ABSTRACT

Title of dissertation: INTEGRATING SUSTAINABLE DEVELOPMENT GOALS INTO CLIMATE FINANCE PROJECTS: ASSESSING THE MARKET IMPACT OF CO-BENEFITS FROM CARBON OFFSETS

Dissertation directed by: Prof. Nathan Hultman
Prof. Anand Patwardhan
School of Public Policy

By design, climate finance projects have two fundamental features: climate benefits and sustainable development benefits. Climate finance is important for cutting emissions, but it can also deliver significant additional benefits, often termed "co-benefits." The concept of co-benefits, although lacking a consist definition in the international arena, is so important, especially for the audiences from the developing world. Co-benefits are the backbone of a green and low-carbon development of these developing countries, where promoting high-quality economic development, maintaining economic, financial and energy security, protecting environment and controlling carbon emissions should achieved together. However, how the climate finance market values co-benefits remains poorly understood. By focusing on local co-benefits, this research highlights the importance of valuing co-benefits where projects are located, and how these projects deliver impacts for local communities. This dissertation looks at the question of co-benefits in three specific contexts by using both quantitative and qualitative methods as follows: First, I assess the likelihood that project co-benefits encourage buyers to pay more for Certified Emission Reductions (CERs) within the Clean Development Mechanism (CDM), the major international offset mechanism within a broader world of carbon finance. Second, I look at potential mechanisms of quality branding associated with the CDM to see whether these

indicators in fact attract a price premium attributable to co-benefits. Third, I study the role of offset co-benefits in corporate behavior and decision-making in voluntary carbon markets.

My research shows that in the CDM context, a project with a likelihood of delivering more co-benefits receives a higher CER price from buyers. The price difference between projects with the highest co-benefits and lowest co-benefits is \$4.9/tCO_2e[1] on average or a difference of 27.6 percent. The large variability in the price of CER partially comes from the locations of the buyer and the project, while CER prices do not differ based on the buyer's profit status, sector, or the number of projects they hosted. In the quality branding context, I see that quality control indicators (particularly the independently generated label of "Gold Standard") have a significant effect on CER prices with the price premium is in the range of \$1.13/tCO_2e (6.6% of price increase due to the Gold Standard certification of co-benefits) to \$4.2/tCO_2e (29%). Additionally, I see a strong commitment from public finance in delivering local co-benefits through their willingness to pay a price premium. In the voluntary carbon markets, I find that corporate motivations show a large degree of consistency and orientation, which aligns with the findings on the purchasing behavior for offset standards. Companies with a primary motivation to reduce emissions will prioritize purchasing cost-effective offset projects. Alternately, companies with primary motivations for non-emission impacts (such as company values or market competitiveness) value co-benefits more, and are willing to pay more to fulfill these goals.

---

[1] All monetary amounts expressed in USD unless otherwise noted.

INTEGRATING SUSTAINABLE DEVELOPMENT GOALS INTO CLIMATE FINANCE PROJECTS: ASSESSING THE MARKET IMPACT OF CO-BENEFITS FROM CARBON OFFSET

By

Jiehong Lou

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements of the degree of
Doctor of Philosophy
2020

Advisory committees:
Professor Nathan Hultman, Chair
Professor Anand Patwardhan, Co-Chair
Professor Irving Mintzer
Professor Yueming Lucy Qiu
Professor Roberton Williams

Acknowledgements

When I recall the path to this dissertation, it is pleasant because of all the people around me who showed me their own way of love and support. I am heartily grateful to have the best Ph.D. advisor I can imagine in the world, Prof. Nathan Hultman, whose advice can always ease the emotional moments that all Ph.D. students have during their journey.

I am grateful to have the best dissertation committee. My co-chair, Prof. Anand Patwardhan, is always skillful and knowledgeable, and able to remove all the roadblocks that I encountered in the course of this dissertation. Prof. Irving Minzter's rich experience in climate finance world always brings excellent ideas from a unique and sharp angle. Prof. Yueming Lucy Qiu is a role model for young scholars like myself, and from her I learned good time management, preciseness, and self-discipline. Prof. Roberton Williams brought me into the world of econometrics with his practices on research integrity and thorough methodology.

I owe my deepest gratitude to Prof. Allen Schick, who provided me with moral support for my entire Ph.D. life. And all the other faculty members in the School of Public Policy, who supported and helped me in the course of this dissertation.

I also want to thank my Ph.D. fellows and colleagues in the Center for Global Sustainability, for staying with me and making a home for me. Special thanks also go to Matt Regan, who took on the last-minute job of editing the dissertation for me.

Finally, I want to thank my parents and friends, who have given me endless love and support. Without them, I could not finish the dissertation. Their support makes me an energetic person who embraced every moment of my Ph.D. life.

Table of Contents

List of Figures

List of Tables

Chapter 1 Introduction

1. Motivation

We live in a world that is affected by climate change, that has finite resources, and that calls for global efforts to achieve a sustainable low-carbon economy. Climate finance is crucial to addressing the concern about climate change because of the large-scale investments that are needed to significantly reduce greenhouse gas emissions and adapt to the adverse effects of climate change. Sustainable development is crucial to addressing this concern because our current actions will have an impact on future generations. The last goal of the Sustainable Development Goals (SDGs) calls for "multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology, and financial resources, to support the achievement of the sustainable development goals in all countries" (Ban Ki-moon Centre for Global Citizens, 2018).

The growing reality of climate change implies the urgency of transitioning to a low-carbon economy, which requires significant financial investments in sustainable climate finance projects.

Climate finance with sustainable development benefits plays a significant enabling role in solving distinct issues at the convergence of carbon emissions, sustainable development, and climate risks. Capital must be drawn into sustainable projects aiming to reduce carbon emissions at scale. Thus, at the heart of this transition resides the strategy of integrating climate action and sustainability.

By design, climate finance projects have two fundamental features: climate benefits and sustainable development benefits. The motivation of this dissertation is the question of how climate finance can be deployed not only to reduce the emissions that cause climate change, but also to serve to improve human well-being and economic development, and be deployed in such ways that it can manifest in both advanced and emerging economies. These sustainable development benefits, such as improving air quality, empowering women, increasing farmers' livelihood, creating local jobs, etc., can be called co-benefits generally. How climate finance and these co-benefits can be best realized to serve the broader sustainable development and climate agenda is the primary focus of this dissertation.

Many climate finance projects are already part of broader sustainable infrastructure efforts. Research shows that the potential sustainable development benefits from sustainable infrastructure can reach $26 trillion by 2030 (New Climate Economy, 2018). Meanwhile, infrastructure with a focus on sustainability will be the primary driver to improve quality and avoid subsequent costs and the risk of stranded assets. Beyond the urgency of transferring investments to sustainable infrastructure, these core questions also arise: How can we mobilize finance for emissions reductions while meeting the goal of sustainability? How can we understand the role of sustainable development co-benefits in deploying finance through sustainable infrastructure?

2. Background: Sustainable Infrastructure

Sustainable infrastructure can be defined broadly as socially, economically, and environmentally sustainable infrastructure (Bhattacharya et al., 2016). Sustainable infrastructure should be socially inclusive, low carbon, and climate resilient (Bielenberg et al., 2016). The category not only includes conventional concepts of infrastructure, such as building, transportation, energy, and water systems (The New Climate Economy, 2018), but also natural "infrastructure," such as forests and wetlands, which is the backbone of our society.

The fundamental challenge of investing in sustainable infrastructure is to close the gap between the demand for sustainable infrastructure and the supply of capital. On the demand side, a tremendous amount of investment is needed. A study conducted by the GCEC estimates that about $90 trillion of investments in infrastructure are needed by 2030 (Arezki et al., 2016; Bhattacharya et al., 2016; GCEC, 2016). However, we are unable to transform the huge needs and opportunities to realize these investments, and too much of what is being invested in is not as sustainable as it could be, due to policy gaps and institutional weaknesses. On the supply side, a largely untapped pool of global long-term savings—around $100 trillion—is under-managed by institutional investors and struggling to find suitable projects to invest in (Arezki et al., 2016). These institutional investors, including pension funds, insurance companies, mutual funds, foundations, universities, NGOs, and sovereign wealth funds have been investing in infrastructure only on a very limited scale. As a result, we are unable to transform the saving pool into the right kind of finance at scale because of a lack of proven and standardized financing models to mitigate risks and crowd in private capital.

Right now, the current scale of infrastructure investments takes up half of the total infrastructure spending from private investments ($1 trillion to $1.5 trillion per year).[2] However, only 25 percent of that comes from institutional investors and 75 percent from corporate actors (Bielenberg et al., 2016). But we also see that sustainable investing is becoming more mainstream, especially in Europe and North America, in the past few years. As a result, sustainable infrastructure can make a big impact on local communities. We should work on creating infrastructure as a new asset class, by integrating a set of sustainability criteria, such as co-benefits, into its core definition, which allows the sustainable infrastructure to access the capital markets.

3. Co-Benefits of Local Communities and Research Challenges

Current research on integrating sustainability criteria or co-benefits into sustainable investing has faced several challenges. First, in the worlds of infrastructure finance and climate finance, while it is fairly simple to calculate the cost of these projects, the effect on the demand side is much harder to measure or estimate. The key question is: How does a change in co-benefits impact a project developer's climate finance choices? Sustainable development benefits normally do not come with a monetary value attached to a climate finance project. Thus, it is quite challenging to evaluate its impact and influence on investments in adaptation and mitigation. Second, there are undefined standards to measure these co-benefits. Third, there is a lack of globally comprehensive integrated assessments for all dimensions related to the SDGs. Due to inadequate co-benefit (or ESG) data

---

[2] Current infrastructure spending of $2.5 trillion to $3 trillion a year. While the future demand for infrastructure spending is 6 trillion per year. (because we need $90 trillion between 2015-2030, and existing infrastructure is $50 trillion).

disclosure standards and performance metrics, these scattered and inconsistent datasets further prevent researchers from conducting solid research on the impact of co-benefits (Lewis et al., 2016).

Despite these challenges, there has been research in a few areas. The first area of literature focuses on the qualitative analysis of climate finance projects. It uses a common methodology of multiple-dimension-multiple-indicators to evaluate the co-benefits of climate finance projects. The most convenient and generally adopted rule of dimension/criteria is based on a three part social-economic-environmental framework. These three pillars, with their own sub-level indicators, provide a complex system to integrate standardized measures across all projects. The simplest method adopts a check-list format to conduct project comparisons (Ellis et al., 2007; Sirohi, 2007). A moderately more complicated method normally conducts a textual analysis for a number of project documents by extracting co-benefit-related information and building up a profile of co-benefits for each project for comparison (Disch, 2010; Olsen and Fenhann, 2008; Spalding-Fecher et al., 2012; Subbarao and Lloyd, 2011a; UNFCCC, 2012; Watson and Fankhauser, 2009). An even more complicated method called Multi-Attributive Assessment is a combination of indicators of qualitative, semi-quantitative, and quantitative natures (Sutter, 2003; Sutter and Parreño, 2007). This method evaluates the contribution of climate finance projects to sustainable development for all indicators and aggregates the ratings to the project level (Alexeew et al., 2010; Crowe, 2013; Drupp, 2011; Nussbaumer, 2009; Sutter and Parreño, 2007). Finally, there is another way to conduct co-benefit analysis in full detail, which is conducting case studies for a specific country with detailed information (Castro and Michaelowa, 2008; Cole and Roberts, 2011; Sirohi, 2007). However, due to the large scale of projects around the world, conducting detailed country-specific evaluations is costly in terms of time and money, and also not necessarily applicable to the broader world. Overall, this research group only focuses on the co-benefits of projects per se by assigning different scores to projects. But it ignores the interaction between the projects and market actors. Thus, we are unable to identify whether market actors value projects that have more co-benefits or not.

The second area of literature analyzes co-benefits quantitatively by limiting co-benefits to specific areas, where these co-benefits are easily measured and calculated, such as environmental indicators (e.g., CO_2, SO_2, etc.) or social/economic indicators (e.g., income, employment, etc.). However, none of the studies analyze co-benefits from a complex view like this dissertation. Literature studying sustainable development benefits in China usually identifies a common definition of co-benefits as reductions in SO_2, NO_x, and particulate matter (Murata et al., 2016; Sun et al., 2010; Zhang and Wang, 2011) because the Chinese government's priority of sustainable development is local environmental protection due to heavy pollution. Papers focusing on co-benefits in Brazil generally pay attention to the income and employment level (Mori-Clement, 2019). However, the consequence of limiting the coverage of co-benefits into one or two areas is that we also limit the evaluation of co-benefits to the local communities to a restricted scale. Thus, it diverges fundamentally from this dissertation's original motivation, which aims to study as many dimensions of co-benefits to the local communities as possible.

4. Research Objective and Approach

To fill the research gap, this dissertation intends to answer the following research questions: Are co-benefits from climate finance valued by stakeholders, institutional investors, organizations, and private companies? If yes, how are they valued?

An important step in this section is to define what is meant by local or community co-benefits in the context of this dissertation. Although the idea of co-benefits has attracted increasing attention from governments, NGOs, financial institutions, and academic research in recent years, there is no consensus on a concrete definition or agreed list of what counts as a co-benefit (Mayrhofer and Gupta, 2016). The Intergovernmental Panel on Climate Change (IPCC) considers co-benefits as "the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare" (IPCC, 2014). In this paper, we focus on a smaller subset of co-benefits, particularly on co-benefits to local communities as a result of Clean Development Mechanism (CDM) mitigation actions (carbon projects) that are targeted at addressing global climate change. Thus, I adopted and adjusted the co-benefits description from World Bank CDCF 2013 report on key community outcomes, where five broad areas are listed (World Bank, 2013). These five areas capture the complex dimensions of co-benefits. The co-benefits of this dissertation will cover the following five areas:[3] Enhanced local infrastructure (e.g., roads, health clinics, schools, water, parks, community centers,

---

[3] This has a practical connection to the literature review itself, because most papers included in the dissertation use the term or concept "sustainable development" benefits. Because of our focus on local co-benefits, I reviewed these papers to see whether they mentioned it the benefits in local communities. If they did, we treat it as targeting co-benefits to local communities, even if they use the word sustainable development as a broad term. The description of local co-benefits is adopted and adjusted from World Bank CDCF 2013 report on key community outcomes (World Bank, 2013).

etc.); access to cleaner and affordable energy for heating and/or cooking; improved income and employment; improved access to electricity and/or energy efficient lighting; and improved natural resource and environmental services (e.g. reduced pollution, natural resource conservation, forest protection, biodiversity).

As there is a need and trend to integrate sustainable development benefits into evaluating climate finance, there is a necessity to study previous experience and see what we can learn from them to inform this process. Additionally, we should also explore how climate finance projects contribute to the SDGs and, accordingly, what kind of value people are willing to place on these projects that generate significant sustainable development benefits.

The challenges to studying co-benefits from climate finance projects empirically motivate us to find a practical entry point that can provide an approximately consistent historical record of both projects and their valuation. As a result, I have chosen carbon offsets as a lens to look at the problem. On the basis of carbon offset markets, a feasible approach of co-benefit research is to apply an analytical framework to the limited but still valuable data sources in this market. In the area of carbon offsets, we have a rich set of experiences and dataset to test the market and inform policy.

A carbon offset, deriving from real-life activities, represents one ton of CO_2e[4] sequestered or prevented from entering the atmosphere (Goldstein, 2016). Thus, by design, carbon projects deliver offsets that can be traded based on their climate benefits. Moreover, these

---

[4] Though usually referred to as “carbon offsets”, many projects focus on other GHGs, such as “projects based on biomass and industrial methane capture, and emission reductions are measured in carbon dioxide equivalent units (CO_2e) (Conte and Kotchen, 2010).

projects can also host additional benefits besides emission reductions. These benefits are called “co-benefits”, which are often in line with many of the aspects of sustainable development. Another important layer of promoting sustainable carbon finance projects is that through projects, SDGs can be realized.

Currently, there are two markets for carbon offsets, the compliance and voluntary markets. The market settings are different for the two markets. In the compliance (mandatory) market, buyers are primarily motivated to purchase offsets that can provide a more economic sense to reduce emissions to fulfill their lawful requirements, such as in a cap-and-trade regime. CDM, as one of the offset mechanisms under the Kyoto Protocol, is responsible for the lion’s share of issued compliance offsets so far (of the 11 considered offset programs, CDM and JI Track 1 account for over 90 percent of credits issued, 59 percent and 33 percent respectively) (World Bank, 2015)[5].

The voluntary carbon market grew later compared to the compliance carbon market. It picked up in the late 2000s and kept a relatively stable trend until the year 2017, when the issuance and retirement[6] of carbon credits reached a record high. While in the voluntary markets, buyers (for example, companies) are largely motivated by their social responsibility and concerns about climate change to reduce their emissions (Anja, 2007; Goldstein, 2016). The bulk of voluntary offset purchases by volume are made by multi-

---

[5] Primary market transactions are comprised of offsets sales from project developers to intermediaries or directly to end buyers; secondary market transactions are comprised of offset sales among intermediaries or from intermediaries to end buyers. In the case of CDM and JI, most of the transactions belong to primary market transactions (Hamrick, 2017).

[6] Issuances reflect the volume of emissions reductions verified under a standard. Normally, issuances represent offsets available for sale, and retirements represent offsets that can no longer be resold (Hamrick and Gallant, 2018).

national, private, for-profit companies. In 2017, companies are the primary buyers in the voluntary markets with a market share of 87 percent by volume.

Both compliance and voluntary markets remain theoretical opportunities for expansion in the future, but their widespread use remains in question due to many challenges. Uncertainty about the potential for double counting, historical lack of transparency, and other questions have meant that the international community cannot reach an agreement on how to perform international cooperation to scale up these actions (Dufrasne, 2018; Evans and Timperley, 2018; IETA, 2018). Nevertheless, despite this controversy, studying the previous experience and skills of the carbon market mechanism presents us with real meaning. Before we have a fully designed new market mechanism, the most common practice of integrating sustainable development into carbon offset projects in history is the CDM.

The CDM is the major international offset mechanism within the broader world of carbon finance and was designed to lead to significant emission reductions that will help reduce the cost of climate mitigation in countries with commitments as well as contribute to sustainable development in the host countries. However, there has been significant discussion about the degree to which these projects fulfilled their dual mission of emissions reductions and sustainable development, particularly with respect to fostering local community co-benefits as a part of broader sustainable development outcomes.

The purpose of this dissertation is to study how co-benefits are valued by customers (stakeholders, institutional investors, organizations, and private companies) in climate finance, how these co-benefits vary based on customers' attitudes, and to what extent that the co-benefits can maximize customers' utilities. According to the traditional view, customers value climate finance projects with high co-benefits more and are willing to pay more. However, as discussed earlier, little research focuses on quantifying these co-benefits, let alone use econometrics to estimate and measure these co-benefits, and their impact on consumers' decision choice. This dissertation fills that gap. Based on the traditional assumption, we hypothesize that customers are willing to pay more to climate finance projects associated with co-benefits when they make their decision on purchasing carbon credits and evaluate that proposition using diverse methods.

5. Dissertation Organization

This dissertation takes a three-paper format. It covers the projects in the carbon markets, and customers specifically by examining both the compliance and voluntary carbon markets. The first paper tests the market of the CDM and gets an indication of whether or not buyers are willing to pay more on projects with better co-benefits. The second paper focuses on studying a quality control indicator of carbon offsets by looking at one of the standards on the carbon markets, the Gold Standard, and then tests whether this Gold Standard attracts a price premium because of these co-benefits. The third paper studies the behavior of corporate efforts in purchasing carbon offsets credits on the voluntary market, and how the co-benefits of these carbon offsets credits are valued at the company level.

First paper
CDM

- Q: Does the likelihood of getting more co-benefits encourage buyers to pay more for the CERs?
- Goal: test the CDM market and get in indication of whether or not buyers are willing to pay more on projects with better co-benefits
- Study domain: CDMs with a price tag
- Method: literature review, OLS regression analysis, hedonic price model

Second paper
Gold Standard CDM

- Q: Does Gold Standard increase buyers’ willingness to pay more for the CERs?
- Goal: test the product and get an indication of whether or not buyers voluntarily purchase carbon credits with higher co-benefits, all other attributes of the carbon projects being equal.
- Study domain: CDM and CDM_Gold standard
- Method: econometrics model (propensity score matching plus exact matching)

Third paper
Voluntary Carbon offsets

- Q: How do diverse corporate motivations to invest in offset projects affect their choices with respect to co-benefits to local communities?
- Goal: study the role of co-benefits in company behavior and decision-making in the voluntary carbon market as end buyers, and what drives them to purchase carbon offsets.
- Study domain: company voluntary carbon credit offsets projects
- Method: A mixed method

Chapter 2 Paper One: Do Potential Co-Benefits from Clean Development Mechanism Projects Encourage Buyers to Pay More?

