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Importance of Well-Functioning Markets in Unlocking Carbon Offset Opportunities

By Philip Rossetti

Properly functioning carbon markets are likely to play a key role in capturing emission abatement opportunities that rely on changes in agricultural and forestry practices.

Executive Summary

Voluntary carbon markets harbor significant opportunities to further incentivize emission abatement in the agricultural and forestry sectors of the U.S. economy. Prior analysis of these opportunities from The Breakthrough Institute and the Environmental Defense Fund highlights that the potential for future emission abatement by 2030 is between 535 million metric tons of carbon dioxide equivalent (CO_2e) and 1.1 billion metric tons of CO_2e.[1] These values are near to or exceed U.S. annual agriculture emissions, which are 589 million metric tons CO_2e.[2] However, we note that existing carbon markets are unlikely to achieve these outcomes on their own, as farmers report not being offered enough funds to incentivize changes in behavior.[3]

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1. Dan Blaustein-Rejto et al., "From Lab to Farm," The Breakthrough Institute, Dec. 12, 2022, p. 69. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf; Alison J. Eagle et al., "Ambitious Climate Mitigation Pathways for U.S. Agriculture and Forestry: Vision for 2030," Environmental Defense Fund, 2022, p. 24. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.
2. "U.S. Inventory of Greenhouse Gas Emissions 2023," U.S. Environmental Protection Agency, 2023, p. ES-17. https://www.epa.gov/system/files/documents/2023-02/US-GHG-Inventory-2023-Main-Text.pdf.
3. "Carbon Contracts Don't Pay Enough, Large-Farm Survey Finds," Successful Farming, Feb. 8, 2023. https://www.agriculture.com/news/crops/carbon-contracts-don-t-pay-enough-large-farm-survey-finds.

We hypothesize that a significant factor in the low cost of carbon offsets available in markets today, and consequently the low level of payments offered to farmers for altering farming practices, is due in part to the complexity and opacity of existing carbon markets. Lack of clarity as to the quality and additionality of carbon offsets that are widely heterogeneous creates a fundamental information deficiency problem, and the costs of remedying such deficiencies may exceed the potential value to the consumer purchasing the offset. As a result, low-quality offsets flood the market and depress prices, which directs capital away from more certain emission abatement opportunities. We note that one estimate of the effect of tighter requirements on carbon offsets would increase prices by up to 3,000 percent, indicating that low-quality offsets may have a substantial negative effect on the proper operation of carbon markets, despite a high willingness among consumers to undertake voluntary actions to achieve carbon neutrality.[4]

Opportunities to address these challenges in carbon markets arise through new programs, such as the Carbon Offsetting Reduction Scheme for International Aviation (CORSIA) and the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM).[5] This paper notes that proper implementation of these programs in valuing life-cycle emissions may also show the benefit of U.S. products that are comparatively lower-emissions than competitors. As an example, we show that U.S. beef is only a third of the emissions per kilogram of meat compared to Brazilian beef, which is the next largest global producer of cattle meat.[6]

For policy recommendations, we note three key opportunities:

1. **Utilize** the new authorizations of the Growing Climate Solutions Act to improve the transparency and credibility of U.S. agriculturally-related offsets. This could alleviate information deficiencies, improve consumer confidence in offset quality and put pressure on providers of competing low-quality offsets to also improve certainty in their offset benefit.
2. **Engage** with United Nations (U.N.) organizations and the EU in their implementation of programs that value international emission outcomes through offsetting or emission intensity in order to develop standards of accounting that emphasize certainty of quality, additionality and accuracy of emission accounting. This will likely show that U.S. products have substantial advantages over foreign competitors, and incentivize that environmentally-focused capital be directed toward genuine emission-abating activities.
3. **Avoid** heavy-handed regulations on firms participating in voluntary carbon markets, which could ironically raise the costs of climate action and reduce investment in emission-mitigating activities.

Key Acronyms

(CO2e):	Carbon dioxide equivalent
EU:	European Union
CORSIA:	Carbon Offsetting Reduction Scheme for International Aviation
CBAM:	Carbon Border Adjustment Mechanism

Policy Recommendations: Key Opportunities

4. Jagteshwar Singh and Tiffanie Tan, "Carbon offsets price may rise 3,000% by 2029 under tighter rules," *Bloomberg*, March 2, 2022. https://www.bloomberg.com/professional/blog/carbon-offsets-price-may-rise-3000-by-2029-under-tighter-rules.
5. "Factsheet: CORSIA," International Air Transport Association, November 2022. https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---corsia; "Carbon Border Adjustment Mechanism," European Commission, last accessed March 16, 2023. https://taxation-customs.ec.europa.eu/green-taxation-0/carbon-border-adjustment-mechanism_en.
6. "FAOSTAT, Food and Agriculture Organization of the United Nations, Nov. 4, 2022. https://www.fao.org/faostat/en/#data/EI.

Introduction

In the United States and internationally, there are rapidly growing carbon markets that allow consumers to invest in climate mitigation through the purchase of credits. These credits serve to verify an action that sequesters a greenhouse gas (GHG) or that avoids its emission.[7] A classic example of a carbon market is paying for new tree planting, where the carbon sink helps to offset another emitting activity. The advantage of these markets is that they allow industries—especially those that cannot decarbonize easily under normal circumstances, like air travel—to invest in climate mitigation actions that negate the climate harm caused by the industry.

From an economic perspective, carbon markets offer a very high level of utility for enabling climate action that otherwise would not take place. A classic challenge of climate economics is the emission abatement curve, in which there are a number of emission abatement opportunities that are low in cost, but also substantial opportunities that are so high in cost that they are not practical.[8] Policies such as a carbon price, cap-and-trade or regulatory mandates may induce industries to capture emission abatement opportunities, but in many cases these policies are largely absent either due to lack of political desire or due to the high cost of enacting a new policy relative to its low economic benefit.

A classic challenge of climate economics is the emission abatement curve, in which there are a number of emission abatement opportunities that are low in cost, but also substantial opportunities that are so high in cost that they are not practical.

However, consumers do have their own preferences, and large companies have been increasingly investing in climate mitigation due to the increased brand value they achieve from such actions.[9] This has allowed capital to flow into carbon markets and capture emission abatements that otherwise would not occur, and does so in a fashion that encourages offset providers to minimize their costs and maximize the profit they yield from selling offsets.

