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Value of performance baseline in voluntary carbon trading under uncertainty

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Voluntary carbon trading has long been criticized for producing a large number of non-additional offsets. The reason for this production lies primarily in the use of a project-based baseline that misrepresents the business-as-usual (BAU) emissions of individual projects. Performance baseline however, as an alternative baseline approach, does not rely on evaluating individual BAU emissions. Instead, it uses a pre-defined emission threshold for a class of project activities. This paper compares the effects of the two baseline approaches on sectoral emission mitigation and compliance costs by modeling dynamic emission abatement behaviors. In the context of the U.S. commercial building sector, the modeling results indicate that while both baseline approaches are capable of reducing sectoral emissions, the use of performance baseline is especially advantageous under private cost information and uncertain market environments. The performance baseline should be stratified by region to ensure the equity in offset allocation in sectors that are highly diversified in emission magnitudes.

1. Introduction

1.1. Background

To address the threat of climate change, high polluting sectors in the United States are regulated through compliance schemes and assigned legally binding emission caps. These caps constitute a finite supply of emission allowances that can be traded among the regulated entities. In contrast to the compliance schemes, voluntary offset programs provide a market that can encourage unregulated entities to participate. The voluntary programs certify carbon offsets that can be traded in the compliance schemes and counted toward compliance goals in the regulated entities [1]. In 2016 alone, over $66 million USD of forest carbon offsets were transacted, most of which were audited to a standard, primarily the Verified Carbon Standard [2]. These transactions contribute to internalizing emissions cost and provide incentives for seeking cost-effective means to control carbon emissions [3].

The voluntary offset program, however, has faced substantial criticism in the last few years, and there is evidence that a significant number of offsets come from projects that would have been undertaken anyway [4]. These non-additional offsets, when traded to the regulated entities, implicitly expand the emission caps in compliance schemes and result in failing to achieve the desired emission targets. This means that the threshold for determining additionality, a baseline against which emission reductions can be certified as carbon offsets, may be systematically biased. This bias is particularly prominent in evaluating project-based reduction against a counterfactual baseline, that is, a level of emissions that would occur in the absence of the project [5]. As future business-as-usual emission has great uncertainty, it would be very unlikely to set a reliable baseline to avoid non-additionality crediting [6].

The use of project based baseline is risky because a certifying agency is limited in its ability to propose counterfactual baselines. It must consign this task to the individual project proponents. This, resultantly, leaves great uncertainty regarding the integrity of baseline determination. As indicated by Burke (2016), the Government cannot know true project counterfactuals, and thus has voluntarily allowed funding projects to be proposed by the private sector. The lowest auction bids are likely to often be non-additional “anyway” projects, which has resulted in a systematic skew towards low-quality abatement [7].

As an alternative approach though, a performance baseline addresses this weakness in that it no longer relies on evaluating individual projects but instead uses a pre-defined emission threshold

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for a class of project activities [8]. Individual projects that meet or exceed the threshold automatically qualify as additional projects, obviating the need for each project to determine additionality in its own right. Previous studies show that sectoral performance baseline can create a robust and credible market for tradeable carbon offsets, building upon the lessons of the project-based baselines [9]. However, the performance baseline is also criticized for producing non-additional offsets [5]. Because it is uniformly applied to a class of project activities, it inevitably over-allocates offsets to some projects and under-allocates offsets to others. The performance baseline is, therefore, also at risk of promoting less cost-effective investment projects and allocating non-additional offsets to those projects.

The impact of a baseline, either a project-based baseline or a performance baseline, has been extensively studied under the Clean Development Mechanism, where the baseline is applied to developing countries for generating certified emissions reductions that relieve the reduction obligation of developed countries [10–12]. This impact analysis centered on alternative baseline rules, such as the rules of historical emissions, expected emissions, and industry-average emissions. Different baseline rules represent different trade-offs between the concerns of information accuracy, participation incentives and investment cost-effectiveness. Because project performance is often context dependent, there has not been a consensus on the most effective baseline rule for a universal case. As suggested by Bento et al. (2016), baseline stringency should be tailored to project characteristics and market conditions that influence the proportion of over-credited offsets to under-credited emissions reductions [13]. This indicates that additional research is needed to evaluate which baseline rule is the most appropriate in which circumstance.