Abstract

The Clean Development Mechanism (CDM) has been the major international offset mechanism within the broader world of carbon finance. It was designed to lead to significant emission reductions that could reduce the cost of climate mitigation in countries with commitments, as well as contribute to sustainable development in host countries. However, there has been significant discussion about the degree to which these projects fulfilled their dual mission of emissions reductions and sustainable development, particularly with respect to fostering local community co-benefits as a part of broader sustainable development outcomes. In this paper, I will review the literature on the co-benefits delivered by the CDM at the local or community level, based on a group of 83 peer-reviewed articles and other reports. While perspectives on co-benefits are diverse, most sources argue or acknowledge that even with more recent procedural improvements, the CDM has not consistently delivered significant co-benefits to local communities. It appears likely that the situation has improved somewhat in recent years as CDM procedures have been refined, and there may be more opportunities for enhancing procedures to favor such benefits. My conclusion from the literature is that there is overall variability in delivering co-benefits depending on the technology type, design features, and the country context. To confirm such observations, this paper takes a further step and conducts an econometric analysis of 2,205 projects based on their interactive Sustainable Development Goals (SDG) scores for the co-benefits in the CDM pipeline to date. Specifically, a regression model and a hedonic model is constructed separately to identify the drivers behind the prices of Certified Emission Reductions (CERs). The empirical analysis shows that a project with the likelihood of getting a higher number of co-benefits receives a higher CER price from the buyers, statistically controlling for projects' features and sellers' background. The price difference between projects with the highest number and the lowest number of co-benefits is \$4.9 /tCO_2e on average or a difference of 27.6 percent. These results are consistent with earlier hypotheses in the literature but provide an additional dimension to study the research question from the dynamic between co-benefits and market behavior.

1. Introduction

The world now has roughly a decade and a half of experience with the carbon offsetting programs established in the Kyoto Protocol, which include the Clean Development Mechanism (CDM) and Joint Implementation (JI). The experience of these programs can inform the next steps in the evolution of finance to support low-carbon sustainable development, including ongoing discussions about possible pathways for implementation of Article 6 of the Paris Agreement. As of the time of writing,[7] there are 7,806 projects registered under the CDM with a total of 1.958 billion issued Certified Emission Reductions (CERs) (UNEP DTU Partnership).[8] The CDM is probably the most salient international offset mechanism within the broader world of carbon finance, and was hoped to lead to significant reductions of greenhouse gas emissions at the project level. Initiated under the Kyoto Protocol in 1997, the CDM was charged with carrying out the goal of assisting "Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments" with "real, measurable and additional" emission reductions (UNFCCC, Article 12). Importantly, The CDM was explicitly designed with a co-equal, second goal, embedded in the Kyoto Protocol, of helping developing countries to achieve sustainable development. [9]

This second, sustainable development (SD) goal stemmed from an interest by the parties and the international community in ensuring that the carbon finance approach in the CDM would not be just to identify low-cost reductions, but also to support broader development goals. The co-equal SD goal created challenges in interpreting and implementing the CDM, and as a result has been the subject of extensive inquiry. Operationalizing such an aspirational goal was always going to be a challenge and has been complicated by the

---

[7] At the time of writing, I used data from UNEP DTU Partnership the by January 10, 2019.

[8] Formerly UNEP Risø Centre (URC)

[9] "The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3" (United Nations, 1998).

absence of an internationally accepted definition of sustainable development in the context of specific projects and national priorities. And because the 2001 Marrakesh Accords confirmed that it is the host country's responsibility to define whether a project contributes to the sustainable development or not, the interpretation of sustainable development varies from country to country. I would expect the impact of CDM projects on local community co-benefits could also differ.

Nevertheless, the extent to which these programs have supported sustainable development goals, and in particular benefits to local communities, has been evaluated by a number of research teams over the past decade. Unfortunately, while this literature was able to present extensive discussion about co-benefits, there was very little about evaluating the link between co-benefits and market behavior. To address this gap, this paper takes a three-part approach. First, it studies the existing literature on the area of to which the extent that carbon finance projects under the CDM led to significant development co-benefits for local communities and what contributed to these outcomes. To do this, I conducted a systematic literature review based on a group of 83 peer-reviewed articles and other reports to generate hypotheses about the relationship between co-benefits and the carbon markets. Second, based on this analysis, I develop a Sustainable Development Goal (SDG) interaction score system to elucidate the relationship between co-benefits and carbon markets, and create eight categories of co-benefits to facilitate the econometric model later. Third, I test the hypotheses about whether buyers are willing to pay more on projects with better co-benefits based on the SDG scoring system. I do this via an econometric analysis of 2,205 projects with a price tag and a contract date for the Emission Reduction Purchased Agreement (ERPA) in the CDM pipeline to date. Specifically, a regression and a hedonic model is constructed to identify the drivers behind the prices of CERs and different levels of co-benefits.

This remainder of this paper is organized as follows: Section 2 provides an overview of the research background and objectives, and a discussion on challenges in defining local community co-benefits in practice. Section 3 describes the methodological approaches and data used for this paper. Section 4 presents the results of the regression analysis. Further econometric analysis with sectoral data is discussed in section 5. I present the discussion and potential for future research in Section 6. Policy implications and conclusions are summarized in section 7.

2. Define and Operationalize Conceptual Approaches to Co-Benefits

This paper studies the topic on the sustainable development co-benefits delivered by CDM projects, with a focus on the local level. Sustainable development has been broadly accepted as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). However, turning this general definition into a specific application under CDM was a challenge. Unlike the additionality goal of the CDM, which is measured and monitored by the CDM Executive Board under the UNFCCC, there was no internationally accepted standard[10] of sustainable development. The assessment of sustainable development benefits including local co-benefits was essentially delegated by the Kyoto Protocol to individual nations as a sovereign matter to its state parties, who essentially then developed

---

[10] Although the definition of sustainable development from the Brundtland Commission is broadly accepted, there is still missing an operationalizable interpretation of sustainable development, which does not have a common standard.

guidelines that were applied to each individual proposed project in their respective countries. This approach, rooted in the Marrakesh Accords, allowed countries flexibility to design their own "menu" of sustainable development options based on their capacities and priorities. Functionally, this was done via a specific institutional process. The international rules under the UNFCCC required each country to designate an agency within the government or other government entity to evaluate and approve CDM projects and oversee their implementation. This Designated National Authority (DNA), appointed by countries, was then also, by extension, charged with shaping the assessment of sustainable development for CDM projects. This assessment usually was rooted in some broader sense of priorities generated by the national government and then interpreted via a set of guidelines, indicators, or preferred project types (Ellis et al., 2007).

Broadly speaking, the nature of the CDM thus creates three challenges for delivering sustainable development benefits, whether at local or national scales. The first challenge is rooted in the diverse interpretations of sustainable development under CDM. As a result of the nationally based structure of CDM, there were no standardized assessment criteria or monitoring systems. This has meant that many countries have not established strong systems for encouraging SD during the project development phase of CDM, or for monitoring sustainable development benefits during the implementation phase, potentially reducing the quality and quantity of benefits delivered (Dirix et al., 2016). Second, the CDM is a market mechanism that is designed to identify low-cost emission reductions. Facing possible trade-offs between easily quantified emission reductions and harder-to-quantify sustainable development benefits, project, developers may favor those things more easily counted and more directly profitable. Third, the CDM does not establish any particular institutional or monetary incentives for projects that benefit the local communities, thus, these co-benefits are not hard to be recognized in the market.

In this paper, I focus on only sustainable development at the local level. This focus presents, in my view, two additional challenges to interpreting local community co-benefits in practice. First, the absence of an internationally accepted definition of sustainable development in the context of specific projects and national priorities moreover makes it challenging to define a clear and consistent set of criteria to evaluate local co-benefits. I address this issue by establishing a set of criteria as detailed in the next section. Second for many countries, local co-benefits are only one dimension of their interpretations of sustainable development, which could include such other priorities as electricity generated for the national grid, enhancement of national income, purchasing of domestically produced goods, and others. Since most papers reviewed in this paper somehow invoke the term or concept "sustainable development," I addressed this issue by reviewing all such papers to see whether they specifically referenced benefits for local communities.

An important step in this section is for us to define what is meant by local or community co-benefits in the context of this paper. Although the idea of co-benefits attracted increasing attention among governments, NGOs, financial institutions, and academic research in recent years, there is no consensus on a concrete definition or agreed list of what counts as a co-benefit (Mayrhofer and Gupta, 2016). The conventional concept of co-benefits as referred by the Intergovernmental Panel on Climate Change (IPCC) as the "the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare" (IPCC, 2014). In this paper, I focus on a smaller subset of co-benefits, particularly on co-benefits to local communities as a result of the CDM mitigation actions (carbon projects) that are targeted at addressing global climate change.

By placing my research proposition in the content of local co-benefits, I am emphasizing the importance of valuing co-benefits where these projects are located, and how these projects deliver impacts on local communities. The motivation of this paper is to illustrate the crucial important of rooting local co-benefits with the climate projects.

Exist literature on how to evaluate co-benefits on carbon offsets projects can be categorized into two groups. The first area of literature focuses on looking at multiple dimensions of the benefits by using a “multiple-dimension, multiple-indicator” approach to evaluate co-benefits of carbon offset projects. The most commonly adopted methodology is to categorize benefits according to environmental, social, and economic benefits (Alexeew et al., 2010; Crowe, 2013; Drupp, 2011; Ellis et al., 2007; Nussbaumer, 2009; Olsen, 2007; Sutter, 2003; Sutter and Parreño, 2007). The second area of literature places the focus of co-benefits on specific areas in which concrete metrics of co-benefits can be feasibly measured or calculated. These include environmental indicators such as emissions (CO_2, SO_2) or social/economic indicators such as income or employment (Mori-Clement, 2019; Murata et al., 2016; Sun Life Financial Inc., 2018; Zhang and Wang, 2011). It was my view that these broad areas were insufficient to fully describe local community co-benefits. In particular, the broad three-part categories lack a focus on specific routes to generating local benefits, and the metrics-focused approach may apply an overly narrow lens that might leave out meaningful qualitative contributions. Accordingly, I adopted a five-category typology in accordance with the World Bank Community Development Carbon Fund (CDCF)'s definition (World Bank, 2017, 2013). These five categories are:

1. Enhanced local infrastructure (e.g., roads, health clinics, schools, water, parks, community centers, etc.)
2. Access to cleaner and affordable energy for heating and/or cooking
3. Improved income and employment
4. Improved access to electricity and/or energy efficient (EE) lighting
5. Improved natural resource and environmental services (e.g., reduced pollution, natural resource conservation, forest protection, biodiversity)

Relatively limited research has been conducted on the topic of carbon finance and community co-benefits. Among this group of literature, most papers are heavily qualitative because of innate difficulties to measure and evaluate the co-benefits. Additionally, several foundational issues remain unaddressed, especially there is no such research on the topic of interplay between CER prices paid by the credit buyers and a broader list of co-benefits. Because eventually, my primary interest is to see how co-benefits can be valued and monetarized partially under the design of the carbon markets. This study aims to fill these gaps in the literature by examining the research question by conducing both qualitative and quantitative research.

The first research question for this paper is:

> *What does the existing literature say about the extent to which carbon finance projects under the CDM led to significant development co-benefits for local communities and what contributed to these outcomes?*

The second research question for this paper is:

> *Does the likelihood of more co-benefits encourage buyers to pay more for the CERs?*

3. Methodological Approach and Data

To answer these research questions, I divide my methodological approach into two components. The first component is using a systematic literature review to answer the first research question. The second component adopts econometrics models to solve the second research question.

3.1. Method 1: Systematic Literature Review (Observations and Empirical Evidence by Co-Benefit Category)

Methodologically, I implement the first component using a specific and emerging approach called the "systematic literature review." This process diverges from a more conventional literature review in using a transparent and systematic approach to finding, selecting, and reviewing literature. More details about systematic literature reviews may be found in Petticrew and Roberts, 2008. While traditional literature reviews have many merits, the systematic review methodology may reduce the possibility of bias in selecting and reviewing papers. For this reason, some organizations, including the World Bank, have created policies that encourage the use of systematic literature reviews.

3.1.1. Data for the Systematic Literature Review

The following databases are used to conduct this literature review: Academic Search Complete; Web of Science; Scopus; GreenFILE (EBSCO). Google Scholar and Google are used to capture additional possible papers. In order to do a systematic backwards citation tracking, I use a bibliographic computation software called VOSviewer,[11] which can help us calculate the total number of cited references from the general search sample. Some sources that have not been published in academic, peer-reviewed literature can also contribute to our understanding of carbon finance. The special characteristics of the carbon markets, as a market mechanism evolved from private and public sectors, multi-level international organizations, non-profit organizations, etc., imply that some perspectives from organizations and actors with direct experience or other perspectives on the market can enhance insight into the questions in this review. This so-called "grey" literature[12] is included in my study, subject to careful review. A more detailed process of how to conduct the systematic literature review can be found in **Appendix C**. **Error! Reference source not found.** presents the final breakdown of references in my review sample. I also summarize a topical breakdown of papers assessed for each local co-benefit area (including reginal focus, research methods, project types, project sizes and externalities in Error! Reference source not found..

---

[11] VOSviewer is a software tool developed by developed by Nees Jan van Eck and Ludo Waltman at Leiden University's Centre for Science and Technology Studies (CWTS). It is a tool used to conduct bibliographic analysis and scientific mapping.

[12] I adopted the IPCC's coverage of grey literature, which are sources have not been published or peer-reviewed (e.g., industry journals, internal organizational publications, non-peer reviewed reports or working papers of research institutions, proceedings of workshops, etc.) (IPCC, Working Group I Approach to the Use of Literature in IPCC Reports).

Table 2-1. Research of applying search protocol.

Total number of papers included in this literature review: 83			
Pure Policy	Survey and Project Analysis	CDM-AR*	Grey Literature
11	32	18	22

*Eventually, I didn't include CDM-AR projects in my final empirically analysis due to the totally different application and evaluation process of CDM-AR projects.

Table 2-2. Typology of co-benefits papers.[13]

Co-benefit type	**Continent**	**Method**	**Project type**	**Project size**	**Externality**
• All five goals (33) [14] • Goal 1 (6) • Goal 3 (25) • Goal 4 (5) • Goal 5 (18)	• Global (40) • Africa (8) • Asia (17) • North America (4) • South America (5)	• Economic (5) • Science and engineering (16) • Social science (33) • Other (18)	• All (39) • A/R (19) • Biomass (1) • Cookstove (2) • EE (3) • Hydro (5) • Landfill (2) • Solar (1)	• Both (53) • Large (3) • Small (16)	• Positive (72) • Negative (14)

3.1.2. Literature Search Result

3.1.2.1. Co-benefit Variations by Project Type

The reviewed literature found substantial variation in local co-benefits across different project technologies. HFC-23 projects with sizeable potential emission reductions are commonly recognized to deliver few tangible local co-benefits (Alexeew et al., 2010; Ellis et al., 2007; Olsen and Fenhann, 2008; Schneider, 2007; Subbarao and Lloyd, 2011a; Sutter and Parreño, 2007; Watts et al., 2015). While they create large quantities of low-cost emissions reductions, these projects have a low impact on generating local employment[15] and no effect on improving local air quality.[16] Most of the profits from the destruction of

---

[13] Developed through the hand-coding of papers from the systematic review according to co-benefit type, continent, research method, project type, project size and externalities of project impacts.

[14] Numbers in parentheses are counts of papers.

[15] The projects are end-of-the-pipe solutions and do not have a substantial employment effect.

[16] Because industrial gases like HFC-23 are not local air pollutants, the destruction of them does not provide local environmental benefits for local communities.

HFC-23 in HCFC-22 facilities went to project developers and government.[17] However, how the government will use this tax revenue and whether this tax revenue can deliver indirect local co-benefits is out of the scope of this paper.

Landfill gas reduction projects also face a similar situation to HFC-23 projects in their capacity to deliver high emission reductions but with low co-benefits, and in many cases, appear to have engendered opposition from local communities. Such projects are associated with few direct employments because the technology they employ does not generate significant additional employment. Regarding to co-benefits on the environmental dimension, landfill gas projects may have contributed to improved sanitation and water quality—with potential health benefits. However, there have also been community concerns about negative impacts on local health of methane gas or other non-methane landfill gases if a new landfills or composting sites around their areas or an extension of the life of an existing site. Two out of five papers expressed the concerns of negative impacts of landfill gas projects.[18]

Hydropower assessments usually distinguish between large-hydro and small hydro projects. Large hydropower projects were broadly criticized in the literatures bringing negative impacts to local communities (Haya, 2007; Haya and Parekh, 2011; Rousseau, 2017), while these negative impacts were omitted by project developers in the PDDs. Also, compared to small hydro, large hydropower plants appear to generate fewer co-benefits to local communities (Sutter and Parreño, 2007). A case study in Yunnan Province in China

---

[17] For example, Chinese government tax 65 percent of the CERs of HFC-23 projects. By 2012, the expected tax revenue from this project type can be 1.5 billion EUR (Schneider, 2007).

[18] The Bisasar landfill CDM project in South Africa was criticized by local communities, who claim that the CDM projects is contributing to postpone the closing down of the waste disposal site, which had a negative impact on people’s health (Boyd et al., 2009).

revealed that the CDM hydropower project negatively changed local people's lives. For example, local smallholders lost their most important asset, their land, for building the dam. Thus, it also changed their livelihood accordingly. As a result, the benefits of the hydro project are captured by the wealthy eastern provinces, where they have a high demand for electricity, and the local communities experience the negative impacts from the CDM.

Renewable energy projects, such as small hydropower projects, wind and EE are generally recognized as having the potential to generate more co-benefits to local communities. Like other types of projects, these projects can provide broad sustainable development benefits for the country, such as increasing energy security improving air quality, and achieving technology transfer. But in addition, they usually have a high possibility to deliver local co-benefits, such as employment generation, income generation, access to energy, improved local air quality compared to other technologies (Olsen and Fenhann, 2008). Alexeew conducted a study of 40 projects with a diversity of project types in India. By looking at their PDDs, he concluded that among the project types, biomass, hydro, and wind projects contribute higher SD benefits compared to HFC-23 (Alexeew et al., 2010). Additionally, renewable energy projects in rural areas offer local communities a sustainable and viable alternative compared to fossil fuels, because expensive and difficult to transmit and distribute energy generated from fossil fuel to remote and rural area (Subbarao and Lloyd, 2011a).

Biomass projects have a medium performance on improving local air quality, while also good performance on employment generation. Sutter's study shows that only biomass power project received A rating (which means they can generate more than 300 person month per 1000 CER).

My studies targeted a diversity of technologies and some of the studies addressed the question of how the technology choice relates to sustainable development outcomes. At one extreme, most studies agree that industrial gas decomposition (HFC) projects have the lowest local co-benefits compared to the other project technologies. On the other end, rural renewable (Boyd et al., 2009) energy projects tend to have a high impact on local co-benefits on two levels. First, it has a higher impact on local co-benefits compared to other project technologies (Kim et al., 2013). Second, rural renewable energy projects in poorer regions tend to yield much higher impacts on poverty and promote local co-benefits (Drupp, 2011; Michaelowa and Michaelowa, 2011). As one example of this, Borges Da Cunha explores the feasibility of CDM projects in isolated Amazon regions to promote local access to electricity via renewable energy technologies (RETs). He concludes that not only will these RETs will result in emission reductions, but more importantly, it will promote universal access to electricity (Borges da Cunha et al., 2007).

3.1.2.2. Co-benefit Variations by Project Size

It is generally accepted that small-scale projects tend to deliver a slightly higher number of local co-benefits per project than large-scale projects[19] (Corbera et al., 2009; Olsen and Fenhann, 2008; Spalding-Fecher et al., 2012; Sutter and Parreño, 2007). Olsen and Fenhann, for example, found out that small-scale projects deliver a slightly higher number

---

[19] Most of the studies have multiple co-benefits indicators. Each indicator represents one benefits. So, they will look at how many indicators one project can get.

of SD benefits than large-scale projects (3.2 benefits per project for small vs 2.9 benefit per project for large) (Olsen and Fenhann, 2008). On the other hand, large scale projects showed outperformance on three indicators: improving air quality, access to water, and improved safety conditions.

Sutter and Parreno rated SD attributes across projects and found that the average SD rating was higher for small scale projects (Sutter and Parreño, 2007). Similarly, Spalding-Fecher's study of 202 projects, where 79 were small-scale and 123 were large -scale projects, indicated that there are more SD benefits for small-scale projects compared to large-scale projects; moreover, for five percent of large-scale projects, no other SD benefits other than technology transfer was mentioned. Dechezleprêtre's study agreed with the technology transfer conclusion but reached a differing view on the relationship to size, concluding that the larger of the project, the bigger the benefits (Dechezleprêtre et al., 2008).

A major limitation of these conclusions, unfortunately, is that most of the studies are conducted based on a desk-study of PDDs. This significantly limits their ability to understand real impacts on the ground. Subbarao and Lloyd conducted one of the few studies using a mixed method of desk-study and case study with five projects. Their results nevertheless similarly show that CDM projects failed to deliver significant or substantial SD benefits to localities. However, three out of the five cases reveal factors that can contribute to the success of the CDM projects (Subbarao and Lloyd, 2011b).

