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Matthew Kotchen
Andrew Vogt

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ABSTRACT

International environment and development agencies increasingly emphasize external cofinancing when selecting projects to fund. This paper considers whether the emphasis on cofinancing helps promote institutional objectives, or creates perverse and inefficient incentives. We present a model of project selection that can apply to any funding agency, but focus on environmental multilateral funds and climate change. We show that introducing cofinancing objectives to a fund that seeks to maximize its immediate environmental impact is redundant as best, and more likely counterproductive. We test implications of our model using project-level data from two of the leading environmental multilateral funds, the Global Environment Facility (GEF) and the Green Climate Fund (GCF). While tradeoffs exist between emission reductions and cofinancing, we find that they are not strong enough to imply that current cofinancing preferences are diminishing the environmental benefits that funds can claim. However, we also find that the emphasis on cofinancing in project selection is likely to be globally inefficient, as projects with greater cofinancing ratios tend to yield smaller emission reductions per gross dollar spent. This finding should sound a note of caution given the overall scarcity of financial resources available to achieve global climate goals.

Matthew Kotchen
School of the Environment,
School of Management,
and Department of Economics
Yale University
195 Prospect Street
New Haven, CT 06511
and NBER
matthew.kotchen@yale.edu

Andrew Vogt
School of the Environment
Yale University
195 Prospect Street
New Haven, CT 06511
andrew.vogt@yale.edu

1 Introduction

International environment and development agencies increasingly emphasize cofinancing from outside sources as a policy priority. Cofinancing refers to joint or parallel financing through loans or grants by other public or private institutions in support of an agency's chosen projects or programs (International Monetary Fund, 2014). The basic rationale for promoting cofinancing is to leverage a greater pool of financial resources to help accomplish environment and development goals.[1] Climate change mitigation is one area where the emphasis on cofinancing is particularly salient. A critical challenge for meeting international targets to limit global warming is a shortage of financing, with estimates calling for a fivefold increase in climate finance by 2030 (Climate Policy Initiative, 2021). Addressing this shortfall is a stated objective of many bilateral and multilateral development finance institutions (DFIs), and the pursuit of greater cofinancing for projects and programs has become part of their strategy.

This paper addresses a key question: Does the emphasis on cofinancing promote the objectives of these funds, or create perverse and inefficient incentives? We develop a theoretical framework that can apply to any DFI, multilateral fund, or state-owned financial institution, yet we focus discussion on environmental multilateral funds and climate change. We identify conditions under which the pursuit of cofinancing is aligned with a fund's central objective to reduce emissions, or when it introduces tradeoffs in the form of lower (rather than greater) environmental benefits. A fundamental insight is that introducing cofinancing objectives to a fund that seeks to maximize its environmental impact is redundant as best, and more likely counterproductive. We also identify conditions under which a fund's incentives to maximize its own environmental benefits may or may not align with incentives to support globally efficient projects.[2] These conditions, as we show, depend on the extent of cofinancing tradeoffs and 'additionality,' where additionality in this context means that cofinancing for a particular project is not transferable to other potential projects with similar objectives.[3]

[1]Other arguments in support of cofinancing aim toward the same goal but are less direct. These include promoting recipient country ownership of projects and programs; increasing the likelihood of follow-up activities and stakeholder support; broadening the scope of what agencies can undertake; and helping ensure that aid finances only the incremental costs to get projects and programs up and running (Kotchen and Negi, 2019).

[2]Although we focus on multilateral funds, the questions we address apply equally to other settings where public financial institutions seek to mobilize outside private or public financing to accomplish stated objectives. The emerging sector on green banking provides a rapidly expanding example in both domestic and international settings.

[3]With this definition, we are not referring to whether a project is additional, but rather to whether the

We then evaluate conditions of the model with an empirical application, using project-level data from two of the leading environmental multilateral funds, the Global Environment Facility (GEF) and the Green Climate Fund (GCF). Like most funds, the GEF and the GCF have explicit cofinancing policies. The GEF is mandated to meet a particular cofinancing ratio across its portfolio of projects, measuring the number of cofinancing dollars for each dollar spent by the fund (Global Environment Facility, 2018a). The GCF mandate, in contrast, does not specify a particular cofinancing target, but aims to achieve greater cofinancing whenever possible (Green Climate Fund, 2018). Also like other funds, the GEF and GCF have begun to measure their own success—and to compete with one another—on the basis of their cofinancing performance. Multilateral funds must actively seek budget replenishments from donor countries, and funds often present cofinancing as evidence of greater impact, based on the assumption that their own spending 'crowds in' outside financing.[4]

Despite growing emphasis on cofinancing, there is surprisingly little research on its determinants, and less still addressing the possibility that cofinancing may have other, unintended consequences. Analysts have long considered how legal and structural approaches at development banks can be tailored to promote private sector cofinancing (e.g., Niehuss and Rey, 1983). More recent studies have examined the factors that influence cofinancing, including recipient country conditions, project quality, and fund characteristics (e.g., Sissoko et al., 2019). Miller and Yu (2012) focus on the GEF, and find that cofinancing also depends on the type of fund support (grants or loans) and on the environmental focal area, with projects focused on climate change mitigation having particularly high levels of cofinancing. While confirming some of the same results for the GEF, Kotchen and Negi (2019) estimate that cofinancing from public sources contributes to more favorable *ex post* project evaluations, whereas private sector cofinancing has the opposite effect. Finally, Carter et al. (2021) discuss the important challenges that DFIs and multilateral development banks face in establishing the additionality of their own investments and the cofinancing they claim to mobilize.

By focusing on the potential unintended consequences of cofinancing, we hope to contribute a perspective that can help funds make the best use of their available resources. Our simple theoretical framework illustrates how the pursuit of cofinancing as a distinct objective is not necessarily consistent with an allocation of financing to projects that maximizes

cofinancing is additional. While a growing body of research has focused on project-level additionality (e.g., Schneider, 2009; Alexeew et al., 2010; Calel et al., 2021), the question of financing additionality has received far less attention.

[4]The GEF's progress summaries report cofinancing ratios broken down by project focal area and region (Global Environment Facility, 2020). The GCF's template for project funding proposals (approved documents are available at https://www.greenclimate.fund/publications/documents) includes fields for a project's expected cofinancing ratio.

environmental benefits, or that is globally efficient from a planner's perspective. As we show, tradeoffs depend on comparisons between project-level cofinancing per fund dollar spent and emission reductions per fund or gross dollar spent.

Our empirical analysis of project-level data for the GEF and GCF yields several main findings. First, tradeoffs exist between emissions reductions and cofinancing, but the two objectives are aligned on average. That is, we find that current cofinancing targets do not appear to increase or decrease environmental benefits. Second, simulations of alternative scenarios sound a word of caution against more emphasis on cofinancing, showing that environmental benefits would diminish under stronger cofinancing preferences. Finally, emphasis on cofinancing in project selection is likely to be globally inefficient. This result follows because projects with greater cofinancing ratios tend to be less efficient at producing emission reductions. This finding is especially important because the majority of GEF and GCF cofinancing comes from other public sources, raising questions about its financial additionality.

The remainder of the paper is organized as follows. Section 2 uses a simple example to motivate the tradeoffs that cofinancing may introduce. Section 3 presents the model of how a fund chooses projects, the different ways it may take account of cofinancing, and the consequences thereof. Section 4 compares a social planner's problem to the fund's problem in order to identify the circumstances when the two are aligned (or not) and the mediating effect of cofinancing. Section 5 describes the empirical setting, sources of data, and the bridge between theoretical results and empirical tests. Section 6 reports results of our regression-based empirical analysis using project-level data from the GEF and GCF. Section 7 discusses further issues related to additionality and cofinancing tradeoffs at the GEF and GCF. Section 8 concludes.

2 A Motivating Example

We begin with a simple example to motivate key questions and introduce some basic insight. Suppose there is a single fund with a fixed budget of $1 million dollars that it can use to finance environmental projects. Table 1 shows characteristics of three potential projects. Each project would cost the fund $1 million, so from the fund's perspective, only one project can be chosen. Projects are associated with cofinancing and avoided carbon dioxide (CO_2) emissions, measured in millions of metric tonnes (MMT).

Consider first the choice between Projects 1 and 2. Project 1 yields greater avoided CO_2, but only half as much cofinancing. If the fund's sole objective were to maximize environmental benefits, it would prefer Project 1. But if the fund also had a mandate to increase cofinancing, it might instead select Project 2 (for cofinancing of $4 *vs.* $2 million),

Table 1: Example set of three potential projects

Project	1	2	3
Fund's Cost	\$1 million	\$1 million	\$1 million
Cofinancing	\$2 million	\$4 million	\$7 million
Avoided CO_2	1.2 MMT	1.0 MMT	2.0 MMT

at the expense of reducing emissions. When comparing these two projects, the fund faces a tradeoff: it cannot simultaneously maximize both cofinancing and mitigation. The extent to which such tradeoffs exist in practice, however, will depend on the distribution of attributes across potential projects. For example, with the possibility of Project 3, no such tradeoff exists, as that project generates both greater avoided emissions and greater cofinancing at the same cost to the fund. Project 3 is therefore the clear choice for a fund that is concerned with reducing emissions, maximizing cofinancing, or both.

While Project 3 offers the best of both worlds to the fund, what about the broader social perspective? Would a social planner focused on maximizing environmental benefits subject to a total financing constraint make the same choice? In this example, the answer is no. Projects 1 and 2 combined have the same total cost as Project 3 (\$8 million), but Projects 1 and 2 have greater total avoided emissions by 0.2 MMT. Choosing Projects 1 and 2 is therefore more globally efficient than choosing Project 3. Whether this is possible in practice depends on whether cofinancing is fungible across projects, and if it is, the example illustrates how fund incentives may not be globally efficient.