Agriculture and forestry in particular are two sectors that provide substantial opportunities for carbon avoidance and sequestration. There are already a number of effective practices in these sectors: the employment of cover crops; the creation and utilization of biochar (a substance similar to charcoal); the inclusion of forestry in agriculture to improve soil health and yield; the introduction of alternative diets for livestock to reduce enteric fermentation; the improvement of manure management; and the use of advanced seeds with larger root structures.[10]

However, a challenge is emerging as confidence in carbon markets has waned, and growing investigation into these markets has cast doubt on many of the claimed environmental benefits.[11] This problem distorts the incentives that undergird carbon markets, where investors may be steering money away from genuine emission abatement opportunities. As such, this paper aims to answer three questions:

7. "What are carbon markets and why are they important?" United Nations Development Programme, May 18, 2022. https://climatepromise.undp.org/news-and-stories/what-are-carbon-markets-and-why-are-they-important.
8. Pauline Blum et al., "Net zero or bust: Beating the abatement cost curve for growth," McKinsey & Company, April 13, 2021. https://www.mckinsey.com/capabilities/operations/our-insights/net-zero-or-bust-beating-the-abatement-cost-curve-for-growth.
9. Rory Clune et al., "Navigating America's net-zero frontier: A guide for business leaders," McKinsey & Company, May 5, 2022. https://www.mckinsey.com/capabilities/sustainability/our-insights/navigating-americas-net-zero-frontier-a-guide-for-business-leaders.
10. Blaustein-Rejto et al. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf.
11. Patrick Greenfield, "Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows," *The Guardian*, Jan. 18, 2023. https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe.

1. What is the fundamental problem that would need to be resolved for carbon markets to function more effectively?
2. Is there a significant benefit that could be attained from better functioning carbon markets?
3. What policies would be needed to better enable carbon markets to capture these outcomes?

Untapped Opportunities and Economic Benefits

In economics, markets are often thought of as self-regulating entities. This is because consumers have a disciplinary effect on producers, demanding a certain level of quality. As an example, there are few regulations on the quality of furniture because the demand from consumers helps to steer producers to find a balance between production cost and quality. People do not want to buy furniture that will fall apart quickly, but they also do not want to overpay for furniture, creating a motivation for producers to capture market share by finding a balance.

Some markets require significant regulation to prevent producers from passing costs onto other entities. A lack of repercussions incentivizes producers to cut costs by polluting more.

However, some markets require significant regulation to prevent producers from passing costs onto other entities. Pollution is a common example, where producers of commodities that involve pollution do not bear the costs of their pollution. A lack of repercussions incentivizes producers to cut costs by polluting more. In this instance, regulation can prevent the "externalization" of costs involved with production by placing specific expectations upon the producer.[12]

But markets for carbon offsets, carbon dioxide removal credits and carbon sequestration presents something of a unique challenge when determining the appropriate role of government. Generally, almost all activity in carbon markets involves the reduction of externalities, which would indicate that government involvement could ironically increase pollution by raising the costs of actions that curtail pollution. In this case, it would seem that a largely deregulated market for carbon sequestration could stimulate market entry.

The challenge for carbon sequestration markets, though, is that the disciplining effect of consumer demand has not stimulated the appropriate increase in the quality of offsets. This is likely because of the opacity and complexity of carbon sequestration and the heterogeneity of offsetting and accounting methods.[13] As the Task Force on Scaling Voluntary Carbon Markets has noted:

> Fragmented and complex markets mean that the typical buyer's journey involves a number of difficulties: insufficient understanding of offsetting, negative publicity on associated projects, difficulty finding sufficiently large project sizes, lack of commonly agreed principles to ensure the quality of credits, regulatory uncertainty, lack of pricing transparency, and limited visibility into project life cycle.[14]

The result is an informational deficiency problem, where the complexity of the market deters consumer participation and inhibits the ability of prices to efficiently

12. Will Kenton, "Externality: What It Means in Economics, With Positive and Negative Examples," Investopedia, Dec. 31, 2022. https://www.investopedia.com/terms/e/externality.asp.
13. "Taskforce on Scaling Voluntary Carbon Markets Final Report," Institute of International Finance, January 2021, p. 41-46. https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf.
14. Ibid, p. 46.

direct capital. Essentially, the cost of acquiring the information necessary to make optimal decisions for carbon sequestration consumption exceeds the value of the product for many consumers. This is because the primary value add that comes from carbon sequestration is additional brand value that consumers gain from claims of carbon neutrality. In some cases, companies that are participating in carbon management schemes like the Carbon Offsetting and Reduction Scheme (CORSIA) receive the value of their compliance under such programs, which is to say the increased brand value from participation or avoided penalties from being non-compliant. Due to the somewhat nebulous value add of carbon sequestration, the discrepancy of quality between one form of carbon sequestration or avoidance and another is rarely reflected in a real-world value to the purchasing company.

The major challenge to the market is that there is also heterogeneity in methods for carbon sequestration or avoidance practices, and they, too, have varying upfront costs that do not always align with their perceived value to consumers.

One exception to the carbon sequestration value issue is that for companies that put an emphasis on the carbon neutrality of their brand, pushback against the utilization of low-quality carbon offsets may stimulate an increased demand for high-quality carbon sequestration efforts. Not surprisingly, firms emphasizing their climate commitments to their customers are among the first to increase investment in more advanced forms of carbon sequestration, like carbon dioxide removal (CDR).[15] Conventionally, carbon offsets vary widely in price, anywhere from a few cents to $100 per ton (though commonly around $15-20 per metric ton), and technologically-based CDR can have a cost of around $300 per metric ton.[16] Despite this high cost, the demand for CDR credits exceeds the available supply, as consumers of CDR credits emphasize the value of their carbon neutrality claims and see reliance on lower-certainty carbon sequestration as damaging to their brand.[17] In this way, we see a heterogeneity of consumer demand for varying levels of quality in carbon sequestration.

The major challenge to the market is that there is also heterogeneity in methods for carbon sequestration or avoidance practices, and they, too, have varying upfront costs that do not always align with their perceived value to consumers. Some consumers care less about the accuracy or credibility of carbon sequestration or offsets, and others care more. For consumers that are less concerned about quality, a market incentive is created to produce as many offsets as is possible at as low a cost as possible. Consequently, the value of the offset to the consumer (providing a claim of carbon neutrality) becomes divorced from the claimed value of the carbon offset (additionality of Greenhouse Gas (GHG) reduction).