3.1.2.3. An SDG-interaction Score

From my previous systematic literature review, I find that a great deal of variation in co-benefits existed not only among project types but also within project type. In this section, I take one step further to assess the co-benefits of these projects in a more quantified way by drawing up studies of scoring exercise at the level of the SDG targets to better understanding the interaction between the CDM project technologies and the SDG dimensions. The two primary studies on this topic are McCollum et al., 2018 and the IPCC special report Global Warming of 1.5° C (IPCC, 2018.)

Both studies have conducted thorough research on the potential SDG targets from the deployment of mitigation options. My paper adopts the structure of integrating the SDG targets into the mitigation options from both studies, while adds another layer of five co-benefit criteria on top of this structure. Thus, the final structure of the assessment is presented in **Error! Reference source not found.**.

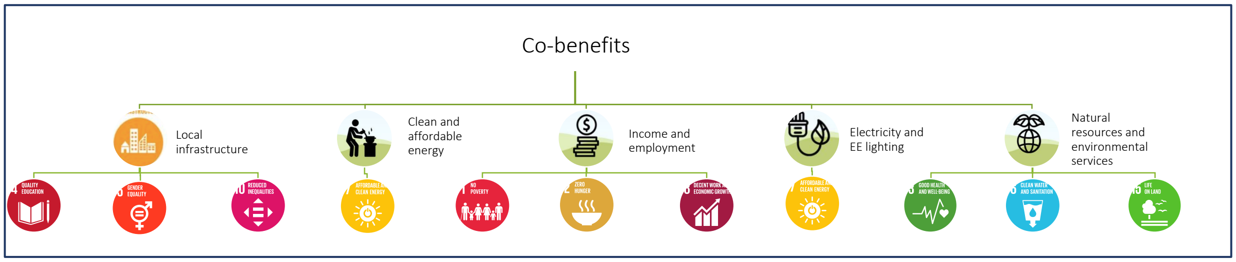


Figure 2-1. Structure of integrating SDGs into five co-benefit criteria. *We have layer five categories as the topic level under the co-benefits. Then each category is associated with one or more SDG goals. Thus, I am able to cover as many as SDGs as possible.*

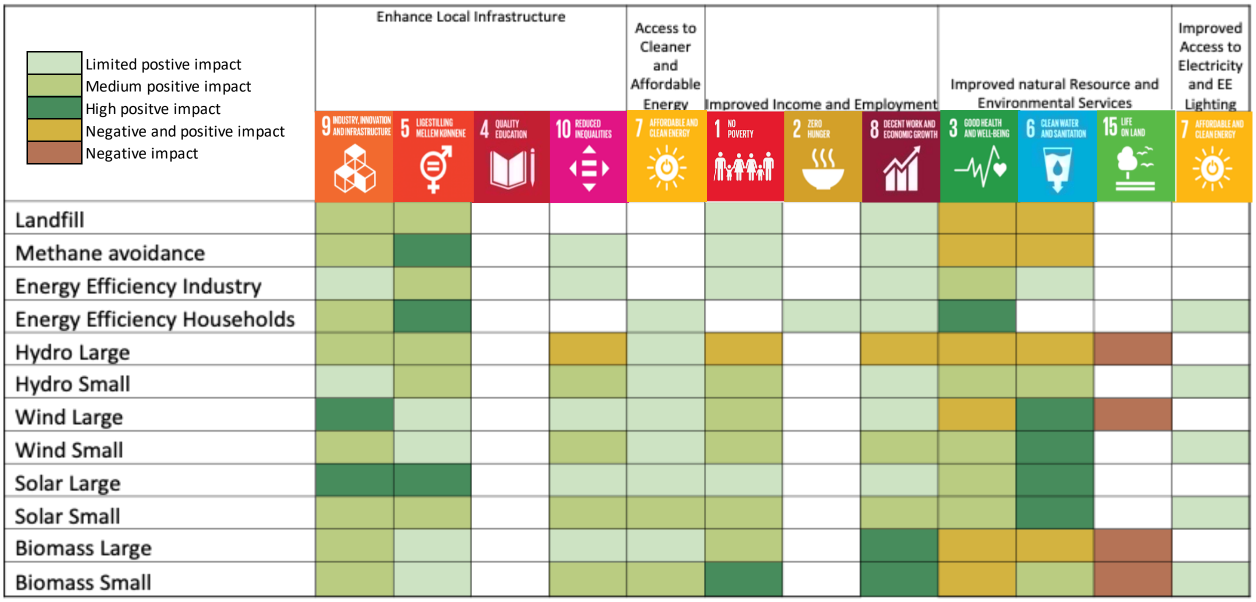
I combine the systematic literature review and the technique from McCollum and IPCC studies to assess the linkage between the co-benefits and the SDG targets. Under each SDG target, I will assign an SDG-interaction score from this specific SDG targets and the project. The SDG-interaction score is a seven-point scale score. Interaction between outcomes of the CDM projects and the SDG targets can be positive or negative. For the positive interaction, I have “significant impact” “high impact”, “medium impact”, and “limited impact” four scales, and for negative interaction, I have “minor damage”, “medium damage” and “massive damage”. Additionally, I present the validity of the results in the literature by examining the quantity, quality, and consistency of the literature into four scales, limited, medium, robust, and extensive. Eventually, I assign the current level of confidence (“low”, “medium”, “high”) to each SDG interaction based on the previous two aspects. This bottom-up direction of assessing the SDG interaction scores eventually can be aggregated at the level of co-benefit criteria. I present the results and the supportive evidence of how I obtain the SDG scores[20] at the end of this paper in **Table 2-10.** But a simplified version of this table is provided in Error! Reference source not found. to give the audiences an overview of the main findings of the SDG-interaction score system in a brief way.

Error! Reference source not found. only presents the different levels of impacts from the CDM projects through the seven-point scale, with dark green color indicating high positive impacts, and light green as limited positive impacts. The mustard color points to the projects which might have both positive and negative impacts on the local communities.

---

[20] Our implication assumption is that the SDG goals are weighted equally, despite that countries may have different focus areas on sustainable development based on their national development priorities.

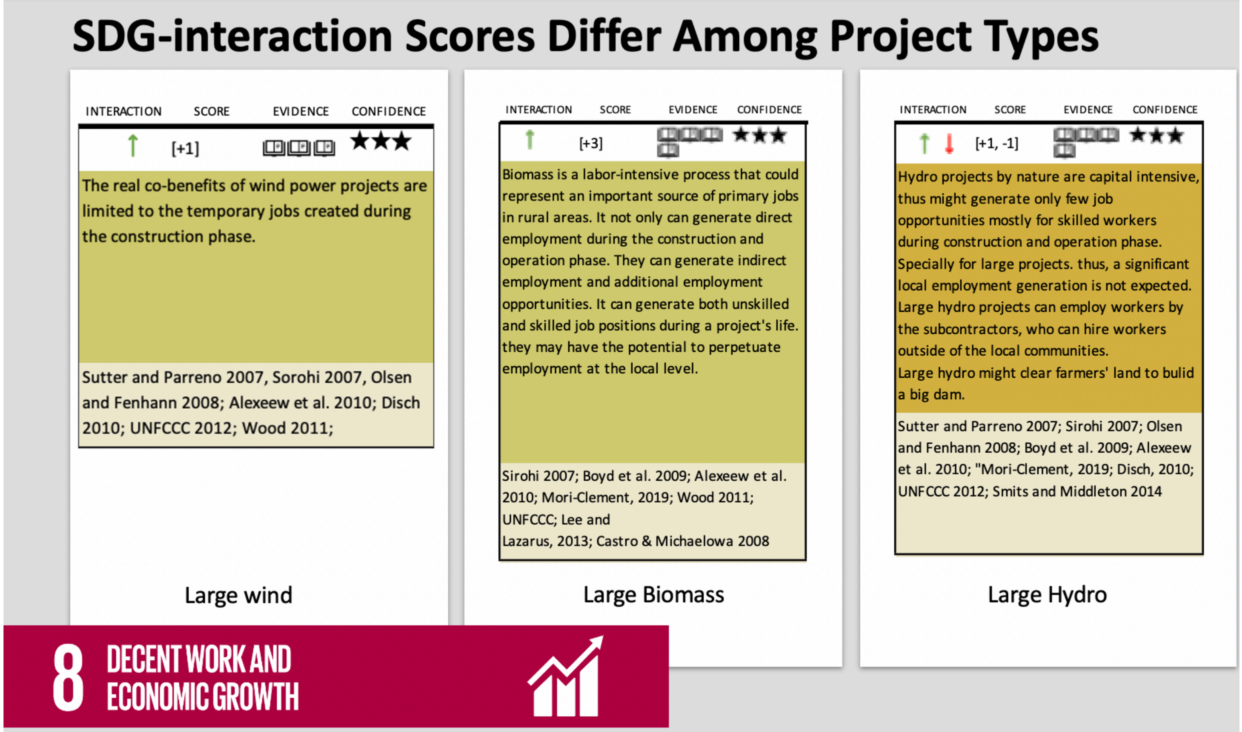
__Table 2-3. Simplified version of table 10.__ This simplified version only contains different levels of impacts from the CDM projects. I use three green colors to indicate limited, medium, and high positive impacts. The mustard color indicates that the two-way interaction from both positive and negative impacts. The cognac color indicates the negative impacts.



░ Limited postive impact ▒ Medium positive impact ▓ High positve impact 🟨 Negative and positive impact 🟫 Negative impact	Enhance Local Infrastructure				Access to Cleaner and Affordable Energy	Improved Income and Employment			Improved natural Resource and Environmental Services			Improved Access to Electricity and EE Lighting
	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	5 LIGESTILLING MELLEM KØNNENE	4 QUALITY EDUCATION	10 REDUCED INEQUALITIES	7 AFFORDABLE AND CLEAN ENERGY	1 NO POVERTY	2 ZERO HUNGER	8 DECENT WORK AND ECONOMIC GROWTH	3 GOOD HEALTH AND WELL-BEING	6 CLEAN WATER AND SANITATION	15 LIFE ON LAND	7 AFFORDABLE AND CLEAN ENERGY
Landfill	▒	▒				░		░	🟨	🟨		
Methane avoidance	▒	▓		░		░		░	🟨	🟨		
Energy Efficiency Industry	░	▒		░		░		░	▒	░		
Energy Efficiency Households	▒	▓			░		░	░	▓			░
Hydro Large	▒	▒		🟨	░	🟨		🟨	🟨	🟨	🟫	
Hydro Small	░	▒		▒	░	▒		░	▒	▒		░
Wind Large	▓	░		░	░	▒		░	🟨	▓	🟫	
Wind Small	▒	░		▒	░	▒		▒	▒	▓		░
Solar Large	▓	▓		░	░	░		░	▒	▓		
Solar Small	▒	▒		▒	▒	▒		▒	▒	▓		░
Biomass Large	▒	░		░	░	▒		▓	🟨	🟨	🟫	
Biomass Small	▒	░		▒	▒	▓		▓	🟨	▒	🟫	░

Figure 2-2 and Error! Reference source not found. are excerpts from **Table 2-10** of this paper at the end showing that the SDG-interaction scores vary among project technologies and between project sizes. These samples illustrate how I assess the 12 SDGs over 12 project-type-size combinations in a much deeper way.

In the capacities of creating potential jobs, many studies agree that large wind projects have limited impacts on local communities because of temporary jobs created during the construction phase. Based on that, I have assigned one SDG-interaction score to the large wind projects with high confidence. Large biomass projects can bring more positive impacts on the job creation to the local communities. They can generate direct and indirect job opportunities to perpetuate employment at the local level. Thus, I have assigned an SDG-interaction of three to the large biomass projects. Large hydro projects have both positive and negative impacts on the local job market.



SDG-interaction Scores Differ Among Project Types

INTERACTION	SCORE	EVIDENCE	CONFIDENCE
↑	[+1]	📖📖📖	★★★

The real co-benefits of wind power projects are limited to the temporary jobs created during the construction phase.

Sutter and Parreno 2007, Sorohi 2007, Olsen and Fenhann 2008; Alexeew et al. 2010; Disch 2010; UNFCCC 2012; Wood 2011;

Large wind

INTERACTION	SCORE	EVIDENCE	CONFIDENCE
↑	[+3]	📖📖📖📖	★★★

Biomass is a labor-intensive process that could represent an important source of primary jobs in rural areas. It not only can generate direct employment during the construction and operation phase. They can generate indirect employment and additional employment opportunities. It can generate both unskilled and skilled job positions during a project's life. they may have the potential to perpetuate employment at the local level.

Sirohi 2007; Boyd et al. 2009; Alexeew et al. 2010; Mori-Clement, 2019; Wood 2011; UNFCCC; Lee and Lazarus, 2013; Castro & Michaelowa 2008

Large Biomass

INTERACTION	SCORE	EVIDENCE	CONFIDENCE
↑ ↓	[+1, -1]	📖📖📖📖	★★★

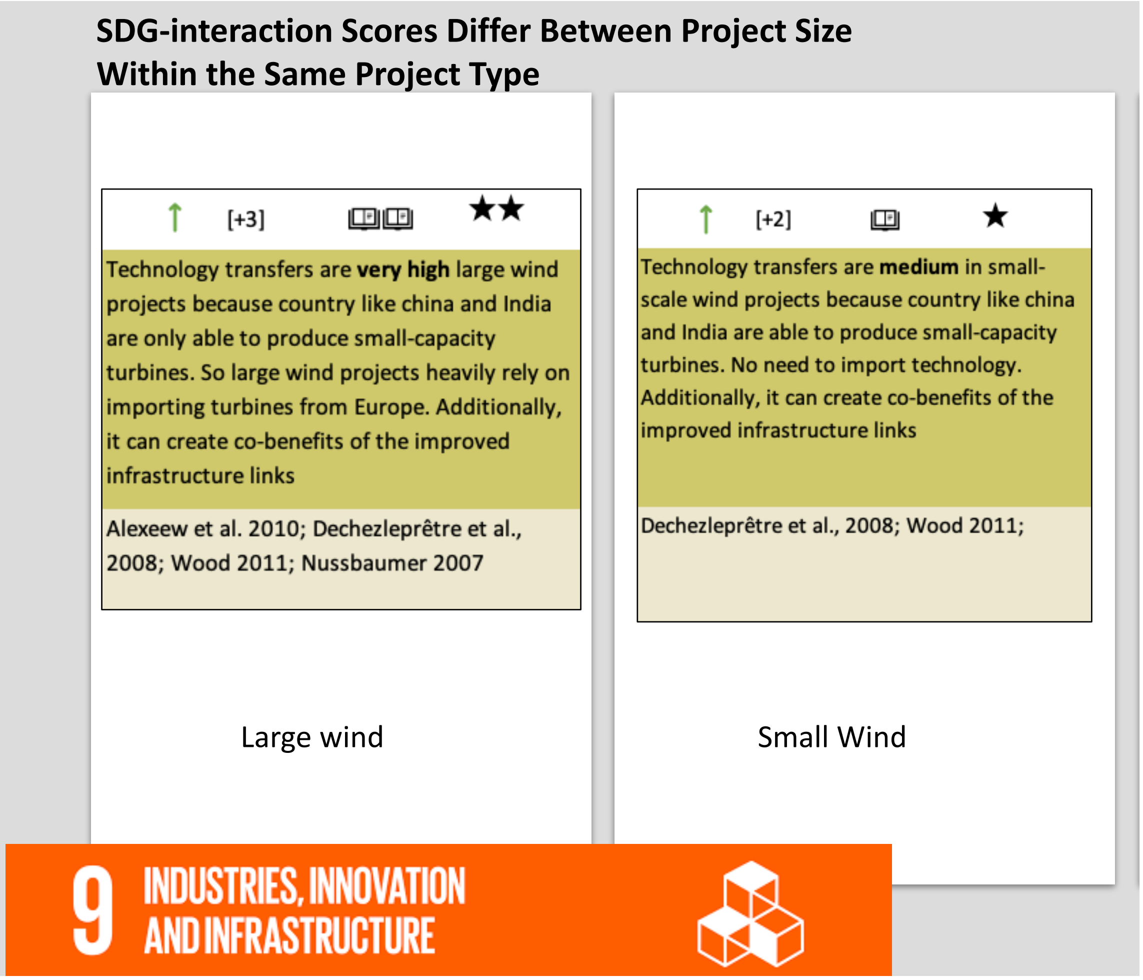
Hydro projects by nature are capital intensive, thus might generate only few job opportunities mostly for skilled workers during construction and operation phase. Specially for large projects. thus, a significant local employment generation is not expected. Large hydro projects can employ workers by the subcontractors, who can hire workers outside of the local communities.
Large hydro might clear farmers' land to bulid a big dam.

Sutter and Parreno 2007; Sirohi 2007; Olsen and Fenhann 2008; Boyd et al. 2009; Alexeew et al. 2010; "Mori-Clement, 2019; Disch, 2010; UNFCCC 2012; Smits and Middleton 2014

Large Hydro

Figure 2-2. An excerpt from table 10 to illustrate variation of co-benefits among project technologies. *These are three examples excerpted from the original table 10. These samples illustrate how I assess the 12 SDGs over 12 project-type-size combinations. Table 10 is presented at the end of this paper due to its length.*

One of the expectations of CDM is to stimulate the North-South transfer of clean technology, which can fit under SDG 9, Industries, Innovation, and Infrastructure. Taking wind technology as an example in Error! Reference source not found., the equipment of wind power generation is usually imported from developed countries. Especially for these projects that have higher capacity, they rely on imported turbines. While local companies normally are able to produce small-capacity turbines. Thus, I have assigned a higher SDG-interaction score to the large wind technologies.



SDG-interaction Scores Differ Between Project Size Within the Same Project Type

↑ [+3] 📖📖 ★★

Technology transfers are **very high** large wind projects because country like china and India are only able to produce small-capacity turbines. So large wind projects heavily rely on importing turbines from Europe. Additionally, it can create co-benefits of the improved infrastructure links

Alexeew et al. 2010; Dechezleprêtre et al., 2008; Wood 2011; Nussbaumer 2007

Large wind

↑ [+2] 📖 ★

Technology transfers are **medium** in small-scale wind projects because country like china and India are able to produce small-capacity turbines. No need to import technology. Additionally, it can create co-benefits of the improved infrastructure links

Dechezleprêtre et al., 2008; Wood 2011;

Small Wind

Figure 2-3. An excerpt from table 10 to illustrate variation of co-benefits between large and small project. *These are two examples excerpted from the original table 10. These samples illustrate how I assess the 12 SDGs over 12 project-type-size combinations. Table 10 is presented at the end of this paper due to its length.*

The previous analysis delivers the final summaries of the literature review. It helps me to build a logical flow by undertaking the literature into a more structured way of interpretation of the SDG targets and the CDM outcomes. Thus, I am able to use this linkage to implement statistical analysis as follows.

Combing the overall assessment of local co-benefits from **Table 2-10**, I am able to aggregate their SDG scores of these project horizontally, and finally group them into eight categories based on their aggregated scores in Error! Reference source not found., with their distribution plotted in **Error! Reference source not found.**. By the order from one to eight, thus, co-benefit 1 has the lowest aggregated SDB scores, and is supposed to yield the lowest co-benefits. Co-benefit 8 has the highest aggregated SDG scores, and is supposed to generate the highest co-benefits. Additionally, the ability of the CDM to generate local co-benefits varies among countries or even regions in part because of different policy approaches of governments. However, I do not consider the impact of project location when I create the categorization of co-benefits, because I want to keep my categorization simple and efficient. I will consider the effect of project locations in my econometric model by controlling for them at the level of country/region later.

