023). Facilitating transactions and establishing standards are additional functions of a market that are "still mostly over-the-counter, and transactions are reported somewhat arbitrarily despite great efforts by exchanges and aggregators to standardise both offset credits and transactions," (Zelljadt, 2022). Pricing is another important function that is struggling. "Although there are some trading exchanges that facilitate offset credit transactions, most transactions occur 'off-exchange,' making price discovery difficult. The price of an offset credit can range from under US$1

to well over US$35," (Broekhoff et al., 2019). Indeed, while pricing is one of the most fundamental roles of a market, many see it as a job for government. Goulder (2013) observes that "price volatility has been a concern for voluntary carbon markets, a problem that government-determined prices can prevent."

However, scholarship on the industrial organization of markets suggests that private firms can implement two-sided markets, or multi-sided platforms (MSPs) to great effect. Diamond and Kuan (2018) detail how private interests can be organized to provide a high-quality market using an MSP as a structure. Their context is the New York Stock Exchange (NYSE), which has been studied extensively in the market microstructure literature, but Parker and Van Alstyne (2005) first identified the stock market as a two-sided market. Rochet and Tirole (2003, 2006) provide an early mathematical representation of MSPs, in which a defining feature is a cross-platform externality: the more customers there are on one side of the market, the more valuable the market is to the other side. Newspaper subscribers and advertisers are an older version of today's social media and search platforms. Applied to the NYSE, a key insight is that the two sides of the exchange are not buyers and sellers of stock but listing firms and investors. Accordingly, a lemons problem exists in the stock market—providing high quality listings and assuring investors of that high quality—just as it does in the carbon offset market. Two key insights arise from this analysis. First, ownership drives the incentive to produce a high-quality market. Second, the incentives drive the selection of the mechanisms that generate efficient outcomes.

3.1 Ownership drives incentives

Diamond and Kuan (2018) explain that the role of ownership in driving incentives is particularly stark in the stock market context, where two exchanges provide virtually all of the listings in the United States, the NYSE and the Nasdaq. Both were member-owned nonprofits until they demutualized in the mid-2000s, but their members differed. The NYSE was controlled by underwriters, who are paid by firms to help list their shares. Underwriters have an incentive to mitigate the lemons problem because they profit more, the more accurate the price of the firm's stock. Just as with used cars, if the buyer lacks accurate information, he will offer a low price for a high quality used car, whereas if he has accurate information, he will offer a higher, more accurate price.

By contrast, the Nasdaq is owned by the National Association of Securities Dealers (NASD). Dealers are on the other side of every investor transaction, so they buy from investors selling stock and sell to investors buying stock, and profit on the difference in these prices, i.e., the price spread. This source of profit for member-owners of the exchanges leads to very different decisions and outcomes in their choice of listing firms, spreads, and more.

Collectively, underwriters, over the course of the exchange's centurieslong history, understood several counterfactuals, such as the low quality of listings on the informal "curb" market and their attendant low share prices, as well as the price volatility in contemporaneous commodities markets, such as that for cotton (Mandelbrot, 1963). A formal organization, through which rules could be implemented

and enforced, could be a vehicle for collective action that promoted the interests and profits of member underwriters.

Because of the two-sidedness of the exchange, underwriters' interests were also aligned with ordinary investors. Long-term investor trust in stock investing had to be won through genuine integrity of information. The more investors were willing to invest in stocks, the more firms would seek to list their shares. The more firms listed, the more investors had to choose from, and the more valuable stock investing was for investors. This cross-platform externality, a key attribute of MSPs, was abundant in this setting.

The outcome of the NYSE's strategy was an efficient stock market in which individual and institutional investors felt secure investing for the long-term in high quality stocks that grew steadily and avoided dramatic swings in price. Meanwhile, listing firms obtained good valuations for their shares, lowering their cost of capital, and their underwriters profited handsomely. Most importantly, this efficient outcome was the result of underwriters' business model and profit motive, which led them to implement several rules and practices, whose goal was to mitigate information asymmetry.

3.2 Incentives drive mechanism design

Features of an efficient market, including transparent and stable pricing and liquidity, apply as much to a stock market as to a supermarket. The MSP owner designs mechanisms to implement a certain level of efficiency. Thus, a grocery store might choose stocking algorithms to never run out of certain items (liquidity) and update prices at most weekly (price stability). MSPs might have an incentive to introduce inefficiency. Because Nasdaq owners are dealers, who profit on the spread between buy and sell prices, they prefer a larger spread, which introduces uncertainty about the true underlying price of the stock.

By contrast, the NYSE's owners were interested in suppressing the information asymmetry at the heart of the lemons problem. Accordingly, they required public and timely disclosure of any information that would affect the valuation of the company and thus the stock price. This included regular, periodic financial reporting, which in turn, created demand for accounting standards.

The NYSE also implemented mechanisms to make price discovery more stable and transparent. Rather than expect a governmental authority to dictate a valuation for each company, the NYSE aggregated information from investors, in effect crowdsourcing prices. The mechanism they chose was a simultaneous double auction performed by their appointed "specialist" for each listed stock.