Because consumers of carbon offsets and sequestration are valuing a utility of outcome that is distinct from the environmental benefit of the commodity, a system that has the potential for abuse emerges due to perverse incentives. Consumers of low-quality offsets or sequestration are not always interested in practices that would remedy informational deficiencies regarding those offsets. This encourages

15. Katie Brigham, Why Big Tech is pouring money into carbon removal," *CNBC*, June 28, 2022. https://www.cnbc.com/2022/06/28/why-companies-like-stripe-meta-and-alphabet-are-behind-carbon-removal.html.
16. Silvia Favasuli and Vandana Sebastian, "Voluntary carbon markets: how they work, how they're priced and who's involved," *S&P Global Commodity Insights*, June 10, 2021. https://www.spglobal.com/commodityinsights/en/market-insights/blogs/energy-transition/061021-voluntary-carbon-markets-pricing-participants-trading-corsia-credits.
17. Matthias Honegger et al., "Who Is Paying for Carbon Dioxide Removal? Designing Policy Instruments for Mobilizing Negative Emissions Technologies," *Frontiers in Climate* 3:672996 (June 7, 2021). https://www.frontiersin.org/articles/10.3389/fclim.2021.672996/full.

offset providers to offer their product at the least possible cost, regardless of its true emission reduction relative to the claimed emission benefit. In this dynamic we see a likely reason why, despite significant private sector interest in carbon offsets, markets providing these options have remained convoluted, confusing and a frequent topic of newsworthy scandal.[18]

Because the public benefit of carbon offsets is derived from emission avoidance, it is not always achieved. Since access to information would reveal the truth of offset additionality, it could be argued that there exists a role for government in addressing the informational deficiency issue, and how policy could be applied to create such an intervention must be carefully assessed.

The value that is offered by remedying informational deficiency is twofold: first, there is great value and public benefit in redirecting carbon sequestration efforts towards practices that produce additional climate benefit; second, there is significant potential value that could be captured by ensuring that carbon offsets sold on open markets truly have additional climate benefits. Redirecting carbon sequestration efforts could work to reduce GHG concentrations in the atmosphere and avoid damages related to climate change, and thus produce a public benefit that is non-exclusionary. For example, Microsoft cannot invest in reducing CO_2 levels to give themselves a climate benefit without also giving everyone else the same benefit. Ensuring that carbon offsets are sold on open markets is similarly beneficial. The degree of public benefit from carbon sequestration depends largely upon the level of permanence in the sequestration, but current estimates are approximately $50 per metric ton of carbon dioxide pollution avoided.[19]

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Impact of Low-Quality Offsets on Capital Flows

A significant source of concern about the quality of available carbon offsets is tied to the large share of offsets from renewable energy projects, who claim that they have avoided utilization of fossil fuel assets. It is estimated that approximately 38 percent of carbon offsets that are purchased are related to renewable energy, and as the total number of carbon offsets available on open markets has increased, the share of renewable offsets as a proportion of total offsets has remained relatively unchanged.[20]

Particularly relevant to renewable offsets is that the falling costs of renewable energy means that, in many cases, renewable energy facilities would be built regardless of payments offered for carbon offsets. This means that they would yield no additional environmental benefit and the environmental value of the carbon offset should be zero.[21] To better understand this, consider the claim that renewable

18. Simon Zadek, "Trouble with Carbon Markets," Project Syndicate, March 1, 2023. https://www.project-syndicate.org/commentary/carbon-offset-markets-scandal-need-to-strengthen-integrity-by-simon-zadek-2023-03.
19. "EPA Fact Sheet: Social Cost of Carbon," U.S. Environmental Protection Agency, December 2016, p. 4. https://www.epa.gov/sites/default/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf.
20. Akshat Rathi et al., "Junk Carbon Offsets Are What Make These Big Companies 'Carbon Neutral,'" *Bloomberg*, Nov. 21, 2022. https://www.bloomberg.com/graphics/2022-carbon-offsets-renewable-energy.
21. "Annual Energy Outlook 2022: Levelized Costs of New Generation Resources," U.S. Energy Information Administration, March 2022, p. 8. https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf.

energy is cheaper than fossil fuels, and that it is this lower cost that is leading renewable energy to displace fossil fuels. If this is true—and falling renewable costs suggest that market forces are a greater factor in renewable deployment than subsidy—then it cannot be simultaneously true that renewable energy requires additional payment to be economically viable.

Because over a third of the entire carbon offset market are renewable offsets, the supply of offsets is flooded and the cost of offsets is depressed. Now compare this to practices that would yield additional environmental benefit through changing behavior that is currently uneconomic, and we see that the low value of offsets occludes activity from the market. For example, a recent survey of farmers found that only 6 percent of farmers were offered $30 or more per metric ton of carbon offset, while two-thirds said they were offered $10-20 per metric ton, and generally found the contracts did not pay enough to incentivize change, with farmers wanting $60 per acre.[22] Comparatively, the Bayer Carbon Initiative requiring new no-till and cover cropping practices only offered $9 per acre.[23] In this we see that the high supply of low-quality offsets depresses the price, and occludes emission-reducing behavior from receiving payment.

There has also been concern about offsets related to forest conservation. The world's largest setter of offset verification standards is Verra, which is also an eligible supplier of offsets for CORSIA compliance through their Verified Carbon Standard program. A recent analysis estimated that more than 90 percent of Verra's "Rainforest Offsets" offer no additional climate benefit at all, casting doubt on the organization's credibility.[24] Similarly, one of the world's largest conservation organizations, The Nature Conservancy, was criticized for selling forest conservation offsets that yielded no additionality.[25]

Quality restrictions would likely raise the value of carbon offsets and increase the capital on offer for genuinely additional behavior. One analysis found that stricter regulations on carbon offset quality could cause a price increase of 3,000 percent.[26] Such restrictions on quality would likely result in larger payments for more credible offsetting activities.