Table 2-4. Categorization of co-benefits of CDM projects

Ranking of Co-Benefits (1 is the least, 8 is the most)	**Number of Projects**	**Project Type**	**Project Size**
Co-benefit 1	680	Landfill gas	All
		Methane avoidance	All
		Hydro	Large
Co-benefit 2	98	EE Industry	Large
Co-benefit 3	69	Biomass energy	Large
Co-benefit 4	843	Wind	Large
Co-benefit 5	396	EE household	Small
		Hydro	Small
Co-benefit 6	55	Wind	Small
		Solar	Large
Co-benefit 7	18	Solar	Small
Co-benefit 8	16	Biomass energy	Small

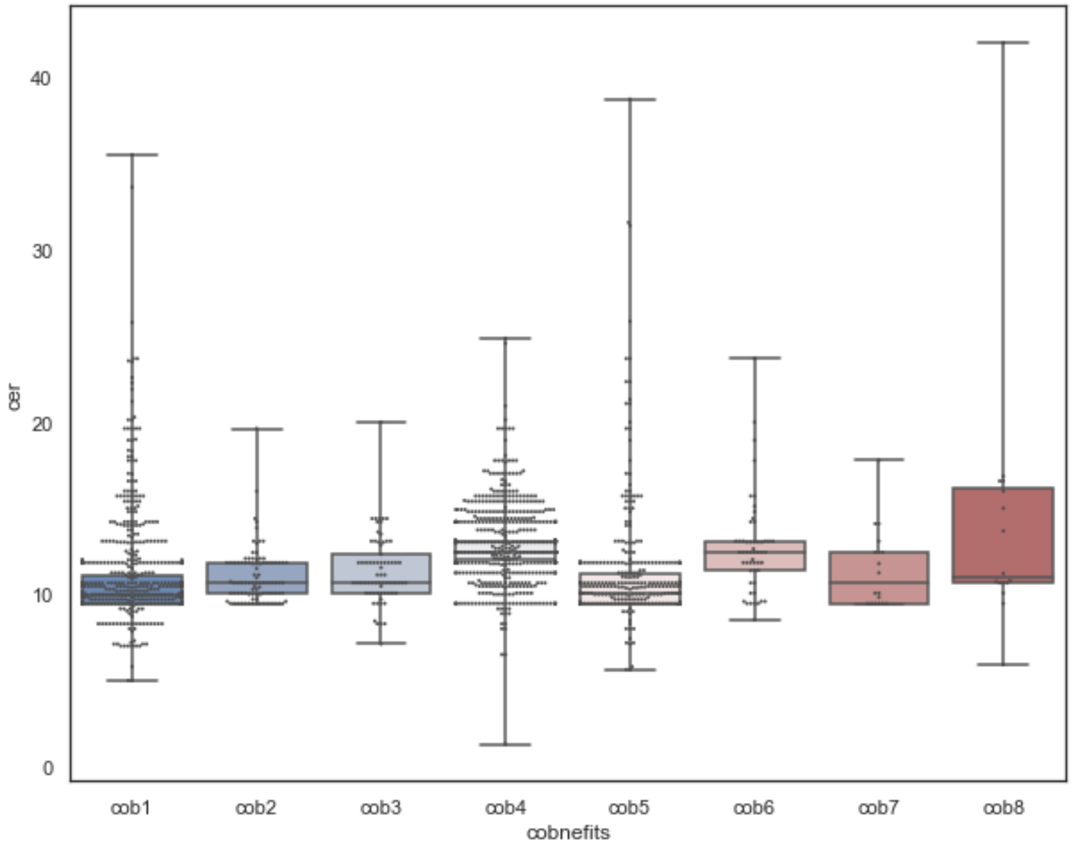


Figure 2-4. Box plot of CERs by co-benefits. *Small black dots are observation. The eight level of co-benefits are created based on the SDG-interaction score from Table 2-10 presented at the end of paper.*

3.2. Method 2: OLS Regression and Data

3.2.1. ERPA

The literature indicates that an Emission Reductions Purchase Agreement (ERPA) is viewed as positively affecting the price of CERs (Kamel et al., 2007). An ERPA is specially developed for contract parties that directly want to deal between project owners and buyers. The contract outlines in detail the various steps of the process, starting with getting the project idea approved by a validator and the CDM Executive Board and continuing on to the actual deliverance of emission reductions and consequent issuance of CERs by the

CDM Executive Board. Under the purchase agreement, buyers are required to pay a fixed price[21] for the CERs to the sellers, usually in U.S. dollars or euros.[22]

However, the CDM pipeline does not include the ERPA information, while most of the ERPA information is only provided in the project design document (PDDs), which is a long PDF document that the original project developer must submitted to the CDM Executive Board for project approval. The problem is that locating the dates of ERPA is quite time-consuming if it is done manually. As a result, the historical studies of the impact of the CERs prices have never controls for the dates of ERPA. Thus, identifying the ERPA dates for each project is crucial and the results will influence the impact from the CERs fundamentally. To solve the problem and improve the accuracy of statistical analysis in the later section, I use Python coding to go over the PDDs and validation reports for all the CDM projects with a CER price in the pipeline, and then extract information of ERPA dates from these documents.

To check the accuracy of the ERPA dates extracted by the machine, I adopted two methods to validate the data in **Appendix A**.

3.2.2. CER Prices

CER prices fluctuate widely and are not closely correlated with traditional macro-economic factors. Although the overall trend of CER prices follows the carbon market, there are also certain factors that can shift the CER prices reflected in the ERPA eventually. The

---

[21] In our paper, I set the assumption is that all the CDM projects in the pipeline are fixed-price contract, since it is the most common contract structure based on UNDP. Based on this assumption, information on the contract date is required in order to control the time variation of the carbon prices.

[22] In our paper, I unify all the currency to US dollars for the purpose of comparison

determinants of the CER prices can be divided into two levels: macro and micro (Kamel et al., 2007). The macro-level determinants of CER prices are the carbon market (including supply and demand), the implementation structure of the global treaties, the expectation of the future market and the whole sector, etc. The micro-level determinants of CER prices are mainly a function of concentrated on the buying and selling parties, and also the project characteristics, such as project duration, investment cost, location, type, etc.

The purpose of this paper is to study the effect of co-benefits (represented by achieving the Gold Standard certification) on the prices of CERs. The first step requires determining the project and extra-project independent variables likely to explain the intrinsic value of the CER as exhaustively as possible while ensuring the robustness of the specification. I have presented the key factors affecting CER prices along with the supporting literature in Error! Reference source not found.. Variables that are included in my analysis also cover the two levels of CER price determinants. Buyers, sellers, and project's characteristics, such as duration of the crediting period, project types, project size, project investment, etc. are adopted into the model as the micro-level determinants. In order to count towards the current and future expectations of the market and international reduction commitment, I include the expected CER volume for 2020 and 2030, plus the crediting period.[23] Additionally, I also use the signed date of ERPA to control for the market spot prices (macro-level) and also variation among buyers and sellers (micro-level).

---

[23] A CDM project can have either a seven-year crediting period, which can be renewed twice to make a total of twenty-one years, or a one-off ten-year period.

Table 2-5. List of key factors affecting CER prices.

Factors	Level	Explanation	Literature	Indicator
Short-term expectation (Volume)	Micro	Phase one and phase two prices	(Meyrick, 2007)	1st period $ktCO_2e/yr$
Credit period	Macro and Micro	Long-term supply; CDM project can have either a seven-year crediting period, which can be renewed twice to make a total of twenty-one years, or a one-off ten-year period	(Nordseth, et al., 2007)	Years of projects
Middle-term expectation (Volume)	Macro and Micro	the likelihood that the project will generate and deliver CERs	(Wilder and Willis, 2007)	Expected accumulated 2020 $ktCO_2e$
long-term expectation (Volume), and project size	Macro and Micro	The likelihood that the project will generate and deliver CERs	(Bishop, 2007; Wilder and Willis, 2007)	Expected accumulated 2030 $ktCO_2e$
Financing	Micro	Production cost	(Gao and Li Liyan, 2007)	Project investment*
Seller	Macro	Carbon-related country risks; host country approval risk	(Ascui and Moura Costa, 2007; Bishop, 2007)	Project location
Project type	Micro	The nature of the project; Specific project influences; limited use of large-scale hydro and exclusion of CERs from forest from EU-ETS	(Bishop, 2007; Wilder and Willis, 2007)	Project type
Buyer	Macro	Buyers' level of sophistication, and the extent to which they provide an underlying debt or equity investment	(Palmisano, 2007; Wilder and Willis, 2007)	Project buyer
Legal contract	Macro and Micro	Contract for CERs are highly heterogenous [24]	(Bishop, 2007)	Emission Reduction Purchase Agreement (ERPA)
Year	Macro	General economy variation	(Koch et al., 2014)	Year of the ERPA

Note: *Total investment cost

3.2.3. Data for Empirical Analysis

The primary data source is the UNEP DTU CDM/JI Pipeline Analysis and Database (CDM/JI Pipeline). Additional information, such as ERPA dates, is extracted by Python from CDM documents in PDF format on the UNFCCC CDM projects site. I include 2205

---

[24] Because of the heterogenous of the contract, therefore CER were traded in a wider price range. It is important to include the ERPA data in my model to control for the variability.

CDM projects in my paper. The dataset covers 20 project types and two project sizes (UNFCCC, 2017). I present the statistical summaries in Error! Reference source not found. and detailed results of project types and size in Error! Reference source not found.. I also plot the distribution of CER prices in Error! Reference source not found..

Table 2-6. Statistical summary.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
CER price \$/CO$_2$e	2,205	11.70592	2.76698	1.31	42.02
Years of projects	2,205	7.454422	1.078723	5	10
1st period **ktCO$_2$e/yr**	2,205	124.9621	186.9285	2	3016.7
Expected accumulated 2020 ktCO$_2$e	2,205	1143.599	1744.64	18	30167
Expected accumulated 2030 ktCO$_2$e	2,205	2206.96	3250.614	38	54489
Methodology	2,205	0.2585034	0.4379114	0	1
ERPA	2,205	2009.222	1.716408	2002	2013
Project investment (million USD)	2,173	53.15113	72.70766	0	999.1

Note: The sample includes all 2205 CDM projects up to Jan 10, 2019. I used data from UNEP DTU Partnership. Additional information such as ERPA dates are collected by author, and project size (methodology) dummy is created by using the UNFCCC CDM Methodology Booklet (UNFCCC, 2017).

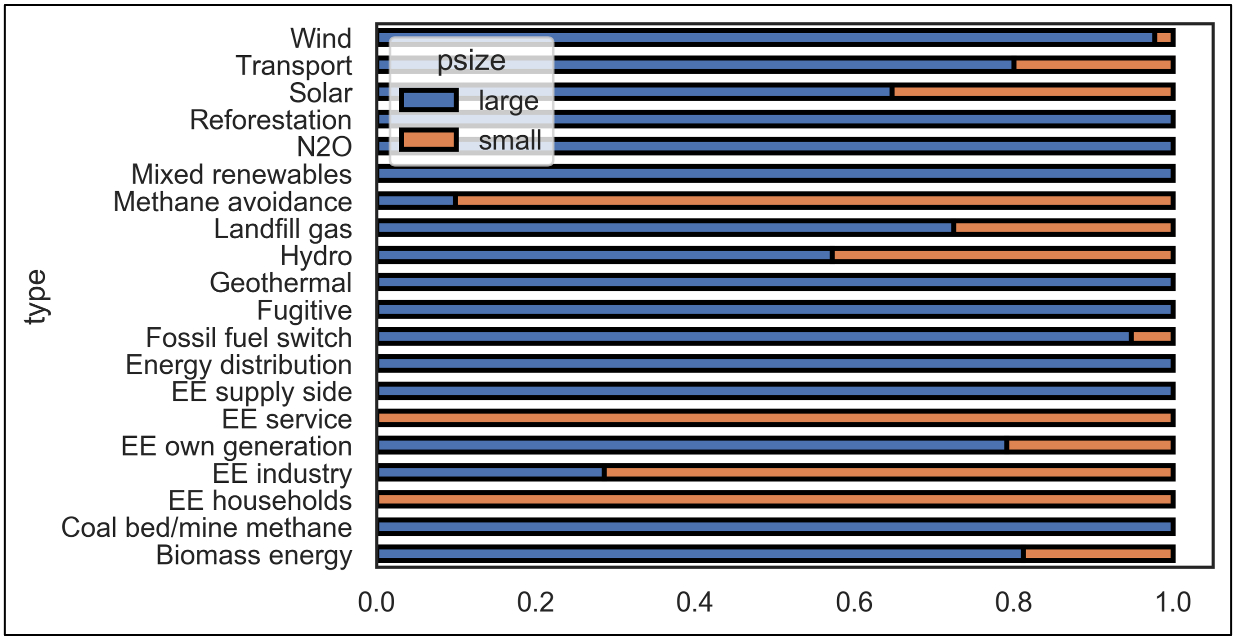


Figure 2-5. CDM projects distribution based on project types and size.

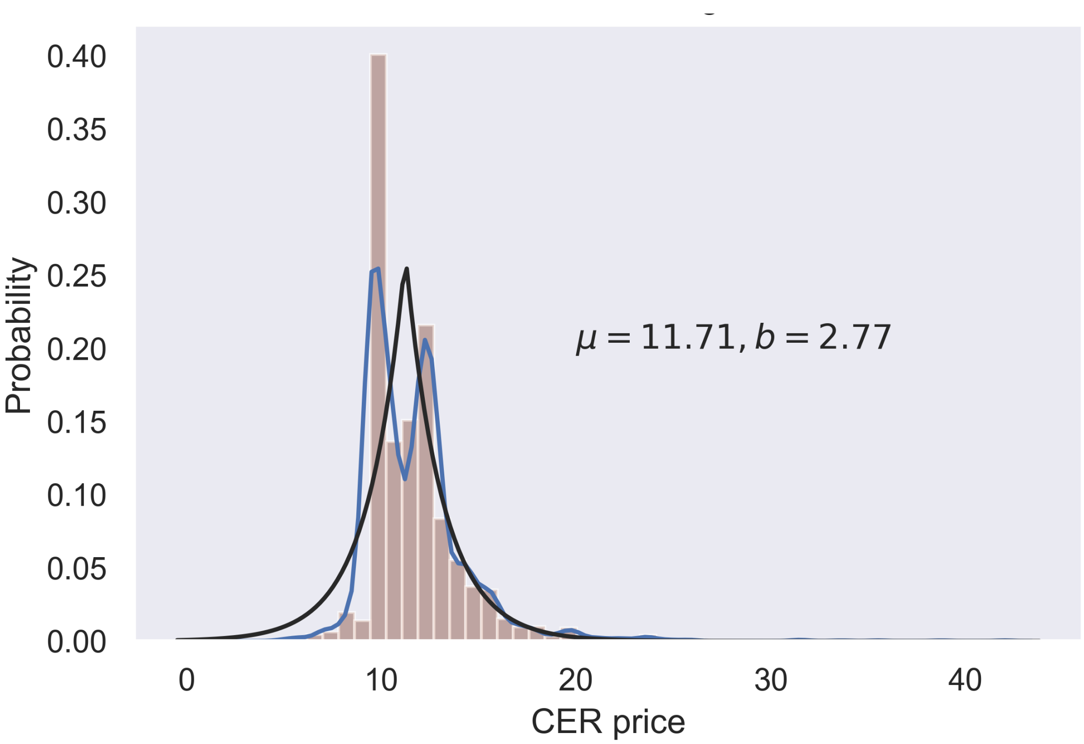


Figure 2-6. Distribution of CER prices. *The blue line indicates the kernel density estimation.*

4. Results

4.1. Main Results: The Effect of CDM Co-benefits

My main model is expressed in the following regression equation:

$$Y_{it} = \beta_0 + \beta_{1-8}(Co - benefit_{1-8}) + \beta_9 X_{it} + \gamma_i + \delta_i + \varphi_i + \omega_t + \theta_i + \varepsilon_{it} \qquad (1)$$

Where, i indicates projects, and t indicates years. In all models, the dependent variable Y_{it} is the CERs price for each project. The variables of interest are $Co - benefit_{1-8}$, with their coefficients β_{1-8} indicate the effect of different levels of co-benefits on the CDM projects. I also control for a group of other variables listed in Error! Reference source not found., e.g., project location fixed effγ_i)ects (, credit buyer fixed effects (δ_i), project type fixed effects (φ_i), year fixed effects (ω_t), and project size dummy (θ_i). Finally, the error term captures unobserved factors affecting our dependent variable that changes over the year.

I conduct the analysis by performing four specifications, and the final results are presented in Error! Reference source not found.. Model 1 conducts OLS regression without controlling for the project type and project size fixed effect. Model 2 controls for project type, and model 3 controls for both project type and project size.[25] Model 3 is our preferred model. Model 4 uses log-linear specification by taking the natural logarithm of the CER prices. I estimate the four multiple specifications to ensure robust results.

Across the four models, coefficients of co-benefits show an increasing trend. In both model 3 and model 4, the coefficients of co-benefits are all statistically significant at a 95-percent confidence level, except for the co-benefit 5 category, which includes EE households and small hydro projects. There is a clear increasing pattern in all models except for co-benefit 6 in model 1 and co-benefit 8 in model 4. The overall trend in the four models shows consistent, with model 2, model 3 and model 4 presenting more smooth estimates. Model 3 indicates that statistically controlling for projects' features and sellers' background, when a project with the likelihood of delivering more co-benefits, it receives a higher CER price from the buyers. For example, projects in co-benefits 2 are likely to have an average \$1.53/tCO_2e price premium compared to projects in co-benefits 1, or receive 11 percent more in CER prices. Additionally, I plot the point estimates and 95th percentile confidence

---

[25] Because the co-benefits variables are correlated with project type and project size, and project type and project size also have an effect on the CER prices. Thus, these co-benefit variables are endogenous variables. I have to control for project type and project size in our model, otherwise, I will have the problem of endogeneity.

intervals of co-benefits of model 3 and model 4 to show the trends visually in Error! Reference source not found..

Coefficients of co-benefit 6 (small wind projects and large solar projects) are higher compared to coefficients of co-benefit 7 (small solar), despite that the difference between the two sets of coefficients in both model 3 and model 4 is quite small. Although the results are not as I expected, due to the small differences, the overall results still fit my original hypothesis.

Table 2-7. Results: effect of different co-benefits on CDM projects.

Models	Model 1 (Linear)	Model 2 (Linear)	Model 3 (Linear)	Model 4 (Log-linear)
Co-benefit 1	0	0	0	0
	(.)	(.)	(.)	(.)
Co-benefit 2	0.696**	1.816***	1.553***	0.111***
	(0.303)	(0.439)	(0.530)	(0.0393)
Co-benefit 3	0.829***	2.127***	1.803***	0.122***
	(0.301)	(0.472)	(0.598)	(0.0443)
Co-benefit 4	2.098***	3.348***	3.022***	0.222***
	(0.149)	(0.402)	(0.545)	(0.0404)
Co-benefit 5	0.139	0.0161	0.374	0.0346
	(0.163)	(0.168)	(0.437)	(0.0324)
Co-benefit 6	1.683***	4.138***	4.164***	0.315***
	(0.360)	(0.665)	(0.665)	(0.0493)
Co-benefit 7	0.396	3.493***	3.878***	0.304***
	(0.570)	(0.948)	(1.043)	(0.0773)
Co-benefit 8	3.440***	4.404***	4.417***	0.259***
	(0.688)	(0.740)	(0.740)	(0.0549)
Year FE	Yes	Yes	Yes	Yes
Project Type FE	No	Yes	Yes	Yes
Project Location FE	Yes	Yes	Yes	Yes
Credit buyer FE	Yes	Yes	Yes	Yes
Project Size Dummy	No	No	Yes	Yes
Gold Standard	1.906***	2.128***	2.127***	0.111***
	(0.406)	(0.408)	(0.408)	(0.0303)
No. of Observation	2173	2173	2173	2173
Adjusted R^2	0.3073	0.3139	0.3138	0.328

Note: The dependent variable in all the first three models is CER prices and is natural log of CER prices in Model 4. Coefficient estimates are reported in this table. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model.
* p<0.10 ** p<0.05 *** p<0.01

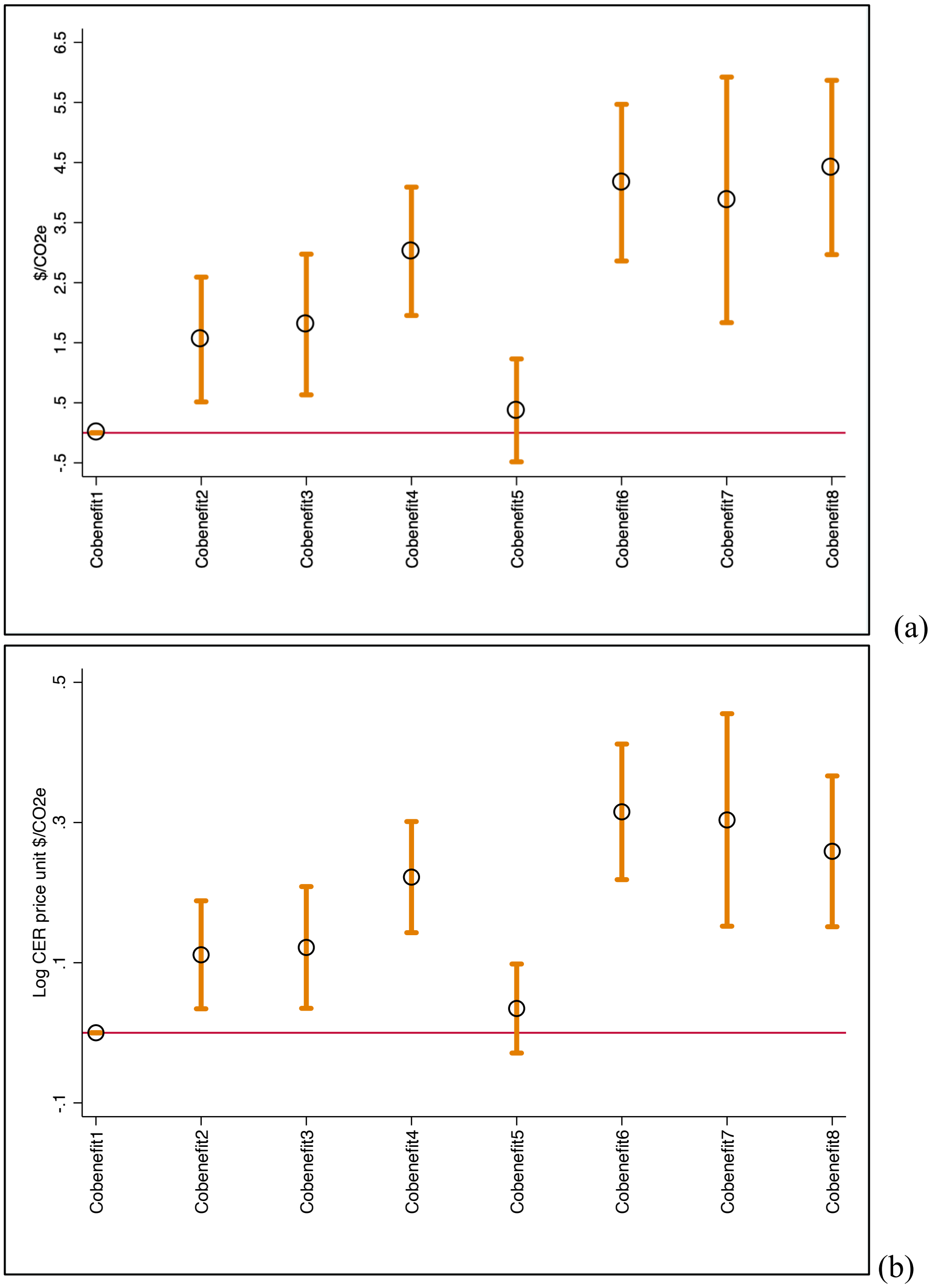


Figure 2-7. Coefficients of co-benefits. *Base case in both models is co-benefit 1. (a) linear model: point estimates with ninety-fifth percentile confidence intervals of co-benefits. (b) log-linear model point estimates.*

4.2. Robustness Check

Many factors can influence the CER prices as indicated in Error! Reference source not found.. One of the many factors is the 2008 financial crisis, which is the main cause of the price drop of CERs in that year. The price decreased by about 50 percent (Koch et al., 2014). Thus, I dropped the 461 projects with a signed ERPA date of 2008, because I think that the year 2008 would have an impact on the CER prices. I re-ran my analysis with the remaining 1744 projects. I get very similar results (results are presented in **Error! Reference source not found.**) across all four models compared to the results in Error! Reference source not found. and all coefficient estimates of variables of interest deliver a similar increasing trend.