The next two sections develop a general framework to analyze issues raised by this motivating example. Section 3 examines the ways in which adding a preference for greater cofinancing can affect a fund's environmental performance. Section 4 examines the potential (mis)alignment between fund objectives and those that are globally efficient. In both cases, the theory generates testable conditions that we use as the basis for our empirical analysis in subsequent sections.

3 The Fund's Problem

We continue to explore the problem of a single fund that chooses how to allocate financial grants across a set of potential projects. Projects may also receive cofinancing from other sources, including the private sector, governments, and other public institutions. We assume that the fund seeks to reduce CO_2 emissions, but the model could apply equally to a different primary objective (e.g., reducing poverty or preventing biodiversity loss) or even multiple objectives, so long as they can be separated from cofinancing and used to make comparisons across projects. Our model setup is not intended to capture the full complexity of a fund's decision process, but instead to elucidate the ways in which emphasis on cofinancing can introduce tradeoffs with primary objectives.

3.1 Projects and Portfolios

Let S denote the set of potential projects. Each project $i \in S$ will yield avoided CO_2 emissions a_i and is associated with outside cofinancing f_i. Both a_i and f_i occur if and only if the project receives financing n_i from the fund. We initially assume the fund's actions are fully additional; that is, any project not selected and financed by the fund provides zero environmental benefits and receives zero cofinancing from other sources.[5] The quantity n_i is project i's net price to the fund, representing the amount the fund itself must pay to realize the project. The quantity $g_i = n_i + f_i$ is project i's gross price, representing the cost of the project across all financing sources. The fund has a budget B to spend across projects, and we assume that the fund can perfectly observe all project attributes and its budget prior to making its funding decisions.

It will also be useful to aggregate these measures across sets of projects. We refer to a selected set of projects as a portfolio $X \subseteq S$. Each portfolio X has total avoided emissions $A(X) \equiv \sum_{i \in X} a_i$, and with analogous summations over the respective project-level characteristics, we can define a portfolio's total cofinancing $F(X)$, total gross price $G(X)$, and total net price $N(X) = G(X) - F(X)$.

3.2 Objectives and Cofinancing

An initial benchmark case to consider is one in which the fund seeks to maximize the amount of avoided emissions without regard to cofinancing. The fund solves a single-objective problem to maximize its environmental impact, which we express as

$$\max_{X \subseteq S} A(X) \text{ s.t. } N(X) \leq B. \tag{1}$$

That is, the fund chooses a portfolio of projects to maximize total avoided emissions, subject to the constraint that its own total spending across the portfolio does not exceed its budget.

[5] Later in the paper, we weaken this assumption and consider some implications of non-additionality depending on the source of cofinancing.

Letting X^* denote the solution to this problem, the achieved level of avoided emissions can be written as $A(X^*)$.

Alternatively, as we have discussed, the fund might seek to integrate cofinancing into its mission. One way this is done in practice is to establish a portfolio-level minimum cofinancing ratio, denoted $C(X) \equiv F(X)/N(X)$, which quantifies the amount of outside cofinancing relative to the fund's own spending. This, for example, is the preferred measure of cofinancing for the GEF. In this case, the fund's problem can be written as

$$\max_{X \subseteq S} A(X) \text{ s.t. } N(X) \leq B \text{ and } C(X) \geq C_{\min}. \tag{2}$$

The only difference between (1) and (2) is the additional constraint that the cofinancing ratio be at least some minimum value $C_{\min}$. Letting $\bar{X}$ denote the solution to (2), two observations follow immediately. First, adding a constraint on the cofinancing ratio can only decrease the level of avoided emissions. Formally, it must hold that $A(X^*) \geq A(\bar{X})$; otherwise, X^* would not have been a solution to (1). Second, and by the same logic, increasing the minimum cofinancing ratio can only decrease the avoided emissions, as increasing $C_{\min}$ (weakly) shrinks the set of portfolios that satisfy the fund's constraints.[6]

Another possible formulation of the fund's problem explicitly models acceptable tradeoffs between cofinancing and the environmental objective of interest. Fund preferences may be specified according to an objective function of the form $U(A(X), F(X))$ that is increasing in $A(X)$ and $F(X)$. This is how some funds, including the GCF, implicitly assess their own cofinancing: more is better, but outside financing is not directly compared to the fund's own spending. To simplify our analysis, it is useful to consider a particular functional form, $U = A(X) + \theta F(X)$. A convenient feature of this specification is that θ has an interpretation as the fund's marginal rate of substitution. Assuming emissions and cofinancing are measured in tonnes and dollars, $1/\theta$ is the fund's willingness to accept (WTA) additional cofinancing to forego a tonne of emission reductions (e.g., $\theta = .02$ implies a WTA of $1/\theta = \$50$).[7] As

[6] We also note that there are two ways that the fund can increase its cofinancing ratio: by selecting a portfolio with greater total cofinancing (larger numerator), or by selecting a portfolio with a smaller total net price (smaller denominator). The latter means that given a sufficiently high $C_{\min}$, a fund might spend less than its entire budget to satisfy the cofinancing constraint. While it may be unlikely in practice that any fund would underspend to increase its cofinancing ratio, and therefore produce less environmental benefit, it is notable that using a ratio to measure cofinancing creates this potentially perverse incentive. We nevertheless assume throughout that $C_{\min}$ is not stringent enough to cause the fund to fall short of fully spending its budget.

[7] To see this, note that θ converts dollars of cofinancing into utility equivalent abatement. A project that offers more than $1/\theta$ of cofinancing per tonne of abatement implies less of a tradeoff than the fund is willing to accept.

the fund's preference for cofinancing θ increases, its WTA cofinancing to forego emission reductions shrinks.

In the case of this double-objective problem, the fund solves

$$\max_{X \subseteq S} A(X) + \theta F(X) \text{ s.t. } N(X) \leq B, \tag{3}$$

where we denote the solution $\hat{X}$. It is clear that $F(\hat{X})$ is increasing in θ. It is also straightforward to see that $A(\hat{X})$ is decreasing in the cofinancing preference θ for all $\theta \geq 0$. This follows because the same portfolios are available under any preference θ, so if the chosen portfolio changes with an increase in θ, then the new portfolio cannot achieve more avoided emissions; otherwise, it would have been chosen with the initial, lower θ. A special case of this result is the comparison of an initial value of $\theta = 0$ to a value of $\theta > 0$, which referring back to problem (1) implies that $A(X^*) \geq A(\hat{X})$ for $\theta > 0$. Trading the initial problem for the dual-objective problem can only reduce the realized environmental benefits.

Although the fund's preference for cofinancing enters problems (2) and (3) in different ways, there is a direct mapping between the two problems based on the levels of θ and $C_{\min}$. The easiest way to see this is to assume a large number of potential projects, each of which has costs to the fund that are relatively small compared to its budget.[8] In this case, it is reasonable to assume that the solution to either problem will satisfy $N(X) \approx B$. It follows that we can write the cofinancing constraint for (2) as $C_{\min} = F(X)/B$. Then substituting in a given solution to (3) as a function of θ, we can write $C_{\min} = F(\hat{X}(\theta))/B$, where we know that the numerator is increasing in θ. Hence any solution to (3) can be replicated with an appropriately calibrated $C_{\min}$ in (2), and any solution to (2) can be replicated with an appropriately calibrated preference parameter θ. In both cases, the set of selected projects changes as a fund pursues more and more cofinancing, but the outcomes do not depend on the particular way the fund chooses to measure cofinancing and incorporate it into its project selection.

3.3 A Production Intuition

We have shown that adding explicit cofinancing constraints or objectives cannot improve environmental outcomes. We now provide an intuitive explanation of the mechanism for this result by conceptualizing the fund as a 'producer' of avoided emissions. This explanation motivates specific questions that ultimately guide our empirical analysis.

[8] This assumption is not, however, necessary for the mapping between problems to exist.

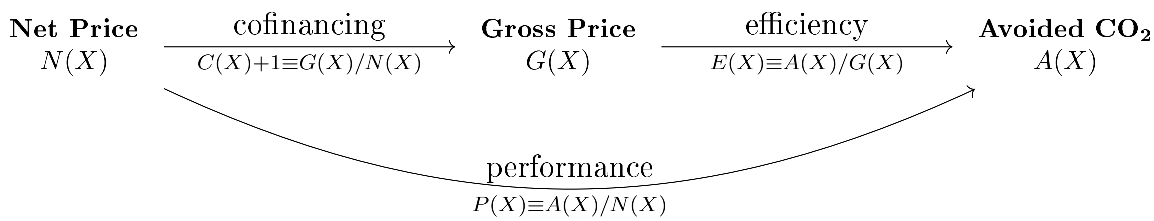

Figure 1: A fund's "production" of avoided emissions

Consider the following decomposition of avoided emissions for any portfolio X:

$$\begin{aligned} A(X) &= N(X) \cdot \frac{G(X)}{N(X)} \cdot \frac{A(X)}{G(X)} \\ &= N(X) \cdot \frac{F(X) + N(X)}{N(X)} \cdot \frac{A(X)}{G(X)} \\ &= N(X) \cdot [C(X) + 1] \cdot E(X). \end{aligned} \tag{4}$$

The first line multiplies and divides by canceling terms, and the second line uses the definition of gross spending $G(X) = N(X) + F(X)$. The third line uses the definition of the cofinancing ratio and introduces a new definition: the portfolio efficiency $E(X) \equiv A(X)/G(X)$, which is the average emissions reduction per gross dollar spent. The final line states, intuitively, that avoided emissions are the product of the fund's total spending, the cofinancing ratio plus one, and the portfolio efficiency.