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The Benefit of Greater Certainty in Additionality

On the supply side, improved information can steer capital toward better practices for carbon offsetting and sequestration, but overcoming informational deficiency can also have an impact on consumption activity beyond investment decisions. Europe's Carbon Border Adjustment Mechanism (CBAM) has highlighted that governments are demanding greater clarity about the carbon content of consumed goods.[27] This, coupled with consumer preference for lower-carbon goods, indicates

22. "Carbon Contracts Don't Pay Enough, Large-Farm Survey Finds." https://www.agriculture.com/news/crops/carbon-contracts-don-t-pay-enough-large-farm-survey-finds.
23. Megan Stubbs et al., "Agriculture and Forestry Offsets in Carbon Markets: Background and Selected Issues," Congressional Research Service, Nov. 3, 2021, p. 15. https://crsreports.congress.gov/product/pdf/R/R46956.
24. Greenfield. https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe.
25. Ben Elgin, "These Trees are Not What They Seem," *Bloomberg*, Dec. 9, 2020. https://www.bloomberg.com/features/2020-nature-conservancy-carbon-offsets-trees.
26. Singh and Tan. https://www.bloomberg.com/professional/blog/carbon-offsets-price-may-rise-3000-by-2029-under-tighter-rules.
27. European Commission. https://taxation-customs.ec.europa.eu/green-taxation-0/carbon-border-adjustment-mechanism_en.

that there is value in remedying information deficiency for producers that are less emission-intensive than their competitors.

For emission-intensive industries, particularly agriculture, there is significant variance in the carbon content of products. Although Europe's CBAM does not apply to food products at this time, a future application of CBAM or other efforts aimed at allowing consumers to express a preference for lower-carbon products would steer more capital towards carbon offsetting and sequestration behavior.

Informational deficiency, or low-confidence in claims of additionality, deprives relatively lower-carbon producers from receiving investment and lowers demand for their products. Continued information deficiency results in low-confidence in carbon offsetting and sequestration practices, with large amounts of capital directed toward practices that have minimal environmental benefit. Remedying information deficiency would result in redirecting capital toward practices that have climate benefit and increase consumer confidence in products that claim carbon neutrality.

Potential Climate Benefits from More Robust Markets

While it is easy to say that more robust carbon markets will stimulate greater climate action, there remains the question of how policymakers could expect carbon markets to facilitate further emission abatement or offsetting. Politicians seem to favor government-led, central planning solutions to climate change over competing policy options.[28] A common critique of utilizing carbon markets or carbon pricing to address climate change is that it would allow firms to "pay to pollute," or that command and control mechanisms may work better to achieve emission abatement.[29]

Market-based opportunities, by contrast to command-and-control policies, can capture opportunities for emission abatement that exist anywhere, allowing for lower-cost options.

Yet such critiques of market-based climate policy mechanisms fail to appreciate the complex dynamism of the U.S. economy, as well as the limitations of government-managed climate policy. The Congressional Budget Office has noted that market-based policies are superior to command-and-control policies (i.e. regulations, subsidies and mandates) because government-led solutions can only affect issues in which there exists authority for intervention.[30] Market-based opportunities, by contrast, can capture opportunities for emission abatement that exist anywhere, allowing for lower-cost options.[31]

Those who prefer central-planning mechanisms would further contest that all that is needed is for Congress to expand the authority of government in addressing climate change, but it should be noted that despite major climate bills being debated even during the presidency of George W. Bush, the United States is no closer to implementing widespread emission caps today than it was 20 years ago.[32]

28. "The Biden Plan for a Clean Energy Revolution and Environmental Justice," JoeBiden.com, last accessed March 16, 2023. https://joebiden.com/climate-plan.
29. Chris Greenberg, "Carbon offsets are a scam," GreenPeace, Nov. 10, 2021. https://www.greenpeace.org/international/story/50689/carbon-offsets-net-zero-greenwashing-scam.
30. "Implications of a cap-and-trade program," Congressional Budget Office, April 24, 2008. https://www.cbo.gov/publication/24775.
31. Ibid.
32. "McCain, Lieberman Laud Bi-Partisan House Climate Change Bill," U.S. Senate Committee on Commerce, Science, and Transportation, March 30, 2004. https://www.commerce.senate.gov/2004/3/mccain-lieberman-laud-bi-partisan-house-climate-change-bill.

It is important to note that the inefficacy of command-and-control climate policies alone does not create an argument in favor of broader adoption of market-based climate policies. Rather, we should also be able to claim that such policies will have a clear impact. In terms of general market-based policies, such as a carbon tax vis-à-vis regulation, research has shown that market-based mechanisms would achieve greater emission benefit than government-centric ones.[33] Additionally, economic modeling has shown that due to the opportunities to substitute market-based climate policies for less-effective tax and regulatory ones, proper implementation would result in net economic growth.[34]

Carbon markets are frequently a focus of the agriculture sector, where there are many opportunities to produce new offsets. Current agriculture emissions in the United States measure 589 million metric tons, which is approximately 11 percent of net U.S. GHG emissions.[35] Globally, agriculture accounts for about a third of all emissions, and given the rising caloric demands of diets this share of GHG emissions is likely to rise.[36] Policies that reduce agriculture emissions in the United States will likely stimulate innovation in agriculture that is taken up elsewhere. It should be noted that agricultural productivity has increased substantially over the decades, owing to better equipment and science that allows for more food production using less land and inputs. As Figure 1 shows, in the United States agricultural output is now 2.7 times higher than it was in 1948, while utilizing less land, less equipment and requiring only a quarter as much labor per unit of output.[37]

Current agriculture emissions in the United States measure 589 million metric tons, which is approximately 11 percent of net U.S. GHG emissions.

Policies that reduce agriculture emissions in the United States will likely stimulate innovation in agriculture that is taken up elsewhere.