Table 2-8. Robustness check: effect of different co-benefits on CDM projects

Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**
	Linear	Linear	Linear	Log-linear
Co-benefit 1	0	0	0	0
	(.)	(.)	(.)	(.)
Co-benefit 2	0.705*	2.536***	2.120***	0.126**
	(0.391)	(0.549)	(0.676)	(0.0503)
Co-benefit 3	0.924***	3.002***	2.445***	0.159***
	(0.342)	(0.549)	(0.697)	(0.0521)
Co-benefit 4	2.013***	4.054***	3.492***	0.245***
	(0.169)	(0.473)	(0.641)	(0.0480)
Co-benefit 5	0.262	0.0956	0.634	0.0566
	(0.191)	(0.197)	(0.540)	(0.0403)
Co-benefit 6	1.463***	4.658***	4.640***	0.345***
	(0.383)	(0.745)	(0.727)	(0.0553)
Co-benefit 7	0.681	4.344***	4.906***	0.371***
	(0.598)	(1.019)	(1.156)	(0.0862)
Co-benefit 8	3.463***	4.865***	4.891***	0.276***
	(0.782)	(0.836)	(0.836)	(0.0618)
Year FE	Yes	Yes	Yes	Yes
Project Type FE	No	Yes	Yes	Yes
Project Location FE	Yes	Yes	Yes	Yes
Credit buyer FE	Yes	Yes	Yes	Yes
Project Size Dummy	No	No	Yes	Yes
Gold Standard	1.284***	1.627***	1.631***	0.0782**
	(0.470)	(0.470)	(0.470)	(0.0348)
No. of Observation	1744	1744	1744	1744
Adjusted R^2	0.2887	0.2976	0.2983	0.3309

Note: The dependent variable in all the first three models is CER price and is natural log of CER price in Model 4. Coefficient estimates are reported in this table. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model.

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

4.3. Project Features

In this section, I assume that project features, such as types and sizes, will have effects on the CER prices, respectively. I further assume that project type has a different effect on the CERs depending on the project size. Thus, I introduce an interaction term of project type and size into my model. My purpose in conducting this model is to provide another robustness check for my primary model (1).

My secondary model is expressed in the following regression equation:

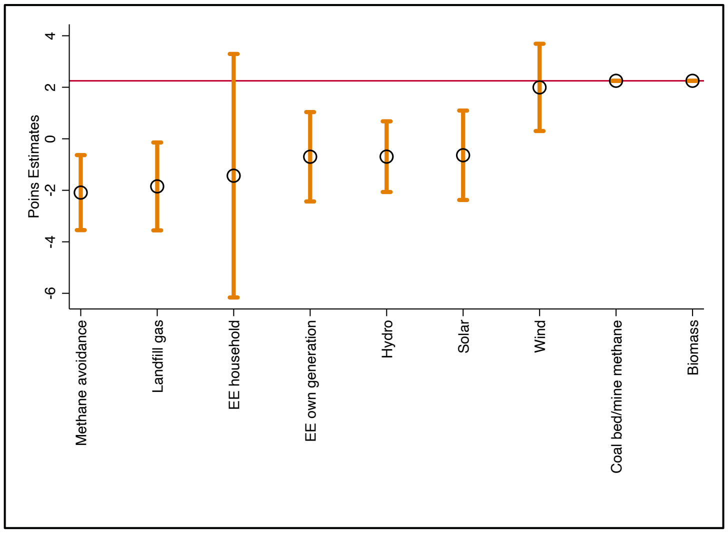
$$Y_{it} = \beta_0 + \beta_{1-10}((Type * Size)_{1-10}) + \beta_{11-19}Type_{1-9} + \beta_{20}X_{it} + \gamma_i + \delta_i + \omega_t + \varepsilon_{it} \quad (2)$$

Where, i indicates projects, and t indicates years. The dependent variable Y_{it} is the CERs price for each project. The variables of interest are the interaction terms $(Type * Size)_{1-10}$and $Type_{1-9}$.

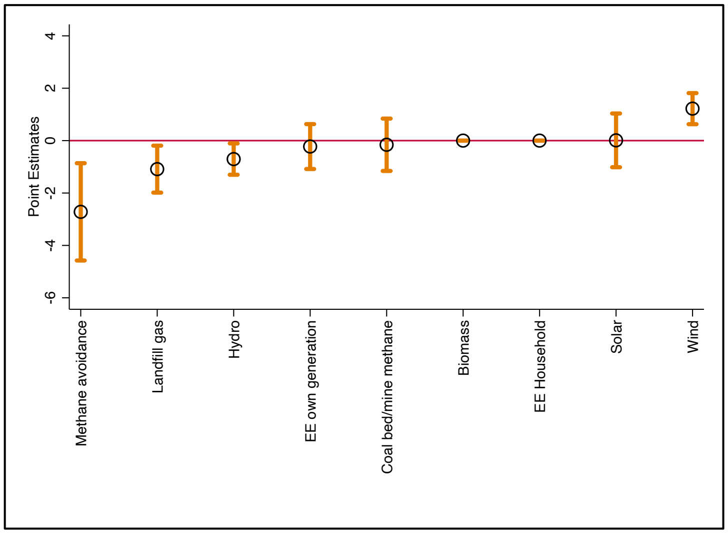
The coefficients of the interaction term β_{1-10} indicate the effects of different levels of small project types on CERs (because large projects are coded as 0, and small projects are coded as 1), and the coefficients of $Type$ indicate the effects of different levels of large project types on CERs.

I have plotted the point estimates and 95th percentile confidence intervals of project types between small and large project sizes visually in Error! Reference source not found.**.** The detailed results of the model are presented in **Appendix B Table B 2-1**. Overall, the model indicates that biomass, wind, and solar projects are at the high end of the price scale, while methane avoidance, landfill, and hydro projects are at the low end of the price scale, with

EE own generation and EE household projects reside in the middle. Additionally, price difference exists between large-size projects and small-size projects, but only in biomass and coal/mine methane projects with statistical significance. Small-scale biomass projects have an average CER price with a $2.25 higher than the large-scale biomass projects.



(a) Small project



(b) Large project

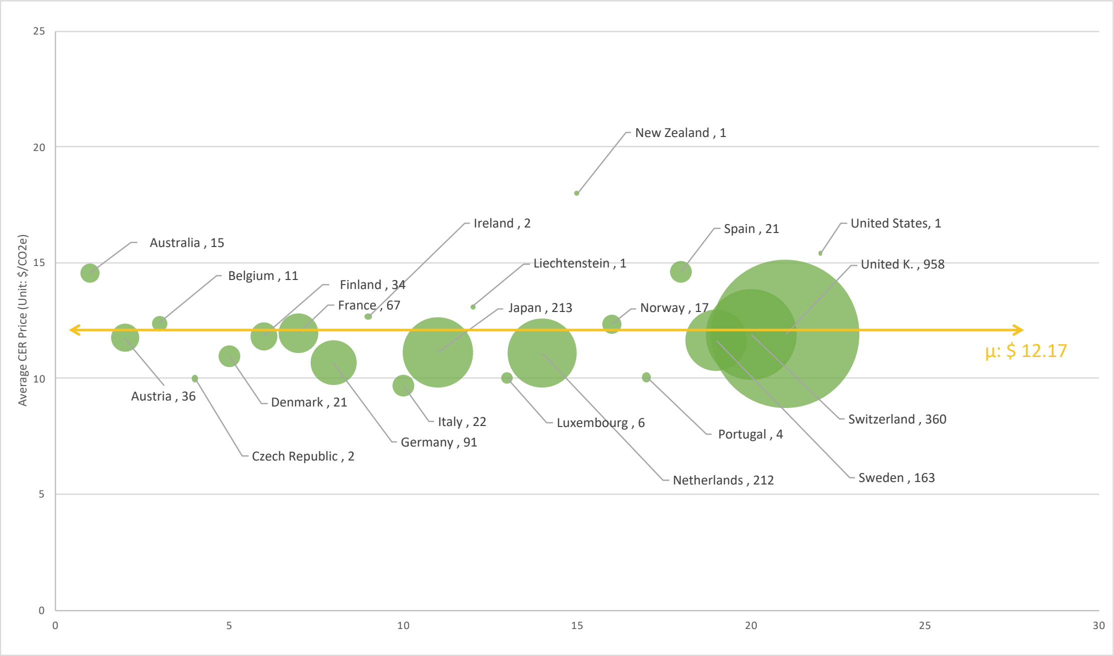
Figure 2-8. Point estimates of project types on CERs based on project size*. Base case in (a) and (b) is small biomass and large biomass project. I have added the price difference of $2.25 between small-scale and large-scale biomass projects in (a), so the red horizontal line in (a) indicates the CER prices at $2.25.*

5. Sectoral Analysis at the Company Level

5.1. Credit Buyers

The CDM mechanism creates CERs as an important share of the global carbon markets. Like the regular markets, the demand side of the CERs is from carbon credit buyers. CDM credit buyers can be categorized into three groups. The first group called compliance buyers who are seeking to buy offsets for compliance in the EU ETS and other regional schemes; the second group called sovereign buyers, mainly Annex I parties, who are obtaining CERs directly to meet their quantified emission limitation and reductions obligations (QELRO) commitments under the Kyoto Protocol; the last groups contains multilateral development banks (MDBs) and carbon funds (Global CCS Institute, 2011).

CER prices vary among countries where these credit buyers reside. It is discussed that not all buyers are concerned with the sustainability development quality of CERs, and some of the buyers still target cheap credits from projects that can yield the large volumes of CERs, such as industrial gas projects (including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrous oxide (N2O) projects) (Parnphumeesup and Kerr, 2011). Error! Reference source not found. presents the scale of purchasing CDM projects and the average CER prices these buyers paid aggregated at the country level. As a result, buyers are no longer view CERs as a homogenous market good. Prices of CERs among countries show variation from the average global carbon price. Additionally, buyers differentiate between CERs by different types of CDM projects. In this section, I use the aggregated information from my dataset to study the credit buyers' behavior. I have 218 companies across 21 countries, most of the companies were located in the EU, with a few in Australia and New Zealand, and one in the United States.



Note: the numbers in the labels are the number of projects purchased by each country

Figure 2-9. Average price of CER and total number of projects by buyer's location. *The average CER price of all countries is US$12.17 t/CO$_2$e. The size of the green circle indicates the number of projects hosted by each country.*

Since CER prices are reported at the buyers' company level in the ERPA. It will be useful to study further the question of what explains the price of CERs from the buyers' perspective. In this section, I will focus on explaining whether CER prices differ systematically based on credit buyers' industry, or their profit status, such as for-profit or not-for-profit status.

In order to do so, I further divide credit buyers into different categories by using two classification systems. First, credit buyers (company level) are classified by their primary business activities using the Bloomberg Industry Classification Systems (BICS). I obtained 14 industries. Second, credit buyers are also categorized into five status based on their profit status, e.g., local private companies, global private companies, government entities, MDBs, and foundations.

The model behind this analysis is the hedonic price method (Conte and Kotchen, 2010; Freeman et al., 2014), where CER prices can be explained as a function of credit buyers and project characteristics. Because I am interested in the general characteristics of credit buyers after I run my preliminary model, and also the prices of carbon credits are available at the credit buyer level, it makes sense to use the hedonic function to study whether the location and profit status of these credit buyers (private, government, MDB) or industries of these buyers would systematically have impacts on the CERs prices I estimated linear and log-linear specifications using ordinary least squares (OLS).

5.2. Results from the Hedonic Model

My hedonic model is expressed in the following regression equation at credit buyers' company level.

$$P_{CERi} = f(numprojects_i, location_i, industry_i, status_i, GS_i + projectsize_i + portfolio(asicapacific, latinamerican, middleeast, africa, centraluropean)_i) + \varepsilon_i \qquad (3)$$

Where, i indicates companies. In all models, the dependent variable P_{CERi} is the average CERs price paid by company i. I also control for a group of variables such as, $numprojects_i$ is the number of offset projects under management; $location_i$ is a categorical variable indicating the country where the credit buyer i is located, $GS_i$is the proportion of projects that have Gold Standard certification. I also control for investment portfolio in terms of project regions. Thus, $asicapacific_i$ is the proportion of projects that company i invests in Asia and Pacific region, $africa_i$ is the proportion of projects that company i invests in Africa, the same to the $latinamerica_i$, $centraleuropean_i$, $middleeast_i$. Finally, $\varepsilon_i$is an error term assumed to be normally distributed.

Model 1 and model 2 in Error! Reference source not found. analyze several expectations about how different variables affect CER prices. With increasing bargain power and returns to scale, credit buyers with a greater number of projects would obtain lower prices. Given that Sub-Saharan Africa is frequently identified as the region benefitting least from the CDM even though these regions are also seen to have large potential for CDM to enhance local co-benefits (Hultman et al., 2019), one might expect that prices would be higher for projects located in Africa compared to projects in other regions.

Error! Reference source not found. shows the results of all company-level regression models. One set of results with statistical significance relates to the location of the projects. Credit buyers paid CERs at higher prices if projects are based in Africa than those based in the other regions. Results from the linear model suggest that a 10 percent increase in the proportion of projects that are located in Asia is associated with a \$0.42/tCO$_2$e decrease in the CER prices compared if the projects are located in Africa. The corresponding result in the log-linear model is that the same 10 percent increase in the proportion of projects in Asia is associated with a 1.9 percent decrease in the CER prices. Another result of statistical significance relates to the effect of Gold Standards. Based on my linear model, the result is interpreted that a 10 percent increase in the proportion of a credit buyer's projects that are Gold Standards certified is associated with a \$0.41/tCO$_2$e increase in the CER price. The corresponding result in the log-linear model is that the same 10 percent increase in the proportion of certified projects is associated with a 2.5 percent increase in the buyer's purchased CER price.

I do not find evidence in support of increasing bargain power and returns to scale. The rest of the coefficient estimates of interest are not statistically significant. I find no price difference among credit buyers' industry or for-profit and not-for-profit status.

Table 2-9. Buyer’s company-level regression results.

Models		**Model 1** (Linear)	**Model 2** Log-linear)
Number of Projects Purchase		-0.00332 (0.0101)	0.0000695 (0.000731)
Buyer's Profit Status			
	Foundation	0 (.)	0 (.)
	Government	4.102 (4.430)	0.304 (0.319)
	MDB	5.713 (4.590)	0.316 (0.331)
	Private Global	1.835 (1.752)	0.0759 (0.126)
	Private Local	1.689 (1.747)	0.0658 (0.126)
Buyer's Sector			
	Business consulting and others		
	Consumer Discretionary	-0.916 (1.109)	-0.0680 (0.0799)
	Consumer Staples	-1.612 (1.741)	-0.128 (0.125)
	Energy	-0.192 (0.920)	0.00337 (0.0662)
	Financials	-0.383 (0.633)	-0.0357 (0.0456)
	Financials (Special)	-0.713 (0.703)	-0.0685 (0.0506)
	Foundation	0 (.)	0 (.)
	Government	-4.355 (4.017)	-0.381(0.289)
	Industrials	0.310 (0.936)	0.0247 (0.0675)
	Materials	0.562 (1.220)	0.0132 (0.0879)
	Utilities	-0.00135 (0.754)	-0.00683 (0.0544)
Buyer’s Purchased Project size %		-0.448 (0.542)	-0.0490 (0.0391)
Buyer’s Purchased Gold Standard %		4.075*** (0.954)	0.260***(0.0687)
Buyer’s Project Portfolio			
	Asia & Pacific %	-4.188** (1.895)	-0.327** (0.137)
	Latin America %	-5.520** (2.265)	-0.502*** (0.163)
	Middle - East %	-9.007** (4.400)	-0.741** (0.317)
	Europe & Central Asia %	-2.641 (4.840)	-0.233 (0.349)
	Africa %	0 (.)	0 (.)
Observations		218	218
Adjusted R^2		0.1894	0.1935

Note: The dependent variable in both models is CER price and is natural log of CER price. Coefficient estimates are reported in this table.
* p<0.10 ** p<0.05 *** p<0.01

Additionally, I plot the point estimates and 95th percentile confidence intervals of credit buyer’s location in Error! Reference source not found.. With Australia as the base case, 14 out of 20 coefficient estimates are negative and statistically significant. I found that a credit buyer’s location affects the CER prices. CERs buyers based in Oceania, specifically, Australia and New Zealand purchase CERs at higher prices than those based in Europe and Asia. The largest point estimates are for Luxembourg, suggest a price discount in Luxembourg of $12.94 on average or a difference of 89 percent. I found the credit buyers located in UK, the country hosts the largest number of projects, purchase the CER at a price discount of $8.9 on average or a difference of 55 percent. There is no statistically difference between CER buyers located in North America and Australia, or within European.

The reason of high CER prices paid by credit buyers of Australia can be explained as follows. As one of the highest country in term of per capita emissions, Australia established its mandatory state-level cap-and-trade program, the New South Wales Greenhouse Gas Reduction Scheme (NSW GGAS) two years before the first trade ever took place on the EU ETS (Bayon et al., 2009)[26]. Then, a national ETS using the Carbon Pricing Mechanism (CPM) came into effect in July 2012, with a fixed price of AUD $24.50/tCO$_2$e in 2013 (Maraseni and Reardon-Smith, 2019; WWF, 2013).[27] In 2014, the Emission Reduction Fund (ERF) replaced the CPM. In the ERF, the average price of the auction is AUD $11.97/tCO$_2$e over the period of 2015 to 2018. The early movement towards a cap-and-trade program of Australia with a high fixed price of carbon credits mean that businesses in Australia paid more compared to businesses in the EU towards carbon credits. Because the trading prices for CERs are around AUD $5.9 in EU in 2013. Even when these businesses are allowed to purchase CERs, they might be willing to pay a little bit more due to the high domestic carbon prices.

---

[26] In the GGAS, the penalty of business exceeds its target is AUD $11.5/tCO$_2$e.

[27] Although at the stage of NSW GGAS, using CERs were not allowed, the CERs can be used in the stage of national ETS when a fixed price moved to the flexible price to match EU ETS.