Figure 1 sequences from left to right the steps in the production of emission reductions. For a given portfolio, the fund must put forth a quantity of its own financing $N(X)$; then that financing is matched by cofinancing to yield gross financing $G(X)$; and finally the selected projects convert the gross financing into avoided emissions $A(X)$ according to the portfolio's average efficiency. If the fund wants only to maximize environmental benefits, as specified in problem (1), its ultimate concern is the full pathway shown in Figure 1 as the conversion of its own spending into avoided emissions. Holding its own spending $N(X)$ and efficiency $E(X)$ constant, greater cofinancing $F(X)$ does yield greater environmental benefits. But, importantly, this effect is already accounted for if the fund simply maximizes avoided emissions $A(X)$, and including cofinancing as a distinct constraint or objective is redundant at best, and more likely counterproductive.

Put another way, a fund solving problem (1) ultimately cares about the performance of its chosen portfolio, shown as $P(X) \equiv A(X)/N(X)$ in Figure 1, which converts its own spending into avoided emissions. Then, because

$$\text{performance} = \text{cofinancing} \times \text{efficiency}, \tag{5}$$

a fund that endeavors to maximize performance subject to a budget constraint need not place added emphasis on cofinancing. Much of our subsequent analysis focuses on the relationship between the three terms in equation (5).

3.4 Performance-Cofinancing Consistency

The tradeoffs between cofinancing and performance arise if portfolios with greater cofinancing are also less efficient. In particular, if the losses in efficiency are sufficiently large, portfolios with greater cofinancing will provide fewer avoided emissions. We now turn to the project-by-project conditions that rule out these potentially perverse outcomes and that provide the basis for our empirical analysis evaluating the extent of such tradeoffs in practice.

The question of central interest boils down to whether adding the constraint in problem (2) or the additional objective in problem (3) changes the rank ordering or selection of projects. The following condition is sufficient to ensure that additional emphasis on cofinancing, while redundant, does not diminish environmental impacts.

> **Condition 1:** *Performance-cofinancing consistency* means that for any pair of projects $\{j, k\} \in S$, it holds that $a_j/n_j > a_k/n_k \Leftrightarrow f_j/n_j > f_k/n_k$.

This condition requires that if one project offers greater emissions reductions per dollar of net price, it must also offer a greater cofinancing ratio.[9]

Note that this comparison does not use the absolute level of avoided emissions and cofinancing across projects (a_i and f_i) but the net-price normalized emissions and cofinancing (a_i/n_i and f_i/n_i). When maximizing avoided emissions and cofinancing, or some combination, the binding constraint is the fund's fixed budget B. The normalized values account for the opportunity cost, in lost budget, of selecting one project instead of another. The performance a_i/n_i quantifies the environmental returns to the fund's spending. Similarly, the cofinancing ratio f_i/n_i can be interpreted as the cofinancing returns to the fund's spending.[10]

The important implication is that, if Condition 1 holds, then introducing cofinancing concerns creates no tradeoff with environmental performance—that is, the solutions to problems (1), (2), and (3) are identical. This follows because, for any budget that is fully spent, the set of projects that maximize emission reductions is also the set of projects with the

[9] To focus on the interesting results without unnecessary complication, we ignore the possibility for identical projects in the sense of $a_j/n_j = a_k/n_k$ or $f_j/n_j = f_k/n_k$.

[10] Other papers similarly use the ratio of outcomes to inputs as a systematic way of making comparisons across different policy outcomes. Borenstein and Kellogg (2023) provide a recent example with a study of alternative policy instruments targeting decarbonization in the U.S. electricity sector.

highest cofinancing ratio.[11]

Finally, it is useful to illustrate how the failure of Condition 1 can introduce tradeoffs. To do so, let us revisit Projects 1 and 2 of our motivating example in Table 1. Project 1 offers greater performance than Project 2 (i.e., $1.2/1 > 1/1$) but a lower cofinancing ratio (i.e., $2/1 < 4/1$), such that Condition 1 does not hold. It is possible, therefore, that a sufficiently binding $C_{\min}$ in problem (2) would cause the fund to forego Project 1 in favor of Project 2. Similarly, a sufficiently high cofinancing preference θ in problem (3) would cause the fund to make the same decision.[12] In either case, the fund's emphasis on cofinancing would lead it to forego the greatest possible mitigation.

4 The Planner's Problem

We have thus far focused on the fund's problem, where the primary resource constraint is the fund's own budget. A central part of the solution has been the fund's performance, which measures the conversion of net financing from the fund into total emission reductions. There is, however, another measure of success in project selection: overall efficiency. A global planner would seek to achieve the greatest environmental benefits subject to a gross—rather than net—financing constraint. In this section, we compare the planner's problem to that of the fund's in order to identify the circumstances when the two are aligned (or not) and the mediating effect of cofinancing concerns.

4.1 Setup

The primary concern of a global social planner is the efficient use of gross financing to maximize emission reductions. Assuming the planner can freely direct gross financing to desired projects, it would solve

$$\max_{X \subseteq S} A(X) \text{ s.t. } G(X) \leq B_{\text{gross}}. \tag{6}$$

The gross budget B_{gross} includes all financial resources available to the planner, adding the fund's budget B and other potential sources: $B_{\text{gross}} = B + B_{\text{other}}$.

Our initial setup assumed that any financing other than the fund's budget could not

[11] Recall that footnote 6 states the assumption that $C_{\min}$ is not high enough to cause the fund to hold back on spending its entire budget. This ensures that the solution to (2) is the same as that for (1) and (3).

[12] In particular, the fund is indifferent between the two projects if $\tilde{\theta} = 0.1$ (i.e., an implied WTA of \$10/tonne), whereas it prefers Project 2 if and only if $\theta > \tilde{\theta}$ (i.e., a lower WTA).

be freely distributed across the portfolio. Instead, from the fund's perspective, outside cofinancing was tied to a particular project, and if the fund did not select that project, the associated cofinancing would not be put to an alternative environmental use. This is essentially an additionality assumption on cofinancing. Taking the current setup (6), this is equivalent to adding the constraint that $B_{\text{other}} = F(X)$, so that the other financing available to the planner is only the project-specific cofinancing available to the fund. With that condition in place, the planner's budget constraint simplifies to $N(X) \leq B$, making the planner's problem (6) exactly equivalent to the fund's single-objective problem (1).[13] Hence, when cofinancing is fully additional for each project, a single fund's selection of projects will be the same as the planner's: the portfolio that the fund chooses maximizes performance but is also globally optimal, because the gross resources are used efficiently.

4.2 Efficiency-Performance Consistency

If cofinancing were not additional, then a project's potential cofinancing would remain available for environmental purposes even if the fund did not implement the project.[14] In that case, a planner could freely allocate both B and B_{other} across projects. This is the sense in which the planner and a fund can face different problems. A fund that seeks to maximize emission reductions as in (1) evaluates projects according to their performance a_i/n_i, while the planner solving (6) evaluates projects according to their efficiency a_i/g_i. This means that if cofinancing is not additional, a fund may select a portfolio that differs from that of the planner. In such cases, the fund's chosen portfolio will be globally inefficient.

The potential inefficiency will depend on how performance and efficiency are related across projects. The following condition is sufficient to rule out inefficiencies.

> **Condition 2:** *Efficiency-performance consistency* means that for any pair of projects $\{j, k\} \in S$, it holds that $a_j/g_j > a_k/g_k \Leftrightarrow a_j/n_j > a_k/n_k$.

This condition requires that when comparing any two projects, if one has greater efficiency with respect to the cumulative gross price, it must also have greater performance with respect to the fund's net price. An implication of Condition 2 is that when environmental impact is the only concern, a single fund and the planner will always rank projects for potential selection in the same order. In particular, for the same expenditure, $B + F(X^*) = B_{\text{gross}}$,

[13] The planner's budget constraint in (6) can be expanded to $N(X) + F(X) \leq B + B_{\text{other}}$. Imposing the constraint that $B_{\text{other}} = F(X)$ reduces the budget constraint to $N(X) \leq B$, which is identical to that for the fund in (1).

[14] Note, as mentioned earlier, that this is a distinct condition from whether or not a project is additional.

the fund and the planner would choose the same set of projects; that is, problems (1) and (6) will have the same solution.

How would Condition 2 fail to hold? A comparison between Projects 1 and 3 in Table 1 provides a clear intuition. Project 3 does better from the fund's net perspective (i.e., comparing performance, $2/1 > 1.2/1$) but worse from the planner's gross perspective (i.e., looking at efficiency, $2/8 < 1.2/3$). The discrepancy arises because Project 3 has far greater cofinancing compared to its greater emission reductions, and the fund does not treat cofinancing as a cost, whereas the planner does.

4.3 Efficiency-Cofinancing Consistency

The final theoretical question we consider is how a fund's explicit focus on cofinancing affects potential global efficiency, which we have just illustrated can be distinct from its performance. Recall that satisfying Condition 1 means that an explicit focus on increasing cofinancing is aligned with maximizing a fund's environmental performance. What is more, satisfying Condition 2 means that a fund maximizing its environmental performance is efficient from the planner's perspective, even if the cofinancing is not additional. It turns out that Conditions 1 and 2 combined are equivalent to the following condition, which relates efficiency and cofinancing:

> **Condition 3:** *Efficiency-cofinancing consistency* means that for any pair of projects $\{j, k\} \in S$, it holds that $a_j/g_j > a_k/g_k \Leftrightarrow f_j/n_j > f_k/n_k$.

The condition states that projects with greater gross efficiency must also have greater cofinancing ratios. That Conditions 1 and 2 imply Condition 3 is immediate. To see the reverse, we must show that Condition 3 implies the performance condition $a_j/n_j > a_k/n_k$. Using the fact that for any project $f_i = g_i - n_i$, the inequality on the right-hand side of Condition 3 can be rewritten as $g_j/n_j > g_k/n_k$. Then multiplying the respective sides of this inequality by those on the left-hand side of Condition 3 and canceling terms yields the desired result.