Other rules, including requiring the specialist to act as buyer or seller of last resort and a rule limiting the size of price changes between consecutive trades, provided liquidity and price stability.

In sum, features of a market, including accounting standards and prices, are endogenous to the ownership and incentives of an MSP. Thus, one route to the adoption and implementation of the carbon accounting principles now being developed (Kaplan et al., 2023a; Roston et al., 2023) is for a private market to be organized as an MSP by motivated owners.

4 Application to a carbon market

Implementing an MSP-based market involves reconfiguring the current market value chain from a typical vertical structure of upstream and downstream firms to a multi-sided market, in which two or more types of customers interact through an intermediary firm, the MSP.

4.1 A. current value chain configuration

The current value chain includes information, pricing, and listing functions in the following configuration. A Verifier sells his services to a Project. A Registry also sells his services to a Project. The Buyer finds the Project on the Registry and then buys the Project over the counter. Figure 1 depicts this market configuration.

An example taken from Verra shows some of the pitfalls and shortcomings of this configuration. Verra gives projects the opportunity to have their offsets certified, and claims to audit and verify the Verifiers who perform the certification. After the project is certified, it chooses a selling price and is entered into Verra's registry. A typical project is the Xinzhou Echeng Afforestation Project by Jingle County Sailing Carbon Sink Development Co. located in Echeng County, Xinzhou City, Shanxi Province of North China. The project

> aims to address climate change and promote sustainable development in the region…[by] planting trees on barren mountains to increase carbon sequestration…through direct planting on previously barren lands in Echeng County. The project will cover 6 towns, 6 townships and 223 administrative villages…. The project is expected to generate GHG emission removals of 19,966,354 tCO_2e in 60 years with an average annual GHG emission removal of 332,773tCO_2e. (Jingle County, 2023)

The planting of nearly 40,000 hectares of forest was deemed complete on June 8, 2021. It is currently deemed to be "under validation" by another mainland Chinese

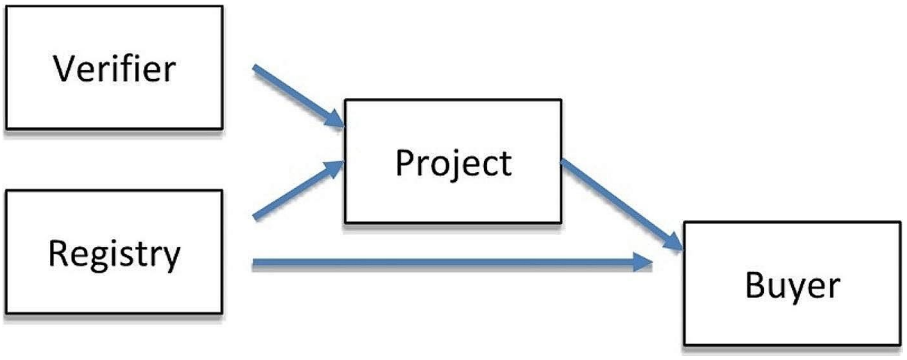

Fig. 1 Current market configuration

Fig. 2 Reconfigured market configuration using an MSP

entity, Centre Testing International, a large entity headquartered in Shenzhen that provides testing and certification services and is listed on Shenzhen's stock exchange.

Some of the challenges of using such a project for carbon offsets include the investigation needed to verify the underlying project and CO_2e estimates. How would a prospective buyer, for example, test whether, over the next 60 years, hundreds of Chinese villages where more than 116,000 residents currently work, farm and live will be able to sustain a massive forestation project on what is described as "barren" land? (Jingle County, 2023 at 11). In addition, Verra is relying on the representations of not just the sponsor but also a verifier, which requires the verifier also be "verified." In this case, the verifier is a mainland Chinese firm, which presents significant barriers and costs associated with verification. As the recent scandals reveal, Verra might require verifiers to meet certain standards but is unable to provide effective oversight or enforcement of those standards. Verifiers are typically paid by the project developers thus generating an inherent conflict of interest (Broekhoff et al., 2019).

4.2 MSP value chain reconfiguration

How might an MSP reconfigure this value chain? A market modeled on the NYSE is one possible configuration. The MSP establishes accounting and reporting standards, sets minimum quality standards for listings, and carefully vets listings to maintain those listing standards. Thus, the MSP—or its members—are involved in the verification and listing function rather than relying solely on outside Verifiers. Projects list on the MSP, Buyers find Projects to buy and then transact on the MSP. Rather than issuing a price for the project, an auction mechanism might be implemented to discover prices. Figure 2 depicts this value chain.

Several open questions would need to be addressed in implementing a carbon market using an MSP. First, the definition of the asset to be bought and sold needs clarification. Currently, carbon credits have not reached the level of standardization and legal definition associated with stocks.[1] That said, the accounting field has methods for defining asset values, incorporating the passage of time, and risk. Thus, forest projects that sequester carbon for decades but could burn down are but one example of the sophistication, clarity, and standardization now being proposed by the evolving field of carbon accounting (Kaplan et al., 2023a; Roston et al., 2023). We argue that

[1] It took several decades at the end of the 19th and beginning of the 20th centuries for the modern market for stocks, as we know them today, to emerge. Both underwriters and the NYSE played leading roles in establishing the standards that made efficient trading possible (Carosso, 1970; Banner, 1998).

certain owners have an incentive to drive the development and adoption of standards and definitions.