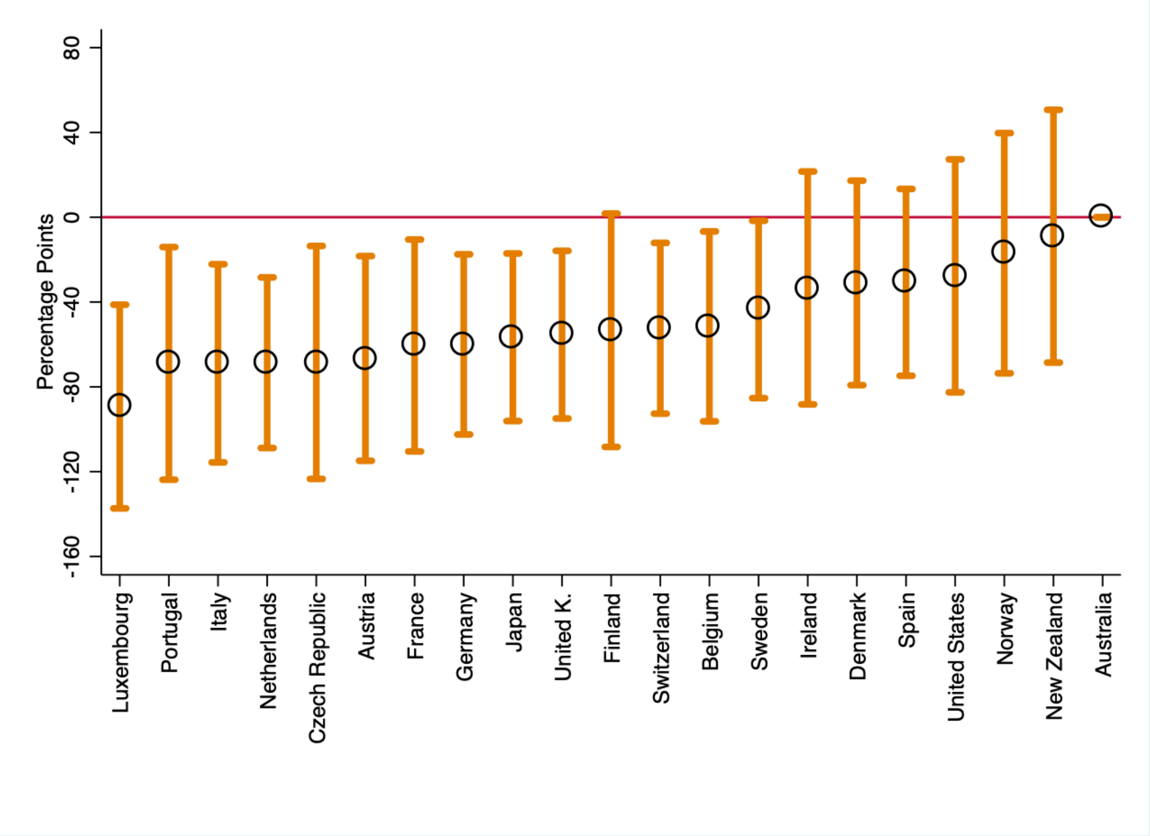


Figure 2-10. Coefficients of buyer's location fix effect. *Base case is Australia. Log-linear point estimates with ninety-fifth percentile confidence intervals of co-benefits.*

6. Discussion

One of the robust findings of my analysis is that statistically controlling for projects' features and sellers' background, when a project with the likelihood of delivering more co-benefits, it receives a higher CER price from the buyers. The price difference between projects with the highest co-benefits and least co-benefits is $4.9 t/CO2e on average or a difference of 27.6 percent.

Another robust finding is that Gold Standard certification delivers a price premium. My result indicates that a 10 percent increase in the proportion of a credit buyer's projects that are Gold Standards certified is associated with a \$0.41/tCO$_2$e increase or a 2.5 percent increase in the CER prices from credit buyer's perspective. It fits the literature that buyers are willing to pay a price premium for the Gold Standard projects.

Somewhat more surprising is that there is large variability in the prices of CER partially coming from the location of buyers and projects, respectively. When considering these projects, I find that projects taking place in Africa region are significantly more expensive than those occurring in Asia, Latin America, and Middle East by an average of nearly 45 percent. When considering credit buyers, I find that companies headquartered in Australia and New Zealand significantly pay more than those companies located in European nations by an average of 52 percent, if holding other variables constant.

I based my analysis on projects, buyers, and sellers listed on a refined CDM pipeline database, to which I contribute by adding ERPA dates and also the buyers' sectoral information and profit status. It is the most comprehensive listing of buyers and sellers in the CDM market. Nevertheless, despite my robust findings, I have to acknowledge some limitations of this analysis. First, I have to admit that the SDG interaction scores are based on authors' expert judgement supported by the literature review. To limit the bias of the expert judgement, I have added a layer of confidence level to the score. I also adopted a strategy to use a second expert to cross-check the score that assigned to the SDG interaction to reduce the bias. But still, I cannot eliminate the bias entirely.

Additionally, a major limitation of the conclusion from the literature is that most of the studies are conducted based on a desk-study of PDDs. From the perspective of studying the real impacts of these projects on the ground, it is quite difficult to measure and monitor the actual co-benefits of these projects based on PDDs. However, it validates my approach of using observations from the systematic literature review as the main factor to explain buyers' willingness to pay in my model. Because buyers' willingness to pay for a project with better co-benefits is largely driven by the description of co-benefits that the project would generate in the PDDs. Buyers have to negotiate and finalize the CER prices based on the ex-ante information provided by the project developers. Thus, a thorough review and understanding of PDDs is the key to study the buyers' willingness to pay.

Third, data quality in the original CDM pipeline is poor; although I have manually improved it substantially. The consequences of the CDM pipeline being poor is that I had to drop half of the projects in the original dataset due to missing information. Although it will not affect my estimates of the impact of co-benefits on CDM projects generally, I could get a more accurate estimation if I can use the full dataset.

Fourth, another potential limitation of using the regression model (1), (2) and hedonic model (3) to assess the factors influencing CER prices is the bias from not able to capture unobservable variables from both project and company level. Although I tried my best to control for as many key factors affecting CER prices identified by the literature in Error! Reference source not found., I cannot claim that I control for everything. One factor might influence CER prices is the bargaining power of credit buyers in my regression model, which I am unable to observe. However, I use the number of projects managed by each credit buyer as a proxy to assess the bargaining power partially in my hedonic model (3), and I do not get the statistically significant result. Thus, even though I did not control for the bargaining power of credit buyers in (1), I am comfortable that this missing variable will not have an impact on my final results.

7. Conclusion

The area of local co-benefits analysis has been a topic of great interest, but most of the studies focus on evaluate co-benefits on projects per se. The motivation of studying the incentive of credit buyers to purchase projects with higher benefits inspires me to look at the linkage among projects, co-benefits and credit buyers, and to examine this topic from a broader picture.

The aims of this paper are twofold: first, to investigate what the existing literature tell me about the delivery of co-benefits for the local communities from CDM projects; second, to examine whether the likelihood of delivering more co-benefits encourages buyers to pay more for the CERs.

What I found is that the delivery of co-benefits from CDM varies across technology types, design features, and country context. Noting that broad generalizations are unlikely to be true for all project cases in a specific category, there were some trends with respect to technologies. Different technologies may be able to deliver different scope and dimensions of co-benefits to local communities based on the very nature of the technologies themselves. Second, there may exist some patterns observable by the country.

As I mentioned at the beginning of this paper, the global financial flow to projects that reduce greenhouse gas emissions has a fundamental tension. What I learned from the study is that financial flow can be jointly achieved with projects with better quality, such as to deliver on higher co-benefits in local communities. Although these co-benefits are difficult to be monetized into every dollar sign, they are the real impact on the local communities.

There is a potential to generate even more financial flow into the project level if the co-benefits can be captured and visualized by the design of the project and monetarized at the buyers' side.

My review has also demonstrated that, while CDM experience was heterogeneous in its ability to deliver community co-benefits, those benefits were more likely to manifest in projects following general best practices for finance, including significant community consultation and engagement in the planning and implementation process. Discussions on any new system focused on sustainable development within respective national systems should also address the more specific question of how such a mechanism would support local co-benefits. While undoubtedly the challenge of nationally mediated sustainable development criteria will remain in some form, opportunities do exist for providing some overarching guidelines or encouragements toward how to include these considerations in any new approach.

Table 2-10. CDM technology and SDG table.

	Enhance Local Infrastructure															
	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE				4 QUALITY EDUCATION				5 LIGESTILLING MELLEM KØNNENE				10 REDUCED INEQUALITIES			
	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE
Landfill	↑	[+2]	🕮	★	↑	[+2]	🕮	★	No direct interaction				No direct interaction			
	Technical transfers can be a knowledge transfer and an equipment transfer or both. They create local technological capacity. Technology transfers are **high** in large landfill gas project because the high temperature flare, blower, gas analyzer, industrial computer are all imported from Europe.				Has the **medium high** score in the creation of education opportunities in MATA-CDM research.											
	Dechezleprêtre et al., 2008				Disch, 2010; UNFCCC 2012, IPCC 2018											
Methan avoidance	↑	[+2]	🕮	★	↑	[+3]	🕮	★	No direct interaction				↑	[+1]	🕮	★
	Technical transfers can be a knowledge transfer and an equipment transfer or both. They create local technological capacity. Technology transfers are **high** in large landfill gas project because the high temperature flare, blower, gas analyzer, industrial computer are all imported from Europe.				Has the **high** score in the creation of education opportunities in MATA-CDM research.								**Low-medium** impact on halting migration for local community.			
	Dechezleprêtre et al., 2008				UNFCCC 2012								Subbarao and Lloyd 2011			
Energy Efficiency Industry	↑	[+1]	🕮	★	↑	[+2]	🕮🕮	★★	No direct interaction				↑	[+1]	🕮	★
	Technical transfers can be a knowledge transfer and an equipment transfer or both. They create local technological capacity. Technology transfers are **medium** in large EE industry projects. additionally, EE industry has a low potential in the creation of infrastructure				Has the **medium** score in the creation of education opportunities in MATA-CDM research. And also EE deployment creates demand for sustainability training.								**Lowest** impact on halting migration for local community.			
	Alexeew et al. 2010; Dechezleprêtre et al., 2008				Alexeew et al. 2010; UNFCCC 2012, Disch, 2010								Subbarao and Lloyd 2011			

Energy Efficiency Households	↑ [+2] 📖 ★★ EE household has **medium-high** impact on capacity building with technology transfer. Dechezleprêtre et al., 2008; Nussbaumer 2007	↑ [+3] 📖📖 ★★ Small-scaled EE household through POAs can build local capacity, and increase institutional learning. It has medium impact in terms of quality time spent at school by children and turnaround in number of children attending school Schomer and van Asselt, 2012; Subbarao and Lloyd 2011; UNFCCC 2012	No direct interaction	↑ [+2] 📖 ★ It reduces household expenditure on fuel, reduce the amount of time they spend collecting fuelwood, thereby allowing them to engage in other activities, which further has a high impact on equal distribution. Wood 2011; Nussbaumer 2007
Hydro Large	↑ [+2] 📖📖 ★★ Technology transfers are **limited** in hydro area due to the fact that hydro is a local mature technology, but road is a part of the project construction. Sirohi 2007; Alexeew et al. 2010; Dechezleprêtre et al., 2008; Nussbaumer 2007	↑ [+2] 📖📖 ★★ Has the **medium** score in the creation of education opportunities in MATA-CDM research. Sirohi 2007; Alexeew et al. 2010; Disch 2010; UNFCCC 2012	No direct interaction	↑ ↓ [+1, -1] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Large hydro benefits affluent areas with a high demand on electricity. Rousseau, 2017; Olsen and Fenhann 2008; Alexeew et al. 2010
Hydro Small	↑ [+1] 📖📖 ★★ Technology transfers are **limited** in hydro area due to the fact that hydro is a local mature technology, but road is a part of the project construction, if properly designed, has the potential to generate the co-benefits. Sirohi 2007; Cole and Roberts 2011; Alexeew et al. 2010; Dechezleprêtre et al., 2008	↑ [+2] 📖📖 ★★ **Medium** impact in terms of quality time spent at school by children and turnaround in number of children attending school. Subbarao and Lloyd 2011; Sirohi 2007; Cole and Roberts 2011; Alexeew et al. 2010; Disch, 2010; UNFCCC	No direct interaction	↑ [+2] 📖📖 ★★ **Low-medium** impact on halting migration for local community. Subbarao and Lloyd 2011; Sirohi 2007; Olsen and Fenhann 2008; Cole and Roberts 2011; Alexeew et al. 2010

Wind Large	↑ [+3] 📖📖 ★★ Technology transfers are **very high** large wind projects because country like china and India are only able to produce small-capacity turbines. So large wind projects heavily rely on importing turbines from Europe. Additionally, it can create co-benefits of the improved infrastructure links Alexeew et al. 2010; Dechezleprêtre et al., 2008; Wood 2011; Nussbaumer 2007	↑ [+1] 📖 ★★ Has the **low-medium** score in the creation of education opportunities in MATA-CDM research. Alexeew et al. 2010; Disch 2010, UNFCCC	No direct interaction	↑ [+1] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008; Alexeew et al. 2010;
Wind Small	↑ [+2] 📖 ★ Technology transfers are **medium** in small-scale wind projects because country like china and India are able to produce small-capacity turbines. No need to import technology. Additionally, it can create co-benefits of the improved infrastructure links Dechezleprêtre et al., 2008; Wood 2011;	↑ [+1] 📖 ★★ Has the **low** score in the creation of education opportunities in MATA research. Disch 2010, UNFCCC	No direct interaction	↑ [+2] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008
Solar Large	↑ [+3] 📖 ★★ Technology transfers are **very high** in large-scale solar projects because larger projects are better able to exploit economies of scale in technology transfer Dechezleprêtre et al., 2008; Nussbaumer 2007	↑ [+3] 📖 ★ Has the **high** score in the creation of education opportunities in MATA-CDM research. UNFCCC 2012	No direct interaction	↑ [+1] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008
Solar Small	↑ [+2] 📖 ★★ Technology transfers are **medium** in small-scale solar projects. Dechezleprêtre et al., 2008; Nussbaumer 2007	↑ [+2] 📖 ★★ Small-scaled EE household through POAs can build local capacity, and increase institutional learning. UNFCCC 2012; Schomer and van Asselt, 2012	No direct interaction	↑ [+2] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Olsen and Fenhann 2008

Biomass Large	↑ [+2] 📖 ★ Technology transfers are **limited** in biomass area due to the fact that biomass is a local mature technology; Indirect infrastructure development in the project area as a result of setting up of rural industries. Alexeew et al. 2010; Dechezleprêtre et al., 2008;	↑ [+1] 📖📖 ★★ Biomass that rely on on-farm residues can offer the **low medium** number of benefits. Sirohi 2007; Lee and Lazarus, 2013; Alexeew et al. 2010; Disch 2010; UNFCCC 2012	No direct interaction	↑ [+1] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008; Alexeew et al. 2010;
Biomass Small	↑ [+2] 📖 ★ Technology transfers are **limited** in biomass area due to the fact that biomass is a local mature technology; Indirect infrastructure development in the project area as a result of setting up of rural industries. Sirohi 2007; Alexeew et al. 2010; Dechezleprêtre et al., 2008;	↑ [+1] 📖📖 ★★ Biomass that rely on on-farm residues can offer the **low medium** number of benefits. Additionally, low impact in terms of quality time spent at school by children and turnaround in number of children attending school Subbarao and Lloyd 2011; Alexeew et al. 2010; Disch, 2010; UNFCCC2012; Lee and Lazarus, 2013	No direct interaction	↑ [+2] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011; Olsen and Fenhann 2008; Alexeew et al. 2010;

	Access to Cleaner and Affordable Energy for Heating or/and Cooking				Improved Income and Employment											
	7 AFFORDABLE AND CLEAN ENERGY				1 NO POVERTY				2 ZERO HUNGER				8 DECENT WORK AND ECONOMIC GROWTH			
	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE
Landfill	No direct interaction				↑	[+1]	📖	★	No direct interaction				↑	[+1]	📖📖	★★
					Benefits of using landfill gas projects are from cost savings associated with using landfill gas as a replacement for more expensive fossil fuel, thus improving income at the local level. However, research shows that little or no impact on poverty alleviation.								Landfill gas projects have the potential to generate employment opportunities for semi-skilled and high-skilled workers along the different phases of the projects. Thus, it is very limited impact on generating employment overall.			
					Sutter and Parreno 2007; Mori-Clement, 2019								Sutter and Parreno 2007; Mori-Clement, 2019; Disch, 2010; UNFCCC 2012			
Methan avoidance	No direct interaction				↑	[+1]	📖	★	No direct interaction				↑	[+1]	📖📖	★★
					Research shows that little or no impact on poverty alleviation.								Methane avoidance projects have the potential to generate employment opportunities for semi-skilled and high-skilled workers along the different phases of the projects. Thus, it is very limited impact on generating employment overall.			
					Sutter and Parreno 2007; Mori-Clement, 2019								Sutter and Parreno 2007; Mori-Clement, 2019; Disch, 2010; UNFCCC 2012			
Energy Efficiency Industry	No direct interaction				↑	[+1]	📖	★	No direct interaction				↑	[+1]	📖📖	★★
					Indirectly, the technical transfer from EE industry project might have a role in play in poverty alleviation. But other research also found out that the this type of projects also has the lowest score in physical well-being.								Has a low score in generating employment.			
					Sirohi 2007; Alexeew et al. 2010								Alexeew et al. 2010; Disch, 2010; UNFCCC 2012			

Energy Efficiency Households	↑ [+1] 📖 ★ Small-scaled EE households (efficient cook-stoves) through POAs can improve the access to modern energy services in the developing world Ellis el at. 2007; Schomer and van Asselt, 2012	No direct interaction	↑ [+1] 📖 ★ It reduces household expenditure on fuel, reduce the amount of time they spend collecting fuelwood, thereby allowing them to engage in other activities. Wood 2011	↑ [+1] 📖📖 ★★ Has limited impact on generating local jobs. Subbarao and Lloyd 2011; UNFCCC 2012; Wood 2011; Nussbaumer 2007
Hydro Large	↑ [+1] 📖 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008	↑ ↓ [+1, -2] 📖📖📖📖 ★★★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; has impact on local poverty reduction through enhanced energy security; Negative impact to local communities due to wide-ranging livelihood changes triggered by dams; Large hydro cause resettlement of villages and flooding of their agricultural lands Sutter and Parreno 2007; Boyd et al. 2009; Alexeew et al. 2010; "Mori-Clement, 2019; Disch, 2010; Smits and Middleton 2014; Rousseau, 2017; Haya 2007; Haya and Parekh 2011	No direct interaction	↑ ↓ [+1, -1] 📖📖📖📖 ★★★ Hydro projects by nature are capital intensive, thus might generate only few job opportunities mostly for skilled workers during construction and operation phase. Specially for large projects. thus, a significant local employment generation is not expected. Large hydro projects can employ workers by the subcontractors, who can hire workers outside of the local communities. Sutter and Parreno 2007; Sirohi 2007; Olsen and Fenhann 2008; Boyd et al. 2009; Alexeew et al. 2010; "Mori-Clement, 2019; Disch, 2010; UNFCCC 2012; Smits and Middleton 2014
Hydro Small	↑ [+1] 📖📖 ★★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-salce Subbarao and Lloyd 2011; Sirohi 2007; Olsen and Fenhann 2008; Cole and Roberts 2011	↑ [+2] 📖📖 ★★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011; Sutter and Parreno 2007; Sirohi 2007; Olsen and Fenhann 2008; Cole and Roberts 2011; Alexeew et al. 2010	No direct interaction	↑ [+1] 📖📖📖📖 ★★★ Hydro projects by nature are capital intensive, thus might generate only few job opportunities mostly for skilled workers during construction and operation phase. specially for large projects. thus, a significant local employment generation is not expected. Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011; Sutter and Parreno 2007; Sirohi 2007; Olsen and Fenhann 2008; Boyd et al. 2009; Alexeew et al. 2010; Disch, 2010; UNFCCC 2012

Wind Large	↑ [+1] 🕮 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits. Olsen and Fenhann 2008	↑ [+2] 🕮 ★★ Has the medium score in physical well-being, and moderate impact of using CERs as income. Sutter and Parreno 2007, Olsen and Fenhann 2008; Alexeew et al. 2010;	No direct interaction	↑ [+1] 🕮🕮🕮 ★★★ The real co-benefits of wind power projects are limited to the temporary jobs created during the construction phase. Sutter and Parreno 2007, Sorohi 2007, Olsen and Fenhann 2008; Alexeew et al. 2010; Disch 2010; UNFCCC 2012; Wood 2011;
Wind Small	↑ [+1] 🕮 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011; Olsen and Fenhann 2008	↑ [+2] 🕮 ★★ Has the medium score in physical well-being, and moderate impact of using CERs as income. Sutter and Parreno 2007, Olsen and Fenhann 2008; Alexeew et al. 2010;	No direct interaction	↑ [+2] 🕮🕮🕮🕮 ★★★ The real co-benefits of wind power projects are limited to the temporary jobs created during the construction phase Small scale RE deliver a slightly higher number of SD benefits than large-scale. Sutter and Parreno 2007, Sorohi 2007, Olsen and Fenhann 2008; Alexeew et al. 2010; Disch 2010; UNFCCC 2012; Wood 2011;
Solar Large	↑ [+1] 🕮 ★ Renewables, including biomas, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic grwoth and energy benefits Olsen and Fenhann 2008	↑ [+1] 🕮 ★ Renewables, including biomas, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic grwoth and energy benefits Olsen and Fenhann 2008	No direct interaction	↑ [+1] 🕮 ★ Has a **medium** score in generating employment. Olsen and Fenhann 2008; UNFCCC 2012; Nussbaumer 2007
Solar Small	↑ [+2] 🕮 ★★ Small-scaled technology, such as solar water heaters through POAs can improve the access to modern energy services in the developing world; Olsen and Fenhann 2008; Schomer and van Asselt, 2012	↑ [+2] 🕮 ★ Renewables, including biomass, hydro, wind, solar, have a higher socio-economic profile with relative many projects contributing with employment, welfare, economic growth and energy benefits; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011	No direct interaction	↑ [+2] 🕮 ★ Has a **medium** score in generating employment; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Olsen and Fenhann 2008; UNFCCC 2012; Nussbaumer 2007