The useful insight of Condition 3 is that it identifies a single condition under which incorporating cofinancing concerns into the fund's mission is not only consistent with maximizing its environmental performance, it is globally efficient—even if cofinancing is not additional. In particular, if Condition 3 holds, problems (1), (2), (3), and (6) all have the same solution. The reason is that all three terms in equation (5) are aligned across projects: performance, cofinancing ratio, and efficiency.[15]

[15] More formally, the result follows by three steps. First, we have established that Condition 3 is equivalent

To see how Condition 3 may not hold, we again refer to the projects in Table 1. The pairwise comparisons between Projects 1 and 2 and between Projects 1 and 3 both fail to satisfy Condition 3, but for different reasons. As noted previously, the first pair fails to satisfy Condition 1, while the second pair fails to satisfy Condition 2. Within each pair, Project 1 brings in less cofinancing but uses its gross financing more efficiently.

Finally, it is worth reemphasizing that Conditions 2 and 3 assess a project's efficiency (i.e., a_i/g_i) against a fund's performance and cofinancing ratio, respectively. But efficiency is only relevant for the planner's perspective if cofinancing is not fully additional. If the cofinancing is fully additional—that is, if the cofinancing is not fungible across projects—then the fund's problem of maximizing performance is identical to the planner's problem, and Conditions 2 and 3 become redundant. We return to this important topic later in the paper when discussing data on the actual sources (and possible additionality) of observed cofinancing.

5 Empirical Setting

We have shown that the pursuit of greater cofinancing can only cut against environmental objectives, and that the actions of a single fund may not always be socially optimal. But the consistency Conditions 1, 2, and 3 also demonstrate that the existence and extent of any realized mitigation losses depend on the distribution of projects characteristics. We now turn to an empirical analysis using real project data to test the consistency conditions and evaluate the extent of tradeoffs between objectives in practice. We examine two of the leading multilateral funds focused on the environment: the GEF and the GCF.

5.1 The GEF and the GCF

The GEF was established before the 1992 Rio Earth Summit, and supports a broad range of environmental projects in developing countries and countries with economies in transition. Part of the GEF's mandate is to help these countries meet the objectives of international environmental conventions. The GEF's initial pilot ended in 1994, and since then it has implemented eight numbered replenishment cycles, each lasting four years, with the current GEF-8 beginning in 2023. In each cycle, the GEF receives funding from donor countries and selects environmental projects to finance from a pool of applicants. Donors pledged a total

to Conditions 1 and 2. Second, we have shown that Condition 1 implies the same solution for problems (1), (2), and (3). Finally, we have also shown that Condition 2 implies the same solution for problems (1) and (6) under the same budget. This proves that all four problems have the same solution.

of \$5.33 billion for GEF-8 (Global Environment Facility, 2022b). As of August 2022, the GEF had provided more than \$22 billion in grants and mobilized an additional \$120 billion in cofinancing for more than 5,000 projects. Part of the GEF's portfolio are 940 projects focused on climate change mitigation, with an estimated 8.4 billion tonnes of CO_2 emissions reductions (Global Environment Facility, 2022a).[16]

The GCF was established as part of the 2010 United Nations Framework Convention on Climate Change (UNFCCC) conference in Cancún, Mexico. It is intended to provide financial support for projects in developing countries that will help achieve and raise the ambition of low-emission and climate-resilient development. The GCF is still in its first funding cycle, to which donor countries pledged more than \$10 billion. As of September 2022, the GCF had financed 200 projects, with an estimated 2.3 billion tonnes of CO_2 emissions avoided. The GCF portfolio also reports \$29.8 billion of cofinancing (Green Climate Fund, 2022).[17]

Both the GEF and the GCF have instituted guidelines to prioritize projects with greater cofinancing. The GEF initially set out a commitment to seek higher cofinancing in 2003. To measure progress, the GEF provides data on realized cofinancing for each of its funding cycles, and the rate has more than tripled over the last 20 years. Consistent with the framing of the fund's problem in (2), the GEF targets an overall cofinancing ratio for the portfolio in each cycle, where the ratio is determined by total cofinancing relative to GEF expenditures. The target was set at 6:1 for GEF-6 (Global Environment Facility, 2014) and increased to 7:1 for GEF-7 (Global Environment Facility, 2018b).

The GCF aims to increase cofinancing when possible, but acknowledges that doing so may not always be aligned with environmental performance. The GCF's Policy on Co-financing states that "[w]henever possible, funded activities should seek to incorporate appropriate levels of Co-financing to maximize the impact of GCF proceeds ... [w]hile maximizing Co-financing is desirable, GCF will avoid using Co-financing metrics as stand-alone targets since maximizing climate mitigation and adaptation results does not necessarily equate with minimizing or optimizing spending on climate mitigation and adaptation" (Green Climate Fund, 2018). The GCF's approach, recognizing potential tradeoffs, is therefore more aligned

[16]Research on the GEF has focused on the role of key actors as well as organizational and institutional structures on project outcomes (Rosendal and Andresen, 2011), the ways in which funds are distributed among countries vulnerable to climate change (Rahman and Ahmad, 2015), and *ex post* evaluations of project performance (Kotchen and Negi, 2019)

[17]Research on the GCF has explored ways in which it can operate as a mechanism to reduce tradeoffs between economic growth and low carbon targets (Markandya et al., 2015), the potential effects of different burden-sharing arrangements among donor countries (Cui and Huang, 2018), how internal regulations and agreements with third parties affect GCF resilience (Bowman and Minas, 2019), and the role that intermediaries play in setting the GCF's approach to funding (Chaudhury, 2020).

with the framing of the fund's problem in (3).

5.2 Fund Data

We obtained project-level data from both the GEF and the GCF. The GEF provided us with data on projects from its GEF-6 and GEF-7 funding cycles. The projects we observe passed the first stage of approval between 2014 and 2021 and received what are designated as large grants. The GCF publicly provides comparable data on its project funding to date through an online dashboard.[18] We captured our data in August 2022. The key project-level variables for our analysis include the fund's own financing (n_i), the level of cofinancing (f_i), the category of intended environmental impact, a quantitative measure of the environmental impact (a_i), and the region where the project takes place.

We continue to focus on climate change mitigation. This requires narrowing the set of projects to include in our analysis. All of the GCF's projects are targeted at climate change, but they are categorized as focused on mitigation, adaptation, or both ("cross-cutting"). We include only mitigation and cross-cutting projects, and use avoided emissions as the measure of environmental impact. Unlike the GCF, the GEF provides funding to projects across several environmental focal areas: climate change; biodiversity; chemicals and waste; and land degradation. Some projects have only a single focal area, while others have more than one. We include only those projects that have climate change as one of the designated focal areas. If climate change is the only focal area, we refer to the project as a mitigation project, and otherwise we label it a cross-cutting project. The reason for the distinction is that we might expect mitigation—and therefore performance and efficiency—to differ between climate change and cross-cutting projects.

Table 2 reports project-level descriptive statistics for all projects included in our analysis separately for each fund. We have 221 observations for the GEF and 117 for the GCF. Although the data set is relatively small, it provides what we believe to be the most comprehensive set of climate-focused, project-level data from multilateral environmental funds. For both funds, the projects are almost evenly split between mitigation and cross-cutting designations. On average, the net prices of GCF projects are more than 10 times that of GEF projects, the emission reductions are more then twice as large, and the cofinancing is more than three times greater. The majority of projects take place in Africa and Asia, with a substantial number in Latin America and the Caribbean. A small number of Global projects are associated with more than one region. We find little to remark on concerning

[18]See https://www.greenclimate.fund/projects.

Table 2: Summary of GEF and GCF project data, pooled and disaggregated by climate change mitigation and cross-cutting categories

	GEF			GCF		
	Total	Mitigation	Cross-cutting	Total	Mitigation	Cross-cutting
# of projects	221	114	107	117	62	55
Net Price n_i	6.3	3.8	9.1	71.5	75.7	66.8
$ millions	(7.0)	(3.7)	(8.5)	(74.6)	(74.8)	(74.9)
Emissions a_i	7.0	6.2	7.9	17.6	20.0	14.9
MMT	(15.2)	(13.0)	(17.2)	(29.7)	(34.2)	(23.7)
Cofinancing f_i	63.1	49.4	77.8	225.6	280.8	163.6
$ millions	(126.7)	(103.6)	(146.5)	(441.6)	(540.2)	(285.9)
Region						
Africa	.35	.25	.46	.29	.26	.33
Asia	.24	.28	.19	.32	.34	.29
ECA	.15	.19	.11	.03	.05	.02
LAC	.20	.17	.23	.26	.26	.27
Global	.06	.11	.01	.09	.10	.09

Notes: Numbers in parentheses are standard deviations. ECA is an abbreviation for Europe and Central Asia, and LAC is for Latin America and the Caribbean. Global projects are those associated with more than one region.

differences within funds based on the mitigation and cross-cutting designations.

Although not reported in Table 2, there are substantial differences in the summary statistics if we report them in aggregate for each fund. The total net price for the GEF is $1.4 billion compared to $8.4 billion for the GCF. The total avoided emissions are 1.55 billion metric tonnes for the GEF compared to 2.06 for the GCF, and total cofinancing is $14 billion compared to $26 billion, respectively. Other comparisons are based on aggregate ratios for the GEF compared to the GCF: performance measured as aggregate avoided emissions over total net price is 1.1 tonnes per dollar compared to 0.3; the aggregate cofinancing ratio is 10 compared to 3.2; and the overall efficiency measured as aggregate avoided emissions over total gross price is 0.1 tonnes per dollar compared to 0.06.[19]

5.3 Within Portfolio Average Consistency

A central aim of our empirical analysis is to evaluate the consistency Conditions 1, 2, and 3. However, to bridge the theoretical framework to empirical implementation, we must relax the stringency of these conditions. The first challenge arises because a strict interpretation

[19]Note that the inverse of the tonnes per dollar indicates the dollars per ton, so the GEF and GCF are paying $10 and $16 per tonne of CO_2 emissions reductions on a gross basis.

of the theory requires evaluation of the full set of projects S from which a fund may choose. But data are not available on the full set of potential projects—we observe only the subset of projects that each fund has chosen to finance.