Figure 1: U.S. Agricultural Productivity Changes

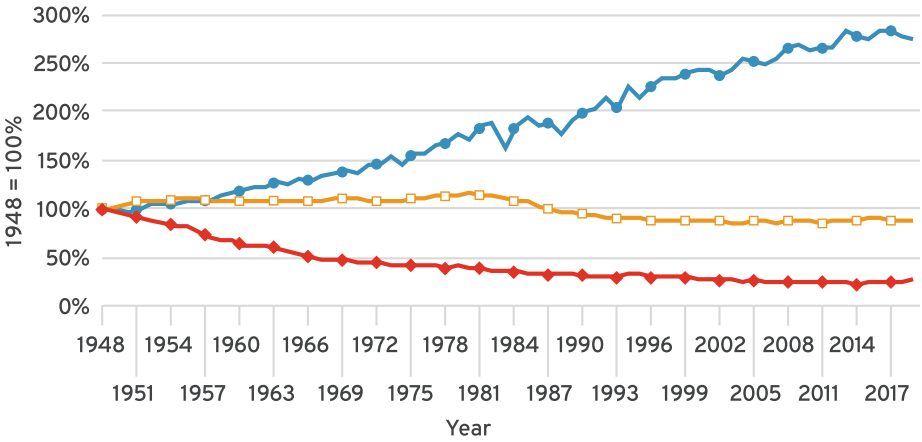


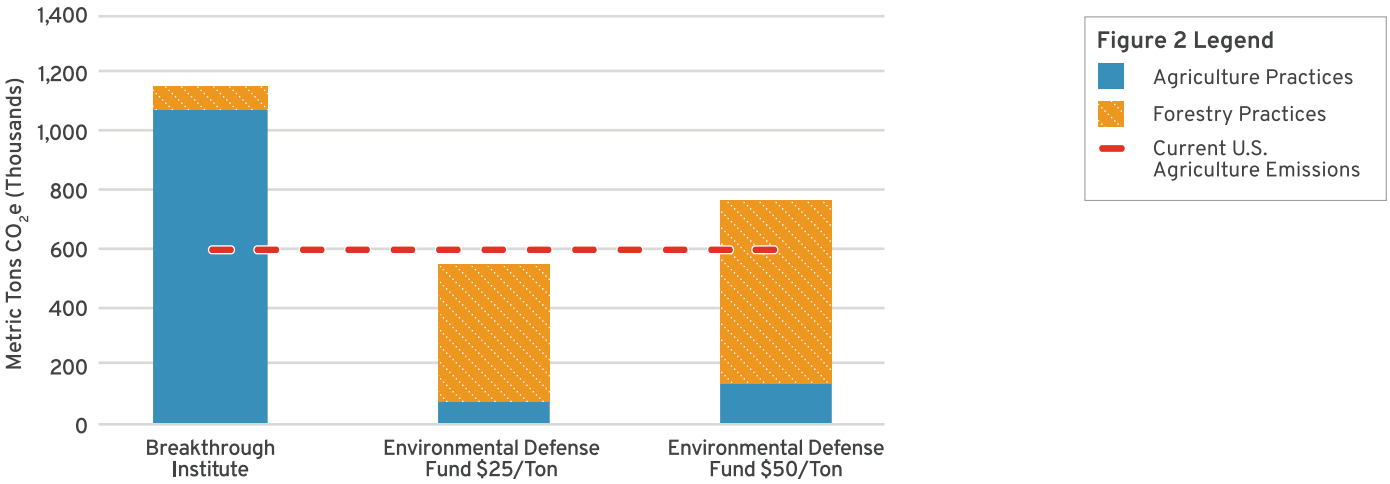
Figure 1 Legend
- Agricultural Output
- Capital Inputs
- Labor Inputs

Source: "Indices of farm output, input, and total factor productivity for the United States, 1948-2019," U.S. Department of Agriculture, Table 1. https://www.ers.usda.gov/webdocs/DataFiles/47679/table01.xlsx?v=8192.3.

33. Marc Hafstead, "Carbon Pricing Calculator," Resources for the Future, Aug. 10, 2020. https://www.rff.org/publications/data-tools/carbon-pricing-calculator; Philip Rossetti, "Testimony on climate change and the Inflation Reduction Act," R Street Institute, Sep. 29, 2022. https://www.rstreet.org/outreach/testimony-on-climate-change-and-the-inflation-reduction-act.
34. Alex Durante et al., "Details & Analysis of the Inflation Reduction Act Tax Provisions," Tax Foundation, Aug. 12, 2022. https://taxfoundation.org/inflation-reduction-act.
35. *U.S. Inventory of Greenhouse Gas Emissions 2023*, U.S. Environmental Protection Agency, 2023, p. ES-17. https://www.epa.gov/system/files/documents/2023-02/US-GHG-Inventory-2023-Main-Text.pdf.
36. Hannah Ritchie, "How much of global greenhouse gas emissions come from food?" Our World in Data, March 18, 2021. https://ourworldindata.org/greenhouse-gas-emissions-food.
37. "Agricultural Productivity in the U.S.," U.S. Department of Agriculture, Jan. 6, 2022. https://www.ers.usda.gov/data-products/agricultural-productivity-in-the-u-s.

Recent research from the Breakthrough Institute (BTI) and the Environmental Defense Fund (EDF) has highlighted two major points regarding the reduction of agricultural emissions: 1) that innovation and changing agricultural practices can yield significant climate benefits that could potentially negate or even exceed the current GHG impacts of farming; and 2) that the economic viability of many of these practices is not far out of reach.[38] Figure 2 shows an overview of the expected emission abatement potential by 2030 from those two studies, with the EDF study showing abatement under either a $25 or $50 per metric ton carbon price.

Figure 2: Potential Emission Abatement from Changing Practices



Source: Blaustein-Rejto et al., Table A6. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf; Eagle et al., Table 3. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.

The BTI study was intended to offer a window into the potential emission abatement opportunities in agriculture, and 65 percent of their total estimated benefit comes from the improved root structure of crops.[39] The innovation effort under the Advanced Research Projects Agency – Energy (ARPA-E) called Rhizosphere Observations Optimizing Terrestrial Sequestration (ROOTS) aims to produce seeds that have greater root structure that can reduce the need for fertilizer (which results in GHG emissions), and also to increase the soil sequestration from plant absorption of CO_2.[40] Even though these improved seeds are not widely available today, they could become commonplace in the future, and the BTI study reflects the optimism for efforts like ROOTS.[41]

The BTI and EDF studies note a potential benefit from increased utilization of forestry in agriculture, referred to as agroforestry.

Importantly, both studies note a potential benefit from increased utilization of forestry in agriculture, referred to as agroforestry. An example of agroforestry is the planting of trees between fields to act as windbreaks as well as to offer shade and improve soil health. The EDF report estimates an upper ceiling of 80 million metric

38. Blaustein-Rejto et al. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf; Eagle et al. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.
39. Blaustein-Rejto et al., p. 69. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf.
40. "ROOTS" Advanced Research Projects Agency – Energy, Dec. 15, 2016. https://arpa-e.energy.gov/technologies/programs/roots.
41. Blaustein-Rejto et al., p. 13. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf.

tons of GHG offsetting from increased agroforestry, and additionally estimates that increased forestry practices could result in 470 million metric tons of increased carbon sinks by 2030 under a $25 per ton carbon price, and 623 million under a $50 per ton carbon price.[42] The EDF estimates that if consumers are willing to pay $25 per ton then an additional 470 million metric tons of CO_2 sinks would be economically viable. However, it is important to note that $25 is below the common value of carbon offsets of around $15-20 per metric ton, indicating that the flood of low-quality offsets into carbon markets is occluding genuine emission abatement from being achieved in the market.