In addition, previous studies raise a concern regarding the co-benefit of carbon mitigation, e.g., production efficiency improvement [14]. The co-benefit sometimes enables a project to be self-profitable, which is, by definition, one type of non-additional project. This issue, however, has yet to be incorporated into a quantitative analysis. Thus, there is a need to advance the understanding of the cost-effectiveness of mitigation projects, taking into account the potential co-benefits of such projects as well as the nature of the price and technology uncertainties.

1.2. Motivation and significance

This paper compares the effects of the two baseline approaches on sectoral emission mitigation and compliance costs by modeling dynamic emission abatement behaviors. The significance of this study includes the following three perspectives and has been summarized in Table 1. First, this paper stands in contrast to the promising perspectives for the existing voluntary carbon trading mechanism, as well as the theoretical attraction of using traditional project baselines to measure emission reductions. The efficiency of traditional baselines relies heavily on the ability to create an accurate prediction of counterfactual BAU emissions. Seemingly small errors in baseline forecasts could result in major increases in carbon leakages that can exceed half of the offsets under most scenarios. If baselines are not accordingly adjusted, there may be no efficiency gain at all due to the increased environmental damage.

Table 1
Comparison of study scope and method.

	This paper	Previous studies
Baseline	Performance & project baselines	Project baseline
	Stratified baseline	Uniformed baseline
	Adjusted for co-benefits	Non-adjustment
Model	Dynamic model	Static model
	Theoretical & empirical models	Theoretical framework model

Second, this paper demonstrates the value of using performance baselines as an alternative to traditional project baselines. While previous studies have advocated for performance baselines as a policy solution, they have focused on conceptual design issues with little detailed baseline analysis [5,15]. This paper offers the first case study of implementing performance standards in the U.S. building sector. The results show that when the BAU emissions are not precisely predicted, the use of performance baselines can avoid up to 80% of carbon leakages. Given rapidly emerging carbon markets, greater impacts should be achieved to equalize marginal abatement costs across the globe [3,16].

Third, this paper proposes the first stratified performance baselines and investigates their abilities in addressing inequity issues in offset allocation. Previous criticism on performance baselines lies in the restriction of attentions to uniformed emission thresholds, which inevitably over-allocate offsets to low BAU emitters and under-allocate offsets to the others [4]. This paper discovered that this problem can be effectively avoided when baselines are stratified based on regional characteristics. At least half of the non-participators can be reengaged to the programs and sectoral emission reductions can achieve the maximum potential.

2. Baseline impact model

Baseline setting is still in its infant stage of development, and there is no consensus on which baseline rule is more cost effective in regulating carbon emissions. The baseline is normally defined in two ways, specifically, project-based baseline and performance baseline. The project-based baseline is the counterfactual business-as-usual (BAU) emission level of a project activity, which represents an emission level without the adoption of any emission abatement technologies. The performance baseline, in contrast, is often a sector-wide threshold that is uniformly applied to a group of buildings without considering individual differences. The United Nations Framework Convention on Climate Change (UNFCCC) established in its Marrakech Accords that an additionality baseline is sufficient if the baseline surpasses the 80th percentile of comparable peers [17]. The comparable peers include the project activities undertaken in the previous five years in similar social, economic, environmental and technological contexts. For simplicity, it is assumed herein that the buildings located in the same climate zone are comparable peers and therefore comprise the bundle for the performance baseline.

A dynamic optimization problem is formulated to study the impact of different baselines on building energy and emission performance. Building owners are assigned with pre-determined baselines and make two-step decisions to reduce energy consumption and associated carbon emissions, as depicted in Fig. 1. In the first step, the owner designs a building by choosing one of the ASHRAE energy standards, namely, ASHRAE 90.1–2007 (standard A), ASHRAE 90.1–2010 (standard B) or ASHRAE 90.1–2013 (standard C). Later versions of the energy standard represent more stringent energy efficiency requirements. Each building has a business-as-usual (BAU) emission $z^0(A)$ based on the minimum requirement of Standard A. If it does not increase energy efficiency, its emission remains as $z^0(A)$ and its incremental cost is zero. If the building complies with a higher energy standard, for example, Standard B, the annual emission is reduced to $z^0(B) = z^0(A) - \Delta z$ and the incremental cost is $ic(B)$. Assuming every unit of emission corresponds to γ utility bill, the annual utility saving is $\gamma[z^0(B) - z^0(A)]$. The use of Standard C is associated with the annual emission $z^0(C)$, and the incremental cost is $ic(C)$. At year t, each building is assigned a baseline $b_{i,t}$ by the regulator. Reductions