Without data on the full choice set S, we cannot determine conclusively that the funds sacrificed environmental benefits to increase cofinancing, nor (conversely) that the funds never face tradeoffs because the consistency conditions hold across all projects that they might select. Instead, we consider whether the conditions hold across the set of chosen projects. One might argue, however, that it is reasonable to expect a similar pattern to hold over the full set of potential projects, as funds tend to select a large fraction of the available projects, making the observed portfolio similar to the full choice set. After our initial set of empirical results, we examine this issue further by considering simulations with reduced budgets that illustrate the sensitivity of results to choosing subsets of a larger menu of available projects.

A second challenge for our empirical analysis arises because our Conditions 1, 2, and 3 as stated require absolute consistency—that is, to guarantee that tradeoffs never exist between performance, cofinancing, and efficiency, the conditions must hold for every possible pair of projects. Absolute consistency is a very strict condition, and unlikely to hold in practice, especially across heterogeneous projects. In Figure 2, we plot projects by performance a_i/n_i against the cofinancing ratio f_i/n_i, separately for each of the two funds. The size of each point corresponds to the net price n_i of the project. To display individual projects more clearly, we use log scales and omit a small number of GEF outliers with cofinancing ratios that exceed 75.

From these plots alone, we can immediately assess that these two portfolios fail absolute cofinancing-performance consistency (Condition 1), which would require project performance to be monotonically increasing in the project cofinancing ratio. Instead, there are some projects that offer high environmental returns and low cofinancing returns (to the upper left) and others that conversely provide low performance and high cofinancing ratios (to the lower right). A fund that seeks greater cofinancing in addition to its environmental goals would face a tradeoff in selecting between those projects, exactly as it does when comparing Projects 1 and 2 in our motivating example in Table 1. Although not shown, similar plots can be used to illustrate failure in an absolute sense of the other two consistency conditions: efficiency-performance (Condition 2) and efficiency-cofinancing (Condition 3).

We can nevertheless assess whether the projects satisfy consistency on average. This requires instead that a given condition is generally satisfied across a set of projects. If projects can be shown to follow average cofinancing-performance consistency—e.g., if there is a positive correlation between the variables in Figure 2—then it could be said that seeking

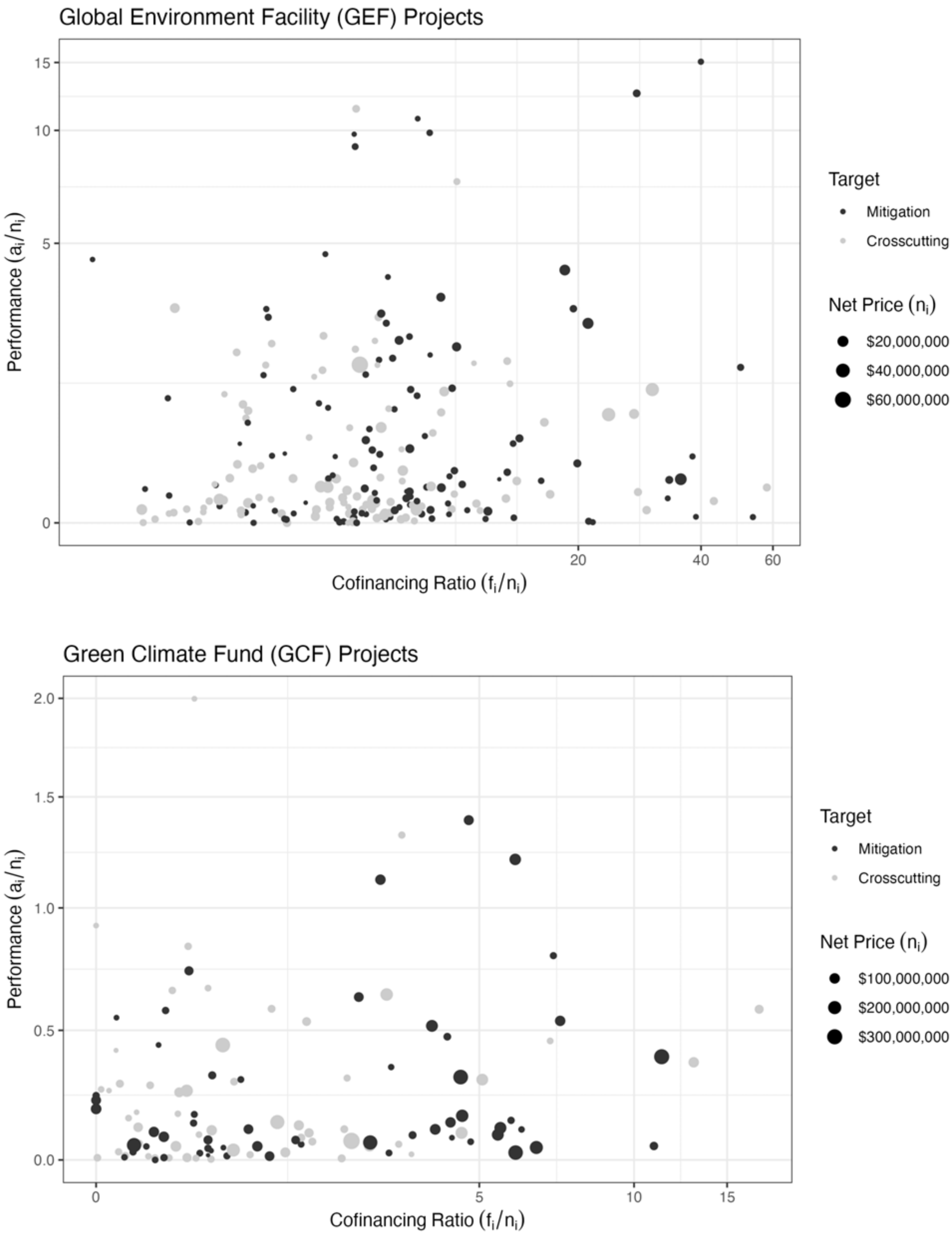

Figure 2: Project-level emission reductions per fund dollar against cofinancing per fund dollar with log scaling. GEF projects are in the top panel, and GCF projects are in the bottom panel.

greater cofinancing is generally consistent with improved environmental outcomes. Moreover, if projects satisfy average efficiency-cofinancing consistency, then projects with greater cofinancing ratios generally have higher efficiency, even if the condition is not met for every individual pair of projects. While the projects plotted in Figure 2 are in fact positively correlated, we examine such relationships more fully in the next section using multivariate regression models to control for other variables.

6 Tests of Average Consistency

In this section, we provide tests of average consistency based on Conditions 1, 2 and 3. Given differences between the GEF and GCF, we carry out the analysis separately for each fund.

6.1 Performance-Cofinancing

We begin with a test of average performance-cofinancing consistency (Condition 1). The question is whether, on average, projects with greater cofinancing per fund dollar also have greater emission reductions per fund dollar. We estimate models where project performance (a_i/n_i) is the left-hand side variable, and the project-level cofinancing ratio is the right-hand side variable of central interest. The first specification also includes an indicator for whether the project has a cross-cutting focus, to control for differences between those and mitigation-only projects. The second specification includes an interaction between the cofinancing ratio and the cross-cutting indicator, as this allows the coefficient of central interest to differ between the types of projects. The third specification includes regional fixed effects to control for unobserved differences in project performance across regions.

It is worth emphasizing that the aim of estimating these regressions is to examine correlation and not causation. One implication is that either ratio could be on the left- or right-hand side. Finally, we estimate the models weighting by the project net prices n_i, as this yields an interpretation of the average relationship between the variables of interest per dollar of the fund's spending. With this weighting, the coefficients represent the average portfolio-level tradeoffs the fund would face if selecting among the observed projects.[20]

Table 3 reports the results, including the three models for both the GEF and the GCF. The coefficient on the cofinancing ratio is positive across all models, although not statistically different from zero in the full models, where there is less variation across observations to

[20] Although not reported, we also estimate unweighted regressions, and these results do not differ in ways that affect the primary conclusions.

Table 3: Evaluation of average performance-cofinancing consistency

	Dependent variable:					
	Performance (a_i/n_i)					
	GEF			GCF		
	(1)	(2)	(3)	(4)	(5)	(6)
Cofinancing Ratio (f_i/n_i)	0.0254**	0.0381*	0.0334	0.0203***	0.0214*	0.0167
	(0.0127)	(0.0226)	(0.0237)	(0.0068)	(0.0111)	(0.0151)
Cofinancing Ratio × Cross-Cutting		−0.0269	−0.0278		−0.0027	−0.0009
		(0.0261)	(0.0285)		(0.0132)	(0.0193)
Cross-Cutting	−0.6608**	−0.3735	−0.1871	−0.0146	−0.0065	−0.0005
	(0.2821)	(0.3000)	(0.3235)	(0.0621)	(0.0647)	(0.0818)
Constant	1.3096***	1.1442***	3.1297***	0.1885***	0.1844***	0.1551*
	(0.2284)	(0.2269)	(1.1647)	(0.0444)	(0.0456)	(0.0867)
Regional Fixed Effects	No	No	Yes	No	No	Yes
Hypothesis Test		0.392	0.649		0.009	0.186
Observations	221	221	221	117	117	117

Notes: $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Heteroscedastic-robust standard errors in parentheses. All specifications are weighted by net price n_i. Hypothesis Test refers to the test of whether the sum of the coefficients on the cofinancing ratio and the interaction are statistically different from zero, and the p-values are reported.

identify an effect because of the regional fixed effects. The positive sign indicates that, on average, fund dollars spent on mitigation projects with greater cofinancing ratios yield greater emission reductions per fund dollar spent. This result confirms average performance-cofinancing consistency, suggesting that among the fund's chosen projects, there appears to be no tradeoff on average between performance and cofinancing. We find no statistically significant differences between projects focused on mitigation or cross-cutting themes, and additional statistical tests of whether the effect itself for cross-cutting projects is different from zero (Hypothesis Test) mostly fail to reject the null hypothesis.