Absent from the BTI and EDF research is the potential benefits of recent (and ongoing) research on the benefits of introducing seaweed into cattle diets. Cattle digestion relies on rumination, in part due to the low nutritional value of grass and other foods for cattle, which results in high levels of methane emission through enteric fermentation.[43] Cattle meat is among the most GHG intensive foods, with a GHG intensity of 13.5 kg of CO_2e per kg of product versus 0.17 kg of CO_2e/kg of product for cereals in the United States.[44]

Absent from the BTI and EDF research is the potential benefits of introducing seaweed into cattle diets. Some species of seaweed are rich in bromoform, a chemical compound that inhibits the production of methane during rumination in cattle, and research has shown the effect of replacing a small portion of cattle diets with seaweed can reduce methane emissions by as much as 82 percent.

Some species of seaweed are rich in bromoform, a chemical compound that inhibits the production of methane during rumination in cattle, and research has shown the effect of replacing a small portion of cattle diets with seaweed can reduce methane emissions by as much as 82 percent.[45] Additionally, research on the effects of seaweed in cattle diet has noted no discernible health impacts, and no discernable change in the flavor or quality of meat from cattle with the altered diet.[46] Seaweed production is scalable, having more than doubled in the last decade to a current 30 million metric tons, and as such may present interesting opportunities for reducing cattle meat emissions.[47]

Current enteric fermentation emissions from meat and dairy cattle in the United States are 188 million metric tons CO_2e, which represents 32 percent of U.S. agriculture GHG emissions and 3 percent of total U.S. GHG emissions.[48] The BTI study estimated a potential to reduce enteric fermentation emissions from feed additives by 34 million metric tons CO_2e, and the EDF study estimated 9 million metric tons.[49] An 80 percent reduction in enteric fermentation across all meat and dairy cattle in the United States would account for 150 million metric tons CO_2e, indicating that even these studies may be underestimating potential emission abatement opportunities in this sector.[50]

42. Eagle et al., p. 24. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.
43. Matthew M. Haan, "Understanding Rumination and Technologies to Monitor Rumination Behavior in Cattle," PennState Extension, July 24, 2020. https://extension.psu.edu/understanding-rumination-and-technologies-to-monitor-rumination-behavior-in-cattle.
44. "FAOSTAT, Food and Agriculture Organization of the United Nations, Nov. 4, 2022. https://www.fao.org/faostat/en/#data/EI.
45. Breanna M. Roque et al., "Red seaweed (*Asparagopsis taxiformis*) supplementation reduces enteric methane by over 80 percent in beef steers," *PLOS ONE* 16:3 (March 17, 2021). https://doi.org/10.1371/journal.pone.0247820.
46. Ibid.
47. "Farmed Seaweed: Overview," World Wildlife Fund, last accessed April 5, 2023. https://www.worldwildlife.org/industries/farmed-seaweed.
48. "U.S. Inventory of Greenhouse Gas Emissions 2023," U.S. Environmental Protection Agency, 2023, p. 5. https://www.epa.gov/system/files/documents/2023-02/US-GHG-Inventory-2023-Main-Text.pdf.
49. Blaustein-Rejto et al., p. 69. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf; Eagle et al., p. 24. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.
50. "U.S. Inventory of Greenhouse Gas Emissions 2023," p. 5. https://www.epa.gov/system/files/documents/2023-02/US-GHG-Inventory-2023-Main-Text.pdf.

Valuing Climate Outcomes Through Consumption

Beyond the opportunities for carbon markets to stimulate investment in changing agricultural practices at the production level, it is also worth considering the utilization of carbon markets or similar pricing schemes in consumption. As noted above, Europe is implementing its CBAM, which would recognize the carbon intensity of commodities in the European Union's existing carbon price mechanisms. Food is not part of the proposed CBAM but represents an interesting opportunity for incentivizing consumers to recognize and prefer lower carbon products, while creating demand for comparatively lower-carbon products.

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For an example of the potential of carbon market mechanisms that value life-cycle emissions and the impact this could have on agriculture, it may be helpful to again consider cattle emissions. Although cattle meat is often noted as an extraordinarily climate-intensive food product, there is less attention on the heterogeneity of the emission intensity of cattle meat. Table 1 utilizes data from the U.N.'s Food and Agriculture Organization to show that, compared to other major cattle meat (such as buffalo meat) producers globally, the United States is among the least emission intensive.

Table 1: CO_2e in Cattle Meat Production

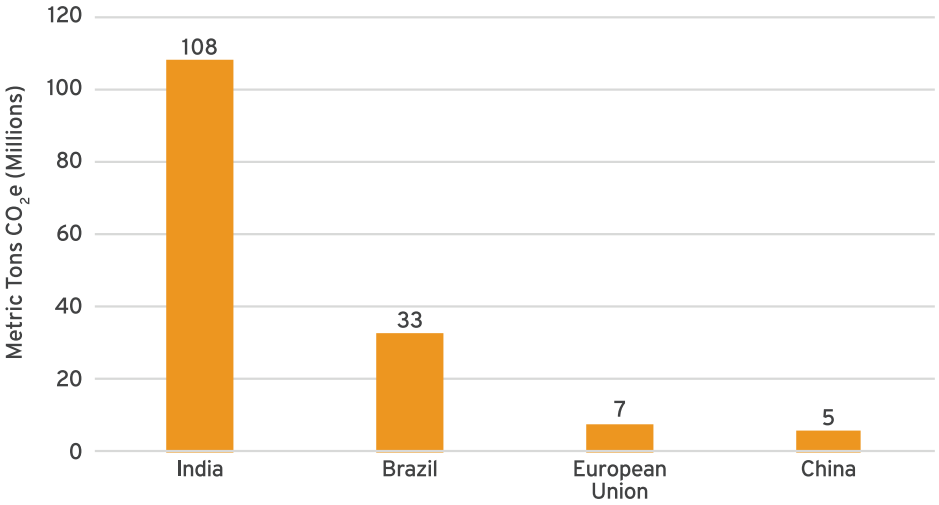
	Production (metric tons of meat)	Emission Intensity (kg CO_2e/kg meat)
United States	12,357,232	13.54
Brazil	10,100,000	39.99
European Union	6,923,681	17.96
China	6,721,394	19.59
India	2,516,140	100.87

Source: "Emission Intensities," United Nations Food and Agriculture Organization Statistics, 2020. https://www.fao.org/faostat/en/#data/EI.