Biomass Large	↑ [+1] 📖 ★ Saving the power at grid that is currently used by them to divert it elsewhere; for country with vast agricultural produce that makes available large quantities of agricultural residues, Biomass can meet energy needs. Sirohi 2007; Olsen and Fenhann 2008;	↑ [+2] 📖📖📖 ★★ Direct: Farmers income from supplying biomass material; Indirect: contribute to farmers' livelihood; It also improved the livelihoods of the poor by creating a value for previously worthless biomass residues. Biomass fuel not being sourced from sustainable sources leads to negative impact to poor people in local community. Sirohi 2007; Olsen and Fenhann 2008; Boyd et al. 2009; Alexeew et al. 2010;Mori-Clement, 2019; Wood 2011	No direct interaction	↑ [+3] 📖📖📖📖 ★★★ Biomass is a labor-intensive process that could represent an important source of primary jobs in rural areas. It not only can generate direct employment during the construction and operation phase. They can generate indirect employment and additional employment opportunities. It can generate both unskilled and skilled job positions during a project's life. they may have the potential to perpetuate employment at the local level. Sirohi 2007; Boyd et al. 2009; Alexeew et al. 2010; Mori-Clement, 2019; Wood 2011; UNFCCC; Lee and Lazarus, 2013
Biomass Small	↑ [+2] 📖 ★ Saving the power at grid that is currently used by them to divert it elsewhere; Small scale RE deliver a slightly higher number of SD benefits than large-scale. Subbarao and Lloyd 2011; Sirohi 2007; Olsen and Fenhann 2008;	↑ [+3] 📖📖📖 ★★★ Direct: Farmers income from supplying biomass material ; Indirect: contribute to farmers' livelihood; creation of jobs as supplementary source of income to conventional farming Minor impact on poverty alleviation"; It also improved the livelihoods of the poor by creating a value for previously worthless biomass residues. Sirohi 2007; Olsen and Fenhann 2008; Boyd et al. 2009; Alexeew et al. 2010;Mori-Clement, 2019; Wood 2011	No direct interaction	↑ ↓ [+4] 📖📖📖📖 ★★★ Biomass is a labor-intensive process that could represent an important source of primary jobs in rural areas. It not only can generate direct employment during the construction and operation phase. They can generate indirect employment and additional employment opportunities. It can generate both unskilled and skilled job positions during a project's life. they may have the potential to perpetuate employment at the local level. Sirohi 2007; Sutter and Parreno 2007; Boyd et al. 2009; Alexeew et al. 2010; Mori-Clement, 2019; Wood 2011; UNFCCC; Lee and Lazarus, 2013;Castro & Michaelowa 2008

	Improved natural Resource and Environmental Services												Improved Access to Electricity and Energy Efficient Lighting			
	3 GOOD HEALTH AND WELL-BEING				6 CLEAN WATER AND SANITATION				15 LIFE ON LAND				7 AFFORDABLE AND CLEAN ENERGY			
	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE	INTERACTION	SCORE	EVIDENCE	CONFIDENCE
Landfill	↑ ↓	[+2, -2]	📖📖📖	★★★	↓	[-1]	📖	★								
	CH4 reduction projects have a medium green profile with many projects contributing to environmental benefits such as improved air and water quality. it is also cheap emission reductions face opposition from local communities opposed to the extension of the life of these sites, or bring negative effects on local health, because CDM postponed the closing down of the waste				Might contaminate ground water is mismanaged.				No direct interaction				No direct interaction			
	Ellis el at. 2005; Boyd et al. 2009; Sutter and Parreno 2007; Olsen and Fenhann 2008; Sun et al. 2010; Disch, 2010; UNFCCC 2012															
Methan avoidance	↑ ↓	[+2, -2]	📖📖📖	★★★	↓	[-1]	📖	★								
	CH4 reduction projects have a medium green profile with many projects contributing to environmental benefits such as improved air and water quality. it is also cheap emission reductions face opposition from local communities because it might bring negative effects on local health, because CDM postponed the closing down of				Might contaminate ground water is mismanaged.				No direct interaction				No direct interaction			
	Boyd et al. 2009; Sutter and Parreno 2007; Olsen and Fenhann 2008; Sun et al. 2010; Disch, 2010; UNFCCC 2012															
Energy Efficiency Industry	↑	[+2]	📖📖📖📖	★★★	↑	[+1]	📖	★								
	Has the **medium-high** impact on reducing air pollution, and promoting of environmental well-being.				A switch to low-carbon fuels can lead to a reduction in water demand, but the impact is the low in improving water quality.				No direct interaction				No direct interaction			
	Alexeew et al. 2010; Nussbaumer 2007; Sirohi 2007; UNFCCC 2012				Alexeew et al. 2010;											

Energy Efficiency Households	↑ [+3] 📖📖 ★★ it can siginificantly improve the air quality within their houses Subbarao and Lloyd 2011; UNFCCC 2012; Wood 2011	No direct interaction	No direct interaction	↑ [+1] 📖 ★ Small-scaled EE households (efficient fluorescent lamps) through POAs can improve the access to modern energy services in the developing world. Ellis el at. 2007; Schomer and van Asselt, 2012
Hydro Large	↑↓ [+2, -2] 📖📖📖📖 ★★★ Large hydro projects are the medium contributor to co-benefits in terms of pollutants mitigations and improving health; Large hydro might have environmental impacts including clearing of the forest and pollution(dust) during the construction phase. It further impacts local health. Sutter and Parreno 2007; Sun et al. 2010; Alexeew et al. 2010; Mori-Clement, 2019; Disch, 2010; UNFCCC 2012, Smits and Middleton 2014; Rousseau, 2017; Haya 2007; Haya and Parekh 2011; Castro & Michaelowa 2008; Nussbaumer 2007	↑↓ [+2, -1] 📖 ★ Has the medium score in improving water quality. Construction will pollute water. While dam have major impacts on the physical, chemical and geomorphological properties of a river. Alexeew et al. 2010; Haya 2007; Haya and Parekh 2011	↓ [-1] 📖📖📖 ★★ Large hydro might have environmental impacts including clearing of the forest and pollution(dust) during the construction phase. It further impacts local health. Rousseau, 2017; Haya 2007; Haya and Parekh 2011; Castro & Michaelowa 2008	No direct interaction
Hydro Small	↑ [+2] 📖📖📖📖 ★★★ Hydro projects are the medium contributor to co-benefits in terms of pollutants mitigations and improving health. Subbarao and Lloyd 2011; Sutter and Parreno 2007; Sun et al. 2010; Cole and Roberts 2011; Alexeew et al. 2010; Disch, 2010; UNFCCC 2012	↑ [+2] 📖 ★ Small hydro reduce water demands to displace other water intensive energy processes, it has the medium score in improving water quality. Cole and Roberts 2011; Alexeew et al. 2010, IPCC) 2018	No direct interaction	↑ [+1] 📖 ★ Low impact on access to electricity. Subbarao and Lloyd 2011

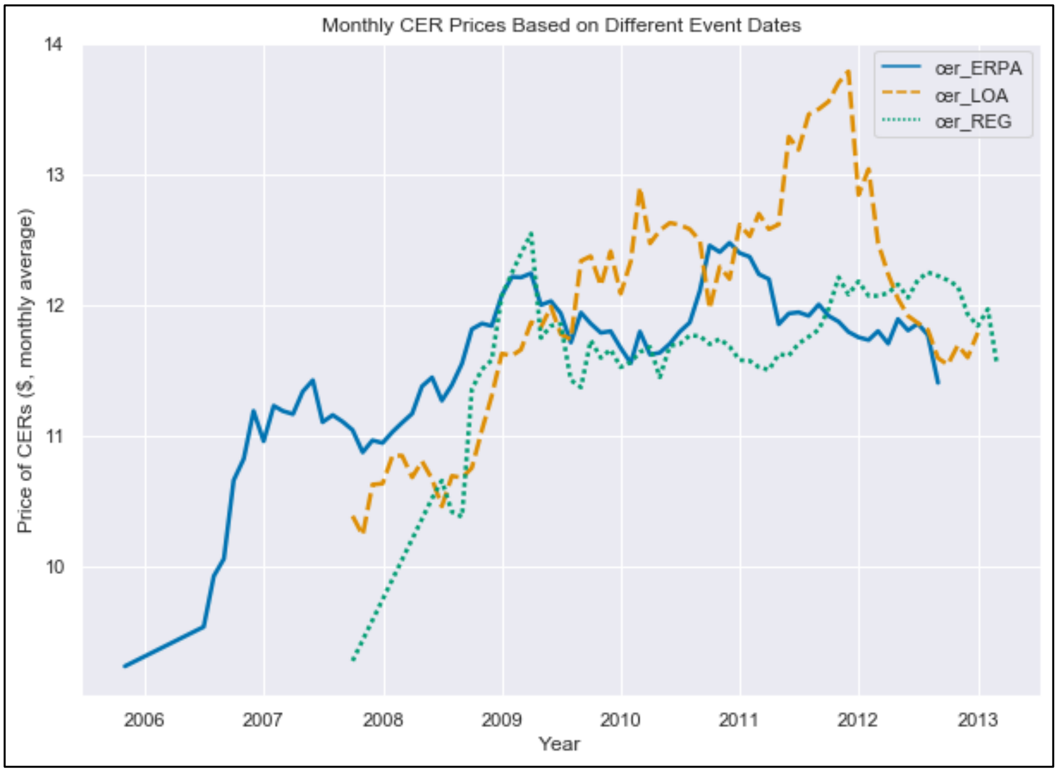
Wind Large	↑ ↓ [+2, -1] 📖📖📖📖 ★★★ Wind power projects can create co-benefits of the absence of any pollution that would have been caused by conventional power generation; Sun et at.2010; Alexeew et al. 2010; Disch 2010; UNFCCC 2012; Wood 2011	↑ [+3] 📖 ★ Wind with very low water requirement leads to the **high** impact in improving water quality. Alexeew et al. 2010, IPCC 2018	↓ [-1] 📖 ★ Has the negative impact on land issue. Nussbaumer 2007	No direct interaction
Wind Small	↑ [+2] 📖📖📖 ★★★ Wind power projects can create co-benefits of the absence of any pollution that would have been caused by conventional power generation. Subbarao and Lloyd 2011; Sun et at.2010; Disch 2010; UNFCCC 2012; Wood 2011	↑ [+3] 📖 ★ Wind with very low water requirement leads to the **high** impact in improving water quality. Alexeew et al. 2010, IPCC 2018	No direct interaction	↑ [+1] 📖 ★ Low impact on access to electricity. Subbarao and Lloyd 2011
Solar Large	↑ [+2] 📖 ★ Has the **medium** score improve air quality. UNFCCC 2012	↑ [+3] 📖 ★ Solar with very low water requirement leads to the **high** impact in improving water quality. IPCC 2018	No direct interaction	No direct interaction
Solar Small	↑ [+2] 📖 ★ Has the **medium** score improve air quality. UNFCCC 2012	↑ [+3] 📖 ★ Solar with very low water requirement leads to the **high** impact in improving water quality. IPCC 2018	No direct interaction	↑ [+1] 📖 ★ Small-scaled EE households (efficient fluorescent lamps) through POAs can improve the access to modern energy services in the developing world. Schomer and van Asselt, 2012

Biomass Large	↑ [+2, -1] 📖 ★	↑ ↓ [+2, -1] 📖 ★	↓ [-1] 📖 ★	
	Biomass that rely on on-farm residues can offer the medium number of benefits. Has the medium score improve air quality; it improved air quality by reducing the burning of biomass in the fields, and supplying villagers with organic fertilizer.	Has the **medium** score in improving water quality, meanwhile large biomass could lead to increased water stress.	Biomass fuel not being sourced from sustainable sources leads to deforestation and affecting poor people that use biomass as cooking in local community.	
	Alexeew et al. 2010; Disch 2010; Lee and Lazarus, 2013; UNFCCC 2012; Castro & Michaelowa 2008	Alexeew et al. 2010, IPCC 2018	Castro & Michaelowa 2008	
Biomass Small	↑ [+2, -1] 📖 ★	↑ [+2] 📖 ★	↓ [-1] 📖 ★	↑ [+1] 📖 ★
	Biomass that rely on on-farm residues can offer the medium number of benefits. Has the medium score improve air quality; it improved air quality by reducing the burning of biomass in the fields, and supplying villagers with organic fertilizer.Biomass fuel not being sourced from sustainable sources leads to negative impact to poor people in local community.	Has the **medium** score in improving water quality.	Biomass fuel not being sourced from sustainable sources leads to deforestation and affecting poor people that use biomass as cooking in local community.	Low **impact** on access to electricity.
	Alexeew et al. 2010; Disch 2010; Lee and Lazarus, 2013; UNFCCC 2012; Wood 11; Castro & Michaelowa 2008	Alexeew et al. 2010	Castro & Michaelowa 2008	Subbarao and Lloyd 2011

Appendix A Accuracy of the ERPA Dates

To check the accuracy of the ERPA dates extracted by the machine, I adopted two methods to validate the data.

First, I plotted the monthly average CER prices over the period of April 2005 to February 2013 against the signed date of ERPA, along with two other event dates (the date of getting the Letter of Approval (LOA) and the date that a project get registered) in **Figure A 2-1.** I can see that the line of CER prices drawn from the ERPA is quite different from the other two lines based on the other two events: LOA date and project registration Date. I expect that the date of LOA will be close to the ERPA line, or might be delayed from the timewise perspective, compared to the ERPA dates, which is confirmed in the figure.



Data is from the CDM project pipelines, with ERPA dates collected by the author.
Note: The three lines are calculated based on a five-year moving average in order to smooth out dramatic price fluctuation. LOA: Letter of Approval. REG: Project Registration Date. Units: US dollar per ton.

Figure A 2-1. Monthly CER prices based on different event dates. *The line of CER prices drawn from the ERPA is very different from the other two lines based on the other two events. Normally, the date of LOA will be close to the ERPA dates (but somewhat delayed), which is confirmed in the figure. The low price at the early stage is due to the uncertainty of whether or not the Kyoto Protocol would even come into force. Thus, it leads to limited demand for CERs with an understandably low price of the CERs (Kamel et al., 2007). The second fall of the CER prices is due to the 2008 economic crisis.*

Second, I compared the overall trend of the monthly average CER prices based on ERPA dates with the spot market price trend. I find that among the three lines, the line of ERPA date fits the spot market trend best in **Figure A 2-2**.

Source: Norwegian Ministry of Finance, 2012

Figure A 2-2. EU ETS spot price ("EUA") and price of approved CDM allowances ("CER") from 1 January 2009 to 3 September 2012. *Units: EUR per ton.*

Appendix B Supplemental Tables and Figures

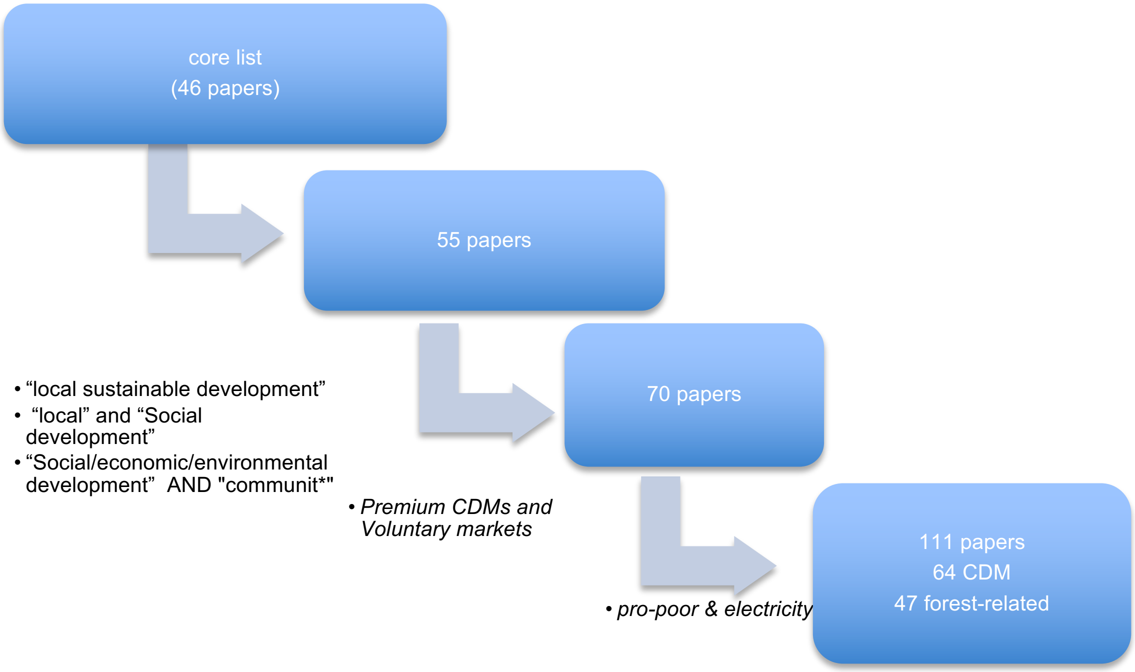
Table B 2-1. Effect of project features on CDM projects.

Models	**Model 1**	**Model 2**
type x size (0)	0 (.)	-2.253*** (0.743)
type x size (1)	2.253*** (0.743)	0 (.)
type x size (3)	-1.431 (2.339)	-3.684 (2.412)
type x size (4)	-0.470 (0.622)	-2.723*** (0.960)
type x size (5)	0.0130 (0.168)	-2.240*** (0.760)
type x size (6)	-0.759 (0.655)	-3.011*** (0.980)
type x size (7)	0.631 (0.893)	-1.621 (1.154)
type x size (8)	-0.648 (0.706)	-2.901*** (1.025)
type x size (9)	0.777 (0.554)	-1.476 (0.914)
Biomass energy	0 (.)	0 (.)
Coal bed/mine methane	-0.158 (0.510)	-0.158 (0.510)
EE households	0 (.)	0 (.)
EE own generation	-0.226 (0.437)	-0.226 (0.437)
Hydro	-0.705** (0.305)	-0.705** (0.305)
Landfill gas	-1.088** (0.458)	-1.088** (0.458)
Methane avoidance	-2.719*** (0.948)	-2.719*** (0.948)
Solar	0.0106 (0.523)	0.0106 (0.523)
Year FE	Yes	Yes
Project Location FE	Yes	Yes
Credit buyer FE	Yes	Yes
Wind	1.221*** (0.303)	1.221*** (0.303)
Gold Standard	2.096*** (0.409)	2.096*** (0.409)
Years of projects	0.0721 (0.0712)	0.0721 (0.0712)
Expected accumulated 2020 ktCO$_2$e	-0.000130 (0.000222)	-0.000130 (0.000222)
Expected accumulated 2030 ktCO$_2$e	-0.0000247 (0.0000775)	-0.0000247 (0.0000775)
Project investment (million USD)	0.00552*** (0.00144)	0.00552*** (0.00144)
Constant	10.99*** (2.885)	13.24*** (2.890)
Observations	2173	2173
Adjusted R2	0.3137	0.3137

Note: The dependent variable in both models is CER price. Coefficient estimates are reported in this table. The base case in model 1 is type x size (0), and in model 2 is type x size (1). Size is a dummy variable, with large projects coded as 0, and small projects coded as 1. I control for project location fixed effects, credit buyer fixed effects, and year fixed effects in the model.

* p<0.10 ** p<0.05 *** p<0.01

Appendix C The Process of Conduction Systematic Literature Review



Chapter 3 Paper Two: Do Gold-Standard-Certified CDM Projects Deliver a Price Premium?