The magnitudes of the coefficients on mitigation projects have an intuitive interpretation. Focusing on the model in column (1) for the GEF, the coefficient implies that mitigation increases by 0.0254 tonnes for each additional dollar of cofinancing. Translating this magnitude to a cost per tonne implies a cofinancing cost of $39 per tonne for the GEF's cofinancing partners. That is, on average across the GEF projects, those with higher cofinancing ratios yield greater emissions reductions at a cost of $39 of cofinancing per tonne of avoided CO_2. The magnitudes are smaller for the GCF; based on the model in column (4), where the coefficient is 0.0203, the cofinancing cost per tonne is $49 for the GCF.

Connecting these results to our theoretical framework, the regressions provide suggestive evidence that from a fund's perspective, cofinancing and environmental goals are aligned (or at least not misaligned) on average—that is, a firm that pursues greater cofinancing in its

Table 4: Evaluation of average efficiency-performance consistency

	Dependent variable:					
	Efficiency (a_i/g_i)					
	GEF			GCF		
	(1)	(2)	(3)	(4)	(5)	(6)
Performance (a_i/n_i)	0.1019***	0.0695***	0.0652***	0.2414***	0.1827***	0.2036***
	(0.0243)	(0.0234)	(0.0215)	(0.0443)	(0.0385)	(0.0392)
Performance × Cross-Cutting		0.0870***	0.0929***		0.1886**	0.1601**
		(0.0322)	(0.0312)		(0.0796)	(0.0768)
Cross-Cutting	0.0530*	−0.0475	−0.0733**	0.0172	−0.0273*	−0.0207
	(0.0293)	(0.0292)	(0.0320)	(0.0145)	(0.0150)	(0.0164)
Constant	−0.0092	0.0441	0.2836**	0.0133	0.0288***	−0.0006
	(0.0297)	(0.0271)	(0.1307)	(0.0112)	(0.0107)	(0.0129)
Regional Fixed Effects	No	No	Yes	No	No	Yes
Hypothesis Test		0.000	0.000		0.000	0.000
Observations	221	221	221	117	117	117

Notes: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Heteroscedastic-robust standard errors in parentheses. All specifications are weighted by net price n_i. Hypothesis Test refers to the test of whether the sum of the coefficients on performance and the interaction are statistically different from zero, and the p-values are reported.

project selection is unlikely to undercut its environmental goals, as the projects that offer greater cofinancing tend to also yield more environmental benefits per fund dollar. We note again, however, that this positive correlation does not imply that emphasizing cofinancing provides any additional environmental benefits, as the greatest mitigation is achieved by choosing the projects that offer the most avoided emissions per fund dollar.

6.2 Efficiency-Performance

We now turn to tests of average efficiency-performance consistency (Condition 2). In this case, we examine alignment between the fund's objective to reduce emissions subject to its own budget constraint and the social planner's objective of reducing emissions in a way that is globally efficient. We have already established that if each project's cofinancing is fully additional—that is, if outside spending cannot be transferred to another project—then the fund and planner's problems are fully aligned. But establishing additionality is difficult, and as we discuss later in the paper, there may be reasons to question cofinancing additionality, because the majority of cofinancing for these funds comes from other public sources. Examining the alignment between efficiency and fund performance is therefore informative and important.

We estimate regression models of the same form as those already discussed. The difference here is that project-level efficiency (a_i/g_i) is the left-hand side variable and performance (a_i/n_i) is now the right-hand side variable of interest. Table 4 reports the results. The coefficient on performance is positive and statistically significant across all models. This suggests that mitigation projects that achieve greater avoided emissions per fund dollar also make more efficient use of gross dollars spent. The positive and statistically significant coefficients on the interaction variable indicates, somewhat surprisingly, that the effect is even larger for cross-cutting projects. Using the GCF estimates in model (6), we find that each additional tonne of mitigation per fund dollar is associated with roughly 0.2 tonnes more per gross dollar, and the magnitude is $\approx 0.2 + 0.16 = 0.36$ tonnes for cross-cutting projects. Although the magnitudes are smaller for the GEF, the same qualitative results apply. Together, these results provide evidence that when funds act in their own interest by pursuing projects with greater performance, they will also tend to select projects with greater overall efficiency.

6.3 Efficiency-Cofinancing

Our final test is for average efficiency-cofinancing consistency (Condition 3). Recall that this condition tests for the previous two simultaneously. It asserts that a fund seeking to increase cofinancing would also be choosing projects in a way that is globally efficient, even if the cofinancing is not additional. When describing the absolute consistency conditions, we showed in Section 4.3 that Conditions 1 and 2 combined are equivalent to Condition 3. But the equivalence holds only for absolute consistency, and not with respect to average consistency. The reason is that correlation is not transitive—and indeed, we find that it is not across regression models for the three conditions.[21]

Table 5 reports the results of regression models that continue to have project-level efficiency (a_i/n_i) on the left-hand side, but now have the cofinancing ratio (f_i/n_i) on the right-hand side. The coefficient on the cofinancing ratio is negative in all models and statistically significant in most. This suggests, focusing on the full models in columns (3) and (6), that mitigation projects with greater cofinancing ratios are less efficient from a gross expenditure perspective. Specifically, a unit increase in the cofinancing ratio of GCF mitigation projects is associated with a 0.01 decrease in the tonnes of emissions avoided per dollar of gross funding. This is equivalent to an average increase of $100 of gross financing per tonne.

[21] Moreover, transitivity does not hold across naive pairwise correlations of performance, cofinancing and efficiency, all of which are statistically significant. Average consistency based on Conditions 1, 2, and 3 are captured with weighted correlations of 0.20, 0.71, and -0.17, respectively, for the GEF. For the GCF, they are 0.22. 0.69, and -0.29. That is, these correlations suggest that on average Conditions 1 and 2 are satisfied, but not Condition 3.

Table 5: Evaluation of average efficiency-cofinancing consistency

	Dependent variable:					
	Efficiency (a_i/g_i)					
	GEF			GCF		
	(1)	(2)	(3)	(4)	(5)	(6)
Cofinancing Ratio (f_i/n_i)	-0.0039^{***}	-0.0029	-0.0033^{***}	-0.0094^{***}	-0.0105^{**}	-0.0101^{**}
	(0.0014)	(0.0022)	(0.0010)	(0.0027)	(0.0045)	(0.0046)
Cofinancing Ratio × Cross-Cutting		-0.0021	-0.0010		0.0025	0.0024
		(0.0028)	(0.0020)		(0.0062)	(0.0057)
Cross-Cutting	-0.0437	-0.0209	-0.0166	-0.0043	-0.0119	-0.0055
	(0.0315)	(0.0534)	(0.0424)	(0.0206)	(0.0303)	(0.0310)
Constant	0.2096^{***}	0.1965^{***}	0.5744^{***}	0.1118^{***}	0.1157^{***}	0.0782^{***}
	(0.0290)	(0.0365)	(0.1646)	(0.0173)	(0.0215)	(0.0265)
Regional Fixed Effects	No	No	Yes	No	No	Yes
Hypothesis Test		0.007	0.010		0.063	0.024
Observations	221	221	221	117	117	117

Notes: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Heteroscedastic-robust standard errors in parentheses. All specifications are weighted by net price n_i. Hypothesis Test refers to the test of whether the sum of the coefficients on the cofinancing ratio and the interaction are statistically different from zero, and the p-values are reported.

The comparable magnitude based on the GEF estimate is even greater: increasing the cofinancing ratio by one will increase the costs of a tonne of carbon by $333 of gross financing. Perhaps surprisingly, we find neither large nor statistically significant differences between mitigation and cross-cutting projects. Overall, these results suggest that—when cofinancing is not additional—a fund's preference for projects with greater cofinancing appear to reduce the average global efficiency of financing across all contributing sources.

7 Discussion

We now turn to further discussion on two topics raised at different points in the preceding analysis. The first relates to whether cofinancing for projects is additional. The second revisits the distinction between absolute and average consistency conditions, and also examines our focus on the observed set of selected projects rather than the set of all potential projects.

7.1 Cofinancing Additionality

We have focused on how cofinancing objectives can affect the provision of environmental benefits. In doing so, we made a distinction between the consequences of seeking greater cofinancing for the environmental performance of the fund and for the globally efficient provision of environmental benefits. The test of environmental performance is based on whether projects with greater cofinancing per fund dollar also have greater emission reductions per fund dollar (Condition 1, which we found to be satisfied on average for both funds). The test of globally efficient provision is based on whether projects with greater cofinancing per fund dollar provide greater emission reductions per gross dollar (Condition 3, which failed in our empirical tests).

Importantly, the distinction between these two conditions is moot if cofinancing is fully additional—that is, if a project's cofinancing could not otherwise be redirected to achieve the same environmental goal. In that case, the social planner would always select the same portfolio as a fund that sought to maximize its own environmental performance, and Condition 1 alone (performance-cofinancing consistency) ensures that any added emphasis on cofinancing does not cut against environmental objectives. If instead the observed cofinancing fails to satisfy this definition of additionality, such that cofinancing is fungible across projects, then the problems of the fund and social planner diverge. Our empirical results would then imply that while cofinancing is consistent with advancing a fund's own environmental performance, it simultaneously creates an incentive for the fund to choose projects that are less efficient on a gross basis.