India, notably, is among the most emission intensive beef producers in the world. Though heavily vegetarian nation, India is in fact one of the world's largest exporters of cattle meat and a major source of beef for Asia.[51] While policy focus is often on curtailing cattle meat consumption for climate purposes in the United States, the presence of carbon markets that value emission outcomes over narrower domestic-focused policy agendas would indicate that there is significant emission abatement potential from increasing U.S. cattle meat production for the purpose of export. Figure 3 shows how much emission abatement would be achieved annually by a 10 percent increase in U.S. cattle meat production through displacing foreign competitors.

51. Virginia Harrison, "Holy cow! India is the world's largest beef exporter," CNN Business, Aug. 5, 2015. https://money.cnn.com/2015/08/05/news/economy/india-beef-exports-buffalo.

Figure 3: Emission Reduction from Supplanting Foreign Cattle Meat with 10 Percent Increase in U.S. Production



Source: R Street estimate based on data from United Nations Food and Agriculture Organization Statistical data.

Displacing Indian beef production offers a significant potential for emission abatement opportunity of 108 million metric tons CO_2e. This is even before considering the potential emission abatement from improved feeding for cattle to reduce enteric fermentation.

Cattle meat is the clearest example in which consumption would likely change, since the GHG intensity of current food products is so low that even if there are large carbon prices for more nutritional food, they may make little difference in end-product costs. At a $100 per ton carbon tax, the difference in price between Brazilian beef and U.S. beef would result in roughly $1.50 per pound price difference.

Climate Change and Commerce are Increasingly Connected

Carbon markets and CBAMs could also have significant implications for other industries. Natural gas, for example, has widely differing levels of life-cycle GHG emissions depending upon origin, transportation method and area of consumption. A recent noted that Europe's consumption of natural gas sourced from Russia via pipeline has similar climate impacts to coal on a 20-year global warming potential, and 41 percent higher life-cycle emissions compared to liquefied natural gas (LNG) exports to Europe.[52] For such products, CBAMs could significantly alter incentives for producers to deliver cleaner products to markets. However, achieving such an outcome depends largely upon the design of the policy mechanism, and the accuracy of its accounting.

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52. Selina Roman-White et al., "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update," National Energy Technology Laboratory, Sept. 12, 2019, p. 20. https://www.energy.gov/sites/prod/files/2019/09/f66/2019%20NETL%20LCA-GHG%20Report.pdf.

CORSIA, on the other hand, aims to offset GHG emissions from international air travel by 85 percent.[53] CORSIA accepts a wide array of carbon offset types, including renewable-based offsets that have difficult-to-verify additionality. This diminishes the climate benefit of the program by steering investment away from activities that would yield additional climate benefit.[54] Airlines participating in CORSIA will likely seek the least cost offset that is compliant with CORSIA, regardless of its climate benefit. Since CORSIA has set a relatively low standard for carbon offsetting, the capital that airlines would otherwise invest in climate change mitigation is directed towards low-value projects, even though there may be more certain opportunities to reduce climate emissions such as changes in agriculture practices in the United States.

Overall, there exist substantial emission offsetting and mitigation opportunities in U.S. agriculture and forestry that are expected to be relatively low cost but remain uncaptured because these opportunities are still below the expected price needed to induce behavioral change from farmers. As such, capturing these benefits is contingent upon policy reform that ensures that low-quality offsets do not hold equal value in carbon markets to efforts that are more certain to yield benefits.

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Policy Recommendations

Policy changes from government should be focused on enhancing the functions of the market to steer capital towards outcomes that consumers value and that offer public benefit, which in this case is carbon offsetting and sequestration. An imprudent policy could deter capital investment from carbon sequestration, erode confidence in climate mitigation practices, and/or retain incentives to ignore environmental impacts related to production. With this in mind, we offer three recommendations to policymakers.

Implement the Authorized Programs Under the Growing Climate Solutions Act to Improve Carbon Offset Transparency.

At the end of 2022, President Joe Biden signed the Growing Climate Solution Act (GCSA) into law.[55] The legislation allows for the U.S. Department of Agriculture (USDA) to offer technical assistance to farmers that consider engaging in carbon markets, helping them identify opportunities for producing and selling offsets. The implementation of the GCSA is an opportunity for the U.S. government to remedy informational deficiencies in carbon markets.

While authorized to assist farmers, the USDA should ensure that its criteria for what constitutes additionality in carbon avoidance, sequestration and other offsetting

53. "Factsheet: CORSIA," International Air Transport Association, November 2022, p. 1. https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---corsia.
54. "CORSIA Eligible Emission Units," International Civil Aviation Organization, November 2022. https://www.icao.int/environmental-protection/CORSIA/Documents/TAB/ICAO%20Document%2008_Eligible%20Emissions%20Units_November%202022.pdf.
55. Office of Congresswoman Abigail Spanberger, "President Signs Into Law Spanberger's 'Growing Climate Solutions Act,' Greenlights Making Carbon Markets More Accessible to American Agriculture," U.S. House of Representatives, Dec. 30, 2022. https://spanberger.house.gov/posts/president-signs-into-law-spanbergers-growing-climate-solutions-act-greenlights-making-carbon-markets-more-accessible-to-american-agriculture.

practices is transparent. It should also identify carbon markets that adhere to the same standards. Through this, participants in carbon markets would be able to rely on a third party to identify what markets to participate in, and that meet the same U.S. criteria of additionality standards.

This represents a significant opportunity for the U.S. government, which should be utilized to establish a high standard that ensures the additionality of new practices, and increases confidence in their climate value. The added benefit is that improving confidence in U.S. agriculture-based carbon offsets and credits will also put pressure on other offset sources (such as renewable energy), to show similar levels of confidence in their additionality.

Encourage International Carbon Offsetting Mechanisms and Carbon Border Adjustment Mechanisms to Account for Certainty of Benefit

Further adoption and expansion of mechanisms like CBAM and CORSIA is likely, given the increasing preference of Western nations to undertake climate action that targets the emission intensity of consumed goods and services. It is in both the economic and climate interest of the United States to encourage these mechanisms to adopt proper accounting methods that value climate additionality, and correctly estimate life-cycle emissions of products. This is especially important given that the United States is a much cleaner relative producer of emission-intensive products, including in the agriculture sector.