Second, carbon credits might, understandably, involve less trading volume than is the case with stocks, especially as they expire with the passage of time. Thus, a mechanism for selling an original carbon credit might be needed more than a mechanism for continuously trading credits. In that case, an auction mechanism might be needed that differs from the continuous double-auction used by the NYSE.

Finally, a remaining issue is who might organize such a high-quality market. In the stock market, underwriters have an incentive to ensure accurate pricing for high quality assets. But underwriters are service providers for clients, in this case, large firms raising money from investors. In the carbon credit case, large firms buying carbon offsets would also be clients. So, if underwriters emerged to serve those buyers with thorough due diligence on carbon projects, it might be profitable to operate an exchange. This could generate forward momentum for a high-quality market where more buyers would emerge, willing to pay appropriate prices for now high-quality offsets. In turn, high quality projects would become more attractive to entrepreneurs so the supply side would become more robust as well. At present, no such intermediaries have emerged. Instead, large firms are organizing themselves. Frontier is "a collaboration between Alphabet, McKinsey, Meta, Shopify, and Stripe," (Stanford Law School, 2022). These collectives, or "private consortiums have moved the quality conversation forward faster than existing stakeholders like Verra, which holds a two-thirds share of the accreditation market and may be under-incentivized to improve standards," (Stanford Law School, 2022).

5 Discussion and conclusion

A natural starting point for designing a voluntary carbon offsets market would seem to be existing markets for carbon- and other pollution-trading, which have been successful in achieving pollution targets. But the voluntary nature of the emergent demand for carbon offsets moves the voluntary offset market away from the Coasean origins of existing carbon markets to a very different theoretical realm, that of the lemons problem. Fortunately, the literature on a key tool for implementing lemons-mitigating markets, MSPs, is extensive and growing, providing guidance on the strategy and design of efficient markets. The application of MSP theory would follow a long history of economic theory being used to improve markets. In this case, though, private parties rather than policymakers would need to act.

In theory, the market for carbon offsets could function just as the New York Stock Exchange has long operated. The current helter-skelter structure of the carbon "market," however, falls far short of the NYSE standard. As the U.S. Congressional Research Service has observed:

> A primary concern regarding the use of offsets in compliance and voluntary markets is their quality and credibility. The availability of offsets that do not actually reduce GHG load in the atmosphere could undermine the overall policy goal of achieving specific GHG emission reductions. Problems with offset

> quality and credibility can raise questions about the effectiveness of compliance and voluntary markets. (Stubbs et al., 2021)

The scholarship being done on such matters as accounting standards, investment vehicles for green investors, government pricing of carbon, and more, are necessary supports of a global market for carbon offsets. Scholars have examined how carbon offsets differ from other tradable assets, including accounting methods that would accurately measure carbon removal and duration (Kaplan et al., 2023a). Time-duration measurements are useful for buyers of offsets seeking to match their activities with the appropriate offsets (Roston et al., 2023). A host of other detailed accounting and verification issues can and should be addressed if firms are to make accurate claims about their zero carbon emissions (Kaplan et al., 2023a, b). Indeed, Kaplan et al. (2023b) points out that such elements are necessary to successful markets, including U.S. equity markets, and that "existing registries might convert from their current passive role as transactional intermediaries into something like exchange authorities."

But our discussion of an efficient spot market for equities suggests that these supports are endogenous features of an efficient market. That is, an efficient spot market creates demand for sensible accounting standards, financial instruments, and prices. Therefore, the use of such supports will be limited until an efficient marketplace is created. On the other hand, when such a marketplace is created, there will be no shortage of thoughtful responses to demand for supporting innovations.

Note that the market we describe is organized and operated by a private firm. Both the NYSE and Nasdaq were member-owned nonprofits. But the differences between them, which were numerous, were driven by their members' incentives, which were, in turn, defined by their business models. How underwriters made a living, compared with how broker-dealers made theirs, determined what structures and rules they implemented.

Given the demand—and hence profit to be made for members of an exchange—we propose two sources of entry for a member-owned exchange. The first closely mimics the NYSE's origins in underwriting. Here, we imagine investment banks, profitably servicing large buyers of offsets, whose task is to find high-quality providers of offsets. Working together, these intermediaries could create a market of carefully vetted offsets. Currently, big buyers of offsets are organizing their own collectives, which could be another avenue to a high-quality offsets market or a demonstration of demand that spurs intermediaries to mobilize.

This study contributes to the literature on carbon markets by identifying a crucial distinction between compliance-based markets and voluntary markets. The theory underlying these markets is based on different sources of market failure. We suggest how a change in theorizing, from Coase (1960) to Akerlof (1970) can direct attention and activity toward a private ordering solution. We also suggest a literature that could guide mechanism design for an efficient and effective MSP. Given the importance and potential impact of voluntary markets, a focus on the lemons problem is most urgent.

Declarations

Conflict of interest The authors have no conflicts of interest related to this research.

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