To provide insight on whether the cofinancing for the GEF and GCF is additional, we examine whether their cofinancing comes from private or public sources. Figure 3 provides a breakdown of the cofinancing sources for the GEF and GCF projects used in our empirical analysis. The GEF categorizes its cofinancing partners at the project level into broad classes, which include "Private Sector," "Donor Agency," "Foundation," "Recipient Country Government," and others. We retain the GEF's classification of "Private [Sector]" and "Other" sources, and group the remaining categories as "Public."[22] We complied similar data for the GCF from public project documents, and classified cofinancing sources as being either Public or Private.[23]

The primary source of cofinancing across these portfolios is—by a wide margin—other public institutions. Much of the cofinancing comes from development banks, governments and other multilateral funds. The World Bank has provided approximately 16% of the GEF's total cofinancing, and 8% of the GCF's. The Asian Development Bank provided 5% and 17%, respectively; the European Bank for Reconstruction and Development contributed 1%

[22]The remaining classes of GEF cofinancing that we take to be public are "GEF Agency," "Civil Society Organization", and "Beneficiaries."

[23]The GCF's dashboard lists the quantity of cofinancing provided by each individual contributor to a project's financing. We matched these contribution quantities to cofinancing sources using the Approved Funding Proposal document for each project. We identified financing from other multilateral funds, government entities, and beneficiaries as public, and financing from equity investors as private. Where we could not make an obvious assessment, we marked the source as "Private."

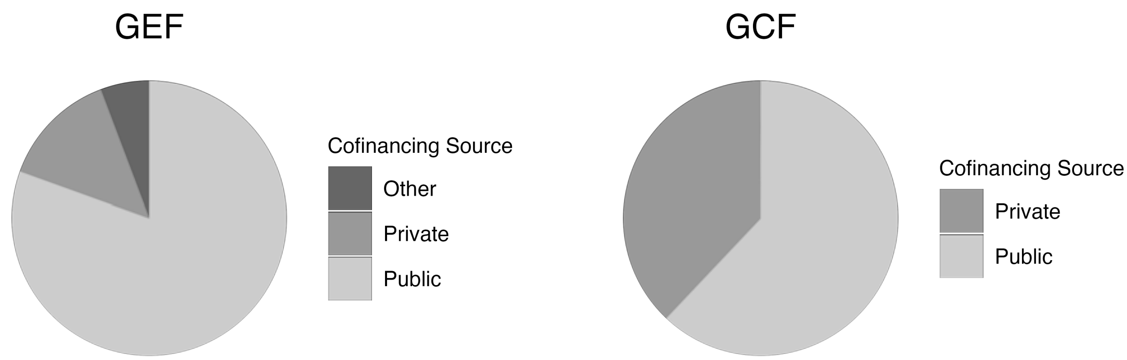

Figure 3: Cofinancing sources for GEF and GCF projects.

and 8%; and the African Development Bank supplied 2% of cofinancing for each fund. In a few instances, the GEF and GCF provided cofinancing to each another, when both funds supported the same project.

These public cofinancing sources are likely to have similar environmental mandates as the GEF and the GCF. As noted previously, many of the multilateral development banks and other public institutions have explicit climate objectives themselves. These results therefore raise the concern that the overall pool of gross financing includes less private investment that is 'crowded in,' and more public money that may always have been targeted to advance climate change mitigation.[24] In other words, the public sources of cofinancing, which comprise a significant majority of both funds' external financing, are plausibly less likely to be additional. Hence our finding that average cofinancing-efficiency consistency fails to hold suggests that cofinancing mandates will on average lead the funds to direct public resources toward projects that achieve fewer avoided emissions per gross (public) dollar. That is, the emphasis on cofinancing is promoting global inefficiency.

7.2 Counterfactuals

We discussed in Section 5.3 how data limitations force us to analyze the portfolios of projects that the GEF and the GCF selected, rather than the choice sets of all potential projects. If we had access to the full choice sets, we could precisely quantify the losses in environmental benefits under increasing emphasis on cofinancing by solving the funds' problems—(2) or

[24]The GEF and the GCF distinguish public from private cofinancing in some of their own reporting. The GEF's progress report breaks down its cofinancing across multiple dimensions, including aggregations by the classes listed above (Global Environment Facility, 2020). The GCF's funding proposal template includes fields for the estimated "Public source co-financed" and "Private source finance leveraged."

(3)—under progressively stronger cofinancing preferences, observing the changes in total avoided emissions of the chosen portfolios. (Recall that the two optimization problems are functionally equivalent for appropriately calibrated choices of the cofinancing ratio constraint $C(X)$ and cofinancing preference parameter θ.)

An important and related point is the distinction between satisfying the consistency conditions in an absolute sense, as required in our theoretical model, and consistency in an average sense, as assessed in our empirical analysis. Although we find, for example, that average performance-cofinancing consistency (Condition 1) is not violated, this does not mean that tradeoffs do not exist. On the contrary, because both the GEF and GCF portfolios fail absolute performance-consistency, they each contain (many) pairs of projects that present choices between greater cofinancing or greater environmental performance. Conceptually, a fund that emphasizes cofinancing must solve a multi-objective optimization problem. Ideally, it would simultaneously maximize both cofinancing and performance, but unless Condition 1 holds absolutely, the solution will depend on how the fund weights its two objectives (as specified by the parameter θ).

To illustrate these ideas and quantify tradeoffs across the projects selected by the GEF and the GCF, we consider how each fund would have selected from their observed projects under a smaller budget, and with different strengths of preference for cofinancing. These counterfactuals offer an alternative description of the environmental losses that occur under different preferences for cofinancing, as determined by the real distributions of characteristics across the observed projects. They allow us to calculate performance—and reductions in performance—under different cofinancing preferences θ, even without access to the full set of available projects S. As with our empirical analysis, this exercise will accurately describe the real tradeoffs that the GEF and GCF face so long as the projects in the unobserved choice sets have characteristics that are similar to the projects we observe.

In Figure 4, we plot the total avoided emissions per total net price of the portfolios that would be selected by a fund solving the double-objective problem (3) under different cofinancing preferences θ (shown on the x-axis) and budgets (shown as different lines). We use three different budgets, set to one quarter, one half, or three quarters of the fund's observed expenditure $N(X)$.[25] For each counterfactual budget, we solve the fund's problem under 1,000 different cofinancing preferences θ, distributed uniformly from 0 to 1. The implied WTA of $1/\theta$ thus ranges from infinite to \$1. With a dashed vertical line, we highlight one

[25] Recall that the observed total expenditures across our datasets are \$1.4 billion for the GEF and \$8.4 billion for the GCF, so using the budget fraction 0.5 means solving problem (3) with $B = \$0.7$ billion and \$4.2 billion, respectively.

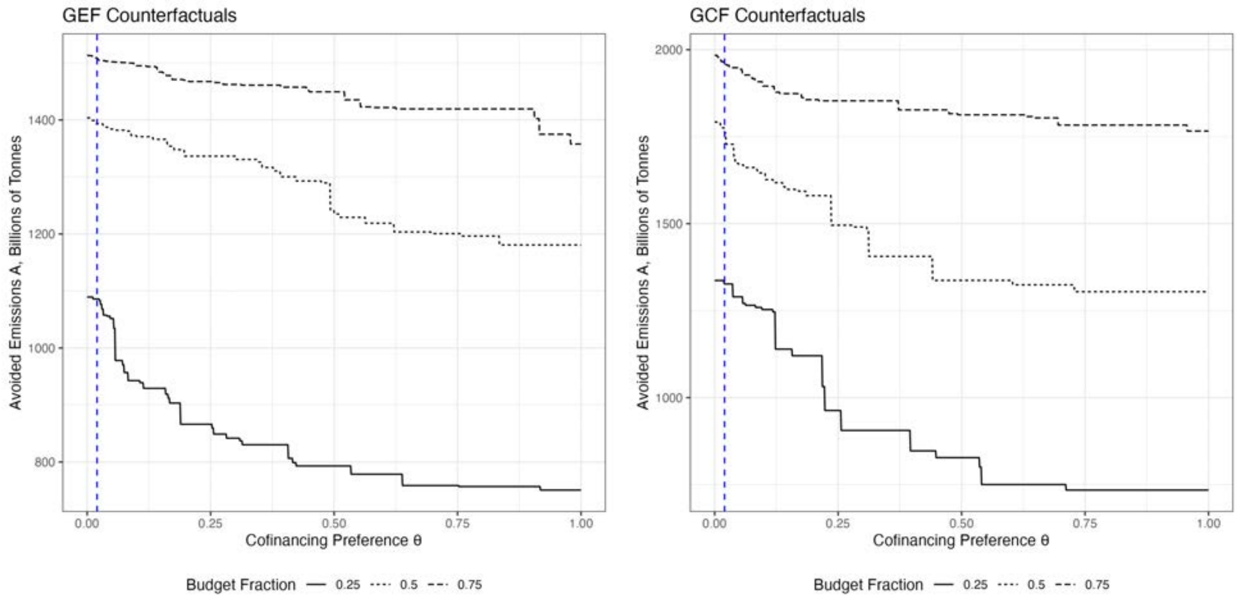

Figure 4: Tradeoff between avoided emissions and the strength of cofinancing preferences at different budgets for the GEF and GCF.

particular cofinancing preference, $\theta = 0.02 = 1/50$, corresponding to a benchmark social cost of carbon of \$50 (measured in dollars of cofinancing per tonne of CO_2). At this level, in other words, a fund would not forego emissions reductions at less than \$50 per tonne of cofinancing.