As CORSIA leaves its pilot phase in 2023, the United States should engage with the International Civil Aviation Organization to encourage changes to the program that would raise the minimum level of quality for offset eligibility, ensuring that less-certain offsets like those coming from renewable energy projects do not offer compliance.[56] Similarly, as Europe begins its first phase of CBAM and considers future expansions to industries covered by the mechanism, the United States should be actively engaged with its European partners to ensure that there is commonality of standards and estimates in estimating the emission intensity of various commodities, which would highlight the emission benefits of consuming U.S. products and thereby increase demand for them.

Europe begins its first phase of CBAM and considers future expansions to industries covered by the mechanism, the United States should be actively engaged with its European partners to ensure that there is commonality of standards and estimates.

Although carbon pricing remains unpopular in the United States, there has been an increase in attention towards a U.S.-developed CBAM that would rectify the incentives for higher-polluting imports over domestic products.[57] As a brief explanation, taxes can be easily "border adjusted," where both imports and domestically produced goods are treated the same and only the input costs of the product are considered. A challenge for climate, though, is that the United States' utilization of regulations instead of a carbon price mean that domestic goods are subject to a shadow carbon price in the form of regulation that does not apply to

56. "Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)," International Civil Aviation Organization. https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.
57. Tori Smith, "U.S. Carbon Border Adjustment Proposals and World Trade Organization Compliance," American Action Forum, Feb. 8, 2023. https://www.americanactionforum.org/insight/u-s-carbon-border-adjustment-proposals-and-world-trade-organization-compliance.

imports, thus creating a mismatched regime where no value is placed on climate benefits outside of U.S. borders. The Bipartisan Policy Center has noted that despite this, there may be opportunities for a U.S. CBAM, and proper implementation of such a policy could eliminate an undue preference for imports and allow for carbon markets to play a more prominent role in steering capital towards the least-cost, most effective methods of abating GHG emissions.[58]

Although we do not explicitly recommend the implementation of CBAM or similar mechanisms due to the complexity of their implementation, we do recommend that in instances where they are adopted that U.S. policymakers engage in the process to ensure that emerging programs properly value lifecycle emission outcomes.

Do not Force Scope-3 Disclosures for Firms Utilizing Carbon Offsets or Sequestration

The Securities and Exchange Commission (SEC) has proposed a requirement that firms claiming carbon neutrality through the use of offsets or sequestration must account for all their emissions and disclose their "Scope 3" emissions—which is to say all emissions involved in their operations, including the emissions of employees commuting.[59] Chairman Gary Gensler has walked back expectations of this requirement, which R Street notes may be exceedingly difficult to comply with.[60] But, the proposal of the policy signals that, if it can legally be done, there are policymakers who would desire this shift.

Such a policy would reduce climate mitigation by increasing the costs to firms that engage in climate mitigation practices. On the surface, a policy forcing emission disclosure would seem to remedy the informational deficiency problems that this paper notes, but some consideration toward outcomes makes the benefits of forced emission disclosure less certain. Firms that engage in carbon offsetting do so because of the comparative brand value they receive and the demands of their consumers. To the extent that the costs of these actions are below the perceived value, firms will continue to engage in them.

Policymakers must appreciate that information deficiencies exist in markets often because the value of the information is below the cost of attaining it. This creates a transaction cost problem, where an otherwise beneficial action is avoided simply because of the costs of performing it. A forced emission disclosure à la the SEC proposal would entail extraordinarily high costs, whereas the preference for a better functioning carbon offset and sequestration market is that verification should be performable easily and at a low cost.

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58. Xan Fishman et al., "Understanding Border Carbon Adjustments," Bipartisan Policy Center, Nov. 29, 2022. https://bipartisanpolicy.org/download/?file=/wp-content/uploads/2022/11/BPC_Energy-CBAM-Report_Final.pdf.
59. "The Enhancement and Standardization of Climate-Related Disclosures for Investors," Securities and Exchange Commission, March 21, 2022, pp. 263-264. https://www.sec.gov/rules/proposed/2022/33-11042.pdf.
60. "Public Input from the R Street Institute on Proposed rule for 'The Enhancement and Standardization of Climate-Related Disclosures for Investors,'" R Street Institute, May 27, 2022, pp. 9-11. https://www.rstreet.org/outreach/public-input-from-the-r-street-institute-on-proposed-rule-for-the-enhancement-and-standardization-of-climate-related-disclosures-for-investors.

Under the SEC's proposal, it is likely that many firms would end up preferring not to make any climate-related commitment at all, and given that fewer firms would do so, it would also reduce competitive pressures among firms to "beat" their competitors in carbon neutrality.

Conclusion

Information deficiencies that create consumer impressions of illusory equality among carbon offsetting opportunities exacerbate the lack of trust in and growth of carbon markets in the United States and abroad. Uncertainty as to the credibility of offsets and complexity of multiple verification regimes creates a cost to potential carbon offset consumers that deters consumers from purchasing offsets that are more likely to yield additional climate benefit.

Information deficiencies that create consumer impressions of illusory equality among carbon offsetting opportunities exacerbate the lack of trust in and growth of carbon markets in the United States and abroad.

Because renewable energy is oftentimes an economic choice even without revenues from offsets, renewable energy-related offsets can be provided at essentially no additional cost to the offset producer, flooding carbon offset markets with offsets that are profitable at any price. Yet the potential climate benefits of carbon markets are largely dependent upon investors willing to fund activities that abate emissions. As higher supply depresses offset prices, the willingness of firms to pay for emission abating activities falls below the cost of undertaking new action.

The effect of this dynamic is likely substantial. Research on the abatement opportunities in agriculture and forestry, two industries most likely to alter behavior in response to incentives provided through carbon markets, shows potential annual emission abatements in the range of between 535 million metric tons CO_2e and 1.1 billion metric tons CO_2e.[61] Properly functioning carbon markets are likely to play a key role in capturing emission abatement opportunities that rely on changes in agricultural and forestry practices.

Additionally, growing interest internationally for carbon offsetting regimes as well as CBAMs is creating new opportunities for U.S. products, which are often cleaner than global competitors. As these programs grow, it becomes increasingly important for the United States to engage in policymaking that encourages carbon markets to reflect the climate value that they offer and reduces the transaction costs associated with involvement in carbon markets from climate-conscious consumers.

61. Blaustein-Rejto et al., p. 69. https://thebreakthrough.imgix.net/From-lab-to-farm-report/Lab-to-Farm_Report_v7.pdf; Eagle et al., p. 24. https://www.edf.org/sites/default/files/documents/climate-mitigation-pathways-us-agriculture-forestry.pdf.

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