When the cofinancing preference θ is equal to zero, at left, the fund selects projects to maximize only avoided emissions, achieving the highest possible total performance $A(X)/N(X)$. Under $\theta = 0$, the fund is precisely solving problem (1), and achieves mitigation equal to $A(X^*)$ given the specified budget. As the cofinancing preference θ increases, moving right along the x-axis, the fund shifts its selection of projects towards those with higher normalized cofinancing. As discussed, an increase in the cofinancing preference can only reduce the realized total normalized avoided emissions $A(X)/N(X)$. The slope gives the change in realized avoided emissions for a unit increase in the cofinancing preference parameter, which must always be weakly negative. The relative reductions are larger for smaller counterfactual budgets, as the funds shift more dramatically between a smaller subset of the very best projects as measured by avoided emissions toward subsets with greater cofinancing ratios.[26]

[26]For a given cofinancing preference, the fund achieves less mitigation under smaller budgets, as expected, but the total avoided emissions decrease proportionally less than the budgets. This is because when the fund's budget is reduced, it will first exclude the projects that offer the least mitigation (and/or cofinancing) per fund dollar.

For both the GEF and the GCF, there are substantial losses in total avoided CO_2, but only as the cofinancing preference θ becomes very large. As one example, the results that use a counterfactual budget equal to half of the total net price of the observed portfolio are shown in each plot as the middle of the three lines. Solving the fund's problem with this 50% budget over the set of GEF projects yields 1.40 billion tonnes of avoided emissions when $\theta = 0$ (such that the simulated fund maximizes only mitigation), 1.39 billion tonnes when $\theta = 0.02$ (the benchmark WTA of \$50), and 1.18 billion tonnes when $\theta = 1$ (a WTA of \$1). For the GCF's projects, the quantities of total mitigation under the same three increasing cofinancing preference parameters are 1.79, 1.76, and 1.30 billion tonnes of avoided CO_2, respectively. This suggests that although losses in mitigation would occur if either fund were to increase its preference for cofinancing, substantial inefficiency is unlikely unless the funds pursue cofinancing far more aggressively. But the counterfactual exercise also illustrates the very real tradeoffs that exist between cofinancing and performance, even though our empirical analysis showed that those objectives are aligned on average.

8 Conclusion

In an effort to crowd in additional spending, environmental multilateral funds have prioritized allocating grants and loans to projects that achieve greater cofinancing. We present a model of project selection under a fixed budget, in which the fund observes each available project's environmental benefits, cofinancing, and cost. In this setting, an increased emphasis on cofinancing—through either a cofinancing ratio constraint or an increased relative preference for cofinancing—can only reduce the achieved environmental benefits of the portfolio of projects that a fund selects. Cofinancing is an important intermediate step in the conversion of the fund's spending into environmental benefits, but given our model's setup, this does not justify placing additional emphasis on cofinancing. In particular, projects with greater cofinancing are not guaranteed to produce the greatest avoided CO_2 emissions, as it is possible that those projects achieve less with the financing they receive.

We also examine the relationship between fund incentives and those that are socially optimal. If the cofinancing for every potential project is fully additional—that is, if the cofinancing would not have achieved any mitigation without the fund's support—then a fund that maximizes environmental benefits will realize the socially optimal use of gross financing across all sources. If cofinancing is not additional, however, then the optimization problems of a single fund and a social planner do not necessarily coincide, and the fund may select projects that make less efficient use of gross resources. And the pursuit of greater cofinancing can only push the fund further from the socially optimal portfolio of projects.

Our analysis of project-level data from two environmental multilateral funds, the GEF and the GCF, finds that some tradeoffs exist between cofinancing and environmental benefits. But these two objectives appear aligned on average, as selected projects with greater cofinancing ratios tend to also provide greater emissions reductions per dollar of fund expenditures. Moreover, we find that on average, projects with greater emissions reductions per dollar of fund expenditures (i.e., better performance) also tend to have greater emissions reductions per dollar of gross expenditures (i.e., better efficiency). This suggests that if cofinancing is fully additional, then funds maximizing environmental performance are also selecting projects in a way that is globally efficient.

But we also find that, on average, the projects that have greater cofinancing ratios are generally less efficient at converting gross dollars into environmental benefits. This result, combined with the fact that the majority of cofinancing for the GEF and GCF comes from other public institutions, identifies a potential source of inefficiency. Because the cofinancing is less likely to be additional, coming from other public sources, the emphasis on cofinancing in project selection appears to be favoring projects that are globally efficient—that is, projects with a higher cost per tonne of avoided emissions. Hence the emphasis on cofinancing by funds appears to be leading to (more) inefficient use of resources across the broader set of stakeholders. This finding is especially concerning given the overall scarcity of financial resources available to achieve global climate goals.

In conclusion, we acknowledge that our model and analysis does not fully capture all of the potentially important elements of real-world project selection. Multilateral funds choose projects in service of many different environmental and social objectives, which are not necessarily accounted for in our theoretical and empirical analysis. It may be that much of the cofinancing for mitigation projects—even from public sources—would not have been put to other environmental goals without the funds' contributions. And there may be valid reasons to sacrifice some avoided CO_2 to realize potential institutional benefits of increased cofinancing, as would be the case, for example, with the prospect of greater emissions reduction in the future. Nevertheless, our analysis suggests that funds should pursue greater cofinancing with caution and a clear understanding of the potential tradeoffs that cofinancing mandates might entail. This paper is an early attempt to identify and quantify these potential effects.

References

Alexeew, J., Bergset, L., Meyer, K., Petersen, J., Schneider, L., and Unger, C. (2010). An analysis of the relationship between the additionality of CDM projects and their contribution to sustainable development. *International Environmental Agreements: Politics, Law and Economics*, 10(3):233–248.

Borenstein, S. and Kellogg, R. (2023). Carbon Pricing, Clean Electricity Standards, and Clean Electricity Subsidies on the Path to Zero Emissions. *Environmental and Energy Policy and the Economy*, 4:125–176.

Bowman, M. and Minas, S. (2019). Resilience through Interlinkage: The Green Climate Fund and Climate Finance Governance. *Climate Policy*, 19(3):342–353.

Calel, R., Colmer, J., Dechezleprêtre, A., and Glachant, M. (2021). Do Carbon Offsets Offset Carbon? Centre for Climate Change Economics and Policy Working Paper 398 / Grantham Research Institute on Climate Change and the Environment Working Paper 371.

Carter, P., Van de Sijpe, N., and Calel, R. (2021). The elusive quest for additionality. *World Development*, 141:105393.

Chaudhury, A. (2020). Role of Intermediaries in Shaping Climate Finance in Developing Countries—Lessons from the Green Climate Fund. *Sustainability*, 12(14):5507.

Climate Policy Initiative (2021). Global Landscape of Climate Finance. https://www.climatepolicyinitiative.org/wp-content/uploads/2021/10/Full-report-Global-Landscape-of-Climate-Finance-2021.pdf.

Cui, L. and Huang, Y. (2018). Exploring the Schemes for Green Climate Fund Financing: International Lessons. *World Development*, 101:173–187.

Global Environment Facility (2014). Co-Financing Policy. https://www.thegef.org/sites/default/files/council-meeting-documents/GEF.C.46.09_Co-Financing_Policy_May_6_2014_2.pdf.

Global Environment Facility (2018a). Guidelines on Co-Financing. https://www.thegef.org/sites/default/files/documents/GEF_FI_GN_01_Cofinancing_Guidelines_2018.pdf.

Global Environment Facility (2018b). Updated Co-financing Policy. https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.C.54.10.Rev_.01_Co-Financing_Policy.pdf.

Global Environment Facility (2020). Progress Report on the Implementation of the Updated Co-financing Policy. https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.C59.Inf_.07_Progress%20Report%20on%20the%20Implementation%20of%20the%20Co-financing%20Policy.pdf.

Global Environment Facility (2022a). Climate Change Mitigation. https://www.thegef.org/what-we-do/topics/climate-change-mitigation.

Global Environment Facility (2022b). Summary of Negotiations of the Eighth Replenishment of the GEF Trust Fund. https://www.thegef.org/sites/default/files/documents/2022-06/EN_GEF_C.62_03_Summary%20of%20Negotiations%20of%20the%208th%20Replenishment%20of%20the%20GEF%20Trust%20Fund_.pdf.

Green Climate Fund (2018). Policy on Co-Financing. https://www.greenclimate.fund/sites/default/files/document/policy-cofinancing.pdf.

Green Climate Fund (2022). Portfolio dashboard. https://www.greenclimate.fund/projects/dashboard.

International Monetary Fund (2014). *External Debt Statistics: Guide for Compilers and Users*. International Monetary Fund, Washington, DC, 2013 edition.

Kotchen, M. J. and Negi, N. K. (2019). Cofinancing in Environment and Development: Evidence from the Global Environment Facility. *The World Bank Economic Review*, 33(1):41–62.

Markandya, A., Antimiani, A., Costantini, V., Martini, C., Palma, A., and Tommasino, M. C. (2015). Analyzing Trade-offs in International Climate Policy Options: The Case of the Green Climate Fund. *World Development*, 74:93–107.

Miller, S. and Yu, B.-K. (2012). Mobilizing Resources for Supporting Environmental Activities in Developing Countries. IDB Working Paper No. IDB-WP-329.

Niehuss, J. and Rey, N. (1983). Changing the Co-financing Agreements of the World Bank. *International Finanacial Law Review*, 2:22.

Rahman, S. M. and Ahmad, M. M. (2015). Climate Finance towards Vulnerable Countries: Evidence from the Global Environment Facility (GEF). *International Journal of Green Economics*, 9(2):199–214.

Rosendal, G. K. and Andresen, S. (2011). Institutional design for improved forest governance through REDD: Lessons from the global environment facility. *Ecological Economics*, 70(11):1908–1915.

Schneider, L. (2009). Assessing the additionality of CDM projects: practical experiences and lessons learned. *Climate Policy*, 9(3):242–254.

Sissoko, M. D. M., Toschi, N., and Martin, L. (2019). IFAD RESEARCH SERIES 37 - Determinants of cofinancing in IFAD-funded projects: A call to rethink development interventions. (2165-2019-1665):78.