Abstract

The Clean Development Mechanism (CDM) is probably the most salient international offset mechanism within the broader world of carbon finance. It was designed with two equally important goals: to lead to significant emission reductions that would help reduce the cost of climate mitigation in countries with commitments and to contribute to sustainable development in host countries. However, in the carbon markets, the pure commodity of CO_2 reductions is likely to devolve into simple emissions reductions, and I am unable to ensure the sustainable development outcomes. Thus, one of the proposed policy strategies is to give these projects quality controls (e.g., the independently generated label of "Gold Standard") and to see whether the quality control indicators attract a price premium because of these co-benefits. I use the Gold Standard CDM as a case study to see whether customers are willing to pay a price premium for the CERs associated with high co-benefits. In this paper, I perform an econometric analysis of a group of projects with 2,195 regular CDM projects and 64 Gold Standard-certified CDM projects. I selected projects for which complete information was available in the CDM pipeline to date. Specifically, a combined method of propensity score matching technique and exact matching technique is constructed to identify the effect of certification of carbon offsets/or higher co-benefits of carbon projects on the buyers' willingness to pay. I found that quality control indicators have a significant effect on CER prices with the price premium is in the range of \$1.13/tCO_2e to \$4.2/tCO_2e. Additionally, I see a strong commitment from public finance in delivering co-benefits in the local commitment by willing to pay a price premium.

1. Introduction

The world now has roughly a decade and a half of experience with the carbon offsetting programs established under the Kyoto Protocol, most notably the Clean Development Mechanism (CDM). The experience of these programs can inform the next steps in the evolution of climate finance to support low-carbon sustainable development, including ongoing discussions about possible pathways for implementation of Article 6 of the Paris Agreement. As a policy tool with dual goals—stimulating both low-cost emissions reductions and sustainable development—the CDM has always had a challenging mandate. One fundamental challenge involves the CDM's ability to deliver local co-benefits via the market mechanism, in that there exists a trade-off between monetized carbon emissions-reducing activities and non-monetized sustainable development benefits. Thus, the dual goals of the CDM create a fundamental tension: the original idea of the CDM is not only to look for the cheapest way to reduce GHG emissions, but also to promote sustainable development by stimulating investing in projects located in developing countries (Pearson, 2007).

This tension leads us to think deeply about how to design a better structure to balance the tension while meeting the challenge: investing in emission reduction projects requires more than simply increasing financial flows to the green industry. This kind of targeted financial flow may not always result in sustainable development, and even when sustainable development benefits accrue, the co-benefits may not always flow to the local receiving communities. In order to optimize the value of these investment and to achieve real and lasting sustainability, project developers and policymakers must place a high strategic value on delivering local co-benefits to receiving communities.

Many researchers have been studying whether the CDM can achieve its dual goals, and found that there has often been a trade-off between emission reductions and sustainable development (Alexeew et al., 2010; Ellis et al., 2007; Freeman and Zerriffi, 2012; Schneider, 2007; Sutter and Parreño, 2007; Torvanger et al., 2013; Watts et al., 2015). This limitation could potentially be addressed by policies that favor certain structural features, such as technology type, or processes. Thus, an important potential tool for linking these goals of emissions reductions and sustainable development is differentiating the quality of avoided emissions that earns carbon credits.

In the context of CDM, various differentiators and “labels” have been applied, including the Gold Standard, as well as others generated under the Community Development Carbon Fund (CDCF) and the Climate, Community, and Biodiversity Standard (CCBS). These have been created for the purpose of identifying projects with high quality of Certified Emission Reductions (CERs) by adding an additional guarantee of sustainable development benefits. The incentive for using labeling CDM is that under regular CDM, there is no momentary value attached to the co-benefits that the CDM projects generate. Theoretically, these quality markers can indicate an additional added value for credits derived from projects that meet a higher standard for co-benefits. Recognition of this added value can incentivize project developers to promote local co-benefits because of additional revenues they get from the transactions. But to date, a robust assessment of such outcomes has not been undertaken.

This paper attempts to fill this gap. Through this paper, I examine the carbon markets and get an indication of whether buyers voluntarily purchase carbon credit with higher co-benefits, all other attributes of the carbon projects being equal. Specifically, I am looking at one of the quality control indicators, the Gold Standard CDM, see whether customers are willing to pay more for the CERs associated with high co-benefits.

The Gold Standard CDM operates in both compliance and voluntary carbon markets. However, customers who purchase Gold Standard-certified credits are voluntarily purchasing carbon credits with higher co-benefits. For this study, I focus on the Gold Standard projects that have been brought forward in compliance markets. Based on data from this market, and comparing the data from the regular CDM market, I analyze whether the prices paid for CERs in the Gold Standard market are significantly higher than those paid for CERs in the regular CDM market. Comparing projects with similar features that are offered in both markets, (e.g., similar volumes of carbon credits, project types, project locations, credit buyers, etc.), I am able to isolate the differences that result solely from the inclusion of co-benefits in the valuation of the CERs. In that context, I am able to conclude that customers are enjoying a higher utility due to the inclusion of co-benefits that are generated from these projects.

For this study, I perform an econometric analysis of a group of 2,195 regular CDM projects and 64 Gold Standard-certified CDM projects. I selected projects for which complete information is available in the CDM pipeline to date. Specifically, a combined method of propensity score matching technique and exact matching technique is constructed to identify the effect of certification of carbon offsets/or higher co-benefits of carbon projects on the buyers' willingness to pay.

The remainder of this paper is organized as follows: Section 2 provides a background discussion on the Gold Standard and the projects it certifies. It identifies how these projects are different from the regular CDM projects with which they will be compared. Section 3 presents a review of recent literature on the impact of the Gold Standard on the realization of co-benefits in CDM projects. Section 4 describes the methodological approaches and data used for the analysis summarized in this paper. Section 5 presents the results of the econometric analysis. Additional econometric analysis using sectoral data is also discussed in this section. I present the discussion and potential for future research in Section 6. Policy implications and conclusions are then summarized in section 7.

2. Gold Standard CDM

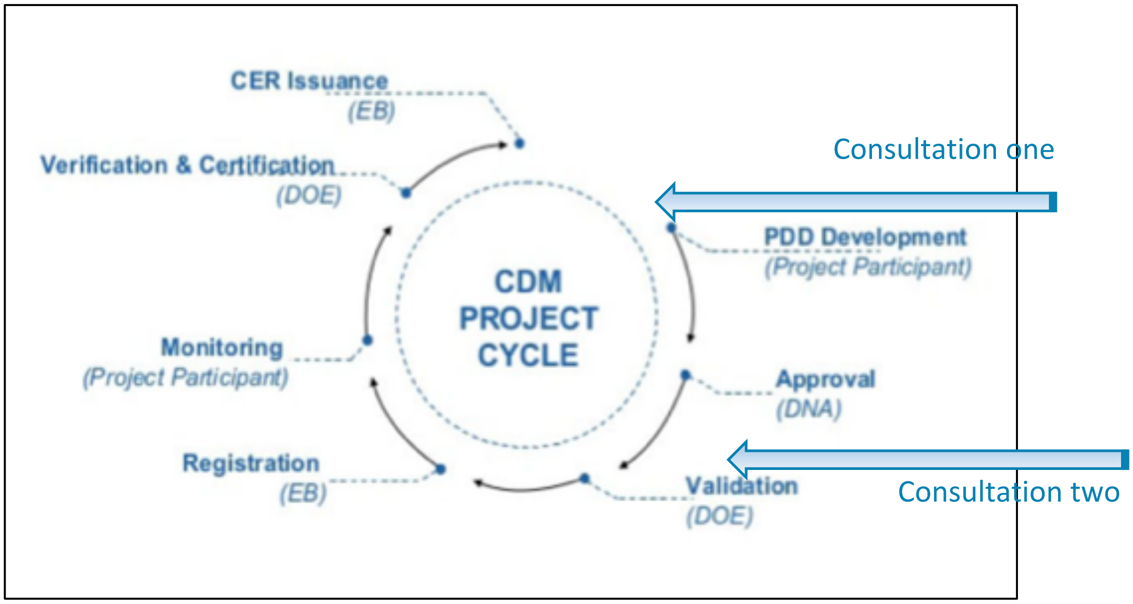
The Gold Standard initiated by the World Wildlife Fund (WWF) in 2003, is a certification standard for carbon offset projects. Since then, the transacted volume of Gold Standard-Certified credits has been growing steadily. In total, from 2003 to 2019, the Gold Standard has issued more than 98.4 million carbon credits, and 15 million credits have been labeled CERs over the entire period (Gold Standard, 2019). A CDM project can use the Gold Standard protocol as an add-on methodology to make it a Gold Standard CDM project. It "proposed a methodology to develop high-quality emission reduction projects with high environmental integrity and secured local, social, environmental and economic benefits" (Nussbaumer, 2009). Gold Standard is a voluntary scheme based on the CDM structure, with three additional "screens" to filter projects. The first screen is "project type screen," which limits projects only to renewable energy and end-use energy efficiency projects.[28] The "additionality and baselines screen" seeks to ensure projects are truly additional. The "sustainable development standards screen" seeks to ensure that projects deliver local, social, environmental, and economic benefits (Gold Standard 2002). Once projects have passed these screens, they can be labeled as Gold Standard-certified projects. To assess CDM projects, the Gold Standard protocol uses the following methods: (1) the sustainable development (SD) assessment matrix;[29] (2) a stakeholder consultation; and (3) an environmental impact assessment (EIA)

---

[28] Only energy efficiency projects, methane to energy projects and hydro projects of size less than 15 MW and other renewable energy projects are eligible.

[29] Gold Standard project developers use a sustainable development matrix to calculate the impact of the project with the help of these consultations. Only projects with an overall positive impact on the environment, social network and local economy are considered for Gold Standard (Indian Ministry New and Renewable Energy).

Gold Standard project developers invite local stakeholders to conduct two consultation meetings (one in the initial stages of the project and one just before validation) to make sure that the project responds to local concerns regarding the environmental and social impacts, as well as impacts on the local economy. This is different from CDM, wherein only one consultation meeting is required. The CDM project cycle is depicted in **Figure** *3-1*, where I can see the first and second stakeholder consultations enter the scene.



Source: Indian Ministry New and Renewable Energy, Global CER - VER Market

Figure 3-1. CDM project cycle.

By adopting these safeguards and requirements, the Gold Standard protocol ensures that the projects not only achieve the goal of emission reductions, but also can deliver on at least two Sustainable Development Goals (SDGs) that are important to ensuring that the benefits are delivered to local communities. A study conducted by the Gold Standard estimated that the issued 669 projects have created nearly $5.5 billion of value in benefits that go beyond carbon (Gold Standard, 2019, 2014).

3. Literature Review

The traditional way to study the influence of co-benefits derived from CDM projects is by using a Multi-Attributive Assessment of CDM (MATA-CDM) methodology. This methodology was introduced by Sutter (2003) to evaluate the contribution of CDM projects to sustainable development in host countries (Sutter and Parreño, 2007). It is a combination of indicators that are qualitative, semi-quantitative and quantitative in nature. The ratings for all indicators are aggregated to the project level in order to obtain the project's overall contribution to a sustainable development. Later on, Nussbaumer conducted an early study comparing the potential local sustainable development benefits of labeled CERs (Gold Standard and CDCF) to regular CDM projects using the MATA-CDM method. A total of 39 CDM projects were evaluated, which includes all Gold Standard and CDCF CDM projects at the time of the study. The study finds that the sustainable development profile of labeling CDM projects tends to be comparable or slightly higher than similar ordinary projects. "Labeled projects do not, however, drastically outperform non-labeled ones" (Nussbaumer, 2009). However, Drupp later noted that Nussbaumer's study was limited by the small number of Gold Standard projects available at that point in time. He conducted a similar study by using MATA-CDM method, with more Gold Standard certified projects in the sample and compared 18 Gold Standard projects with 30 regular CDM projects. He finds that: (1) Gold Standard can be associated with distinctly higher potential co-benefits to local communities than these 30 unlabeled CDM projects; (2) the impact from Gold

Standard is even more pronounced if compared with unlabeled CDM projects whose project technologies are unqualified for the Gold Standard requirements; (3) Gold Standard's impact on co-benefits is "inclusive"[30] in a within-project-type comparison (Drupp, 2011). The author did not find detectable potential co-benefits surplus generated by the "sustainable development standards screen." However, their analysis did suggest that the "project type screen" works, which means renewable energy projects outperform non-RE projects on delivering co-benefits. Crowe expands the sample further to consider a total of 114 projects, including 17 Gold Standard, 4 CCBS, and 89 regular CDM projects. He concludes that regular CDM projects are only "marginally" successful at delivering pro-poor benefits, while Gold Standard projects are only slightly better at delivering co-benefits compared to regular CDM, but that all four CCB projects performed well in delivering pro-poor benefits.

Another small group of literature studies the market segments of credit buyers. In 2003, Sutter first suggested differentiating the market for CERs into normal CERs and premium CERs, rewarding institutions publicly for good projects (Sutter, 2003). Parnphumeesup and Kerr's study was the first one to validate the buyer's market and identified that there are two separable sub-markets: the premium market and the normal market (Parnphumeesup and Kerr, 2011).

Crowe's approach also included a market survey to analyze the extent to which carbon market participants would be willing to pay higher prices for projects with stronger local

---

[30] Inclusive, means that the author cannot conclude from their analysis that Gold Standard projects can be associated with higher co-benefits than similar unlabeled CDM projects.

development benefits(Crowe, 2013).[31] Additionally, another study of willingness to pay for the Gold Standard projects finds that 56 percent of the buyers are willing to pay a price premium (Parnphumeesup and Kerr, 2015).

The third group of literature focused on the impact of third-party labeling on the realization of co-benefits. The CCBS was created to foster the development and marketing of projects that deliver credible and significant climate, community, and biodiversity benefits in an integrated, sustainable manner (CCB Standard version 3). It has a strong focus on engagement of local stakeholders, requiring multiple consultations with those stakeholders (Wood et al., 2011).

Additionally, there are some carbon funds initiated by the World Bank Group with the aim of utilizing the CDM to promote targeted areas and project types. The CDCF represents a specific approach for using a funding mechanism to support projects that bring benefits to local communities. Created in 2002, the CDCF's original goal is to support small-scale projects within underprivileged communities[32] and promote the local co-benefits by offering the project developers a price premium for their CERs if the projects meet certain criteria. By May 2017, by its own assessment, 25 out of 36 registered CDCF CDM projects successfully delivered tangible co-benefits "aligned with the SDGs for approximately 17.5 million people" (World Bank, 2017). In December 2011, the World Bank launched the Carbon Initiative for Development (Ci-Dev) to "build capacity and develop tools and methodologies to help the world's poorest countries access carbon finance, mainly in the

---

[31] Of course, as the author also identifies, there might be a response bias in the survey because people tend to gravitate toward good behavior by picking better answers (Crowe, 2013)

[32] "Underprivileged communities" described communities that are characterized by low educational attainment and income, high rates of substance use, unemployment, crime, and violence (Eloff, 2019).

area of energy access" (World Bank, 2015). By June 2016, there were 13 CDM PoAs were selected by the Ci-Dev to promote energy access through the implementation of rural electrification, energy efficient cookstoves, and low-carbon water filtration (Michaelowa et al., 2016). Within these specific targeted areas of energy access, the Ci-Dev has the potential to deliver tangible co-benefits to many underprivileged communities. Created in 2004, the BioCarbon Fund (BioCF) had financed 18 CDM-AR projects by the end of 2012 and successfully reduced deforestation in over 350,000 hectares of land over the past decade (World Bank, 2012). Another study looking at 21 CDM-AR projects shows that the co-benefits to the local communities in environmental, social, and economic dimensions increased in a significant manner (World Bank, 2011).

Table 3-1 summarizes the results of and differences between these studies.

Table 3-1. Literature summaries by 10 studies.

Author	N. of Project	Detailed projects	Assessment
Nussbaumer 2007	39	Conduct a comparison study between regular CDM and 6 Gold Standard, 10 CDCF.	Labeling CDM is slightly better than regular CDM
Drupp 2011	48	Use an increased sample of 18 instead of 6 Gold Standard projects	Gold Standard CDM projects are better at delivering co-benefits than regular CDM projects before controlling for project types; but are only marginally better after controlling for project types.
Crowe 2013	114	89 +17 Gold Standard +4CCBs	CCB all performed well in delivering pro-poor benefits
Wood 2011	161	142 Gold Standard + 19 CCBs	Gold Standard and CCB standards successfully reward high-quality projects which have a demonstrated commitment to local co-benefits
World Bank, 2013	22	CDCF project portfolios, interviews and consultations, 8 case studies	All CDCF projects directly or indirectly benefit local communities
World Bank, 2017	36	36 CDCF projects	25 out of 36 projects have been collectively reduced emission reductions, while 25 projects have created community co-benefits aligned with the SDGs for approximately 17.5 million people.
Spalding-Fecher et al. - 2015	5	Ci-Dev	These five PoAs are focused on the area of energy access such as improved cookstoves, rural electrification, lighting.
Michaelowa et al. - 2016 -	13	Ci-Dev	These selected 13 PoAs are focused on the areas of energy access to sustainable energy including rural electrification (grid extension, mini-grid, solar lighting, and solar home systems), low-carbon cooking and low-carbon water filtration in Sub-Saharan African countries.
World Bank, 2011	21	BioCF	This experience shows that the benefits associated with A/R CDM projects support the livelihood of rural people and their local environment in a significant manner across environmental, social and economic c0-benefits.
World Bank, 2012	18	BioCF	Over the past decade, the BioCF reduced deforestation in over 350,000 hectares of land.

Thus, the broader literature indicates that indicators of quality, such as labeling or institutional endorsements, might correlate with higher delivery of intangibles or non-monetary returns on investments, such as community co-benefits. Unlike the regular CDM, which makes no claim to the specific co-benefits that the CDM generates, these labels or other indicators can potentially send a signal to CER purchasers that a labeled project has higher co-benefits and this might then stimulate higher market prices for the CER prices. This could incentivize project developers to promote local co-benefits in a different way than just for standard CDM projects (Hultman et al., 2019).

However, none of these studies analyzes the CDM and Gold Standard CDM markets empirically by using a refined dataset, and none of these studies tries to articulate the actual price premium a buyer is willing to pay. This study serves the purpose of bridging the research gap by using a refined dataset to quantify the price impact of Gold Standard on CDM projects.

4. Methodological Approach and Data

4.1. Data

The primary data source for the present study is the UNEP DTU CDM/JI Pipeline Analysis and Database (CDM/JI Pipeline). Additional information such as Emission Reduction Purchase Agreement (ERPA) dates, are extracted from CDM documents in PDF format on the UNFCCC CDM projects site through Python.

I include 2,259 CDM projects in this study, where 1,655 are regular CDM projects, and 64 are Gold Standard CDM projects in our paper. Our dataset covers 20 project types and two project sizes (UNFCCC, 2017). Detailed results segregated by project types and size are listed in **Table 3-2**.

Table 3-2. Projects distribution based on project types and size by Gold Standard and regular CDM.

	Regular CDM			Gold Standard CDM		
	Project Size			Project Size		
Project Type	**Small**	**Large**	**Total**	**Small**	**Large**	**Total**
Biomass energy	15	67	82	1	2	3
Coal bed/mine methane	0	39	39	0	0	0
EE households	6	0	6	1	0	1
EE industry	3	2	5	2	0	2
EE own generation	19	70	89	0	2	2
EE service	0	0	0	3	0	3
EE supply side	0	8	8	0	0	0
Energy distribution	0	3	3	0	0	0
Fossil fuel switch	1	18	19	0	0	0
Fugitive	0	4	4	0	0	0
Geothermal	0	1	1	0	0	0
Hydro	383	518	901	6	2	8
Landfill gas	19	48	67	0	2	2
Methane avoidance	63	8	71	19	1	20
Mixed renewables	0	1	1	0	0	0
N2O	0	1	1	0	0	0
Reforestation	0	2	2	0	0	0
Solar	13	31	44	5	2	7
Transport	0	2	2	1	2	3
Wind	18	832	850	2	11	13
Total	540	1,655	2,195	40	24	64

As the literature indicates that ERPA is viewed as highly attribute affecting the price of CERs (Kamel et al., 2007). ERPA is specially developed for contract parties that directly want to deal between project owners and buyers. The contract outlines in detail the various steps of the process of starting with getting the project idea approved by a validator and the CDM Executive Board and continuing on to the actual deliverance of emission reductions and consequent issuance of CERs by the CDM Executive Board. Under the purchase agreement, buyers are required to pay a fixed price [33] for the CERs to the sellers, usually in US dollars or Euros.[34]

However, the CDM pipeline does not include the ERPA information, while most of the ERPA information is only provided in the project design document (PDDs), which is a long PDF document that the original project developer must submit to the CDM Executive Board for project approval. The problem is that locating the dates of ERPA is quite time-consuming if it is done manually. As a result, the historical studies of the impact of the CERs prices have never controlled for the dates of ERPA. Thus, identifying the ERPA dates for each project is crucial and the results will influence the impact from the CERs fundamentally. To solve the problem and improve the accuracy of the statistical analysis in the later section, I use Python coding to go over the PDDs and validation reports for all the CDM projects with a CER price in the pipeline, and then extract information of ERPA dates from these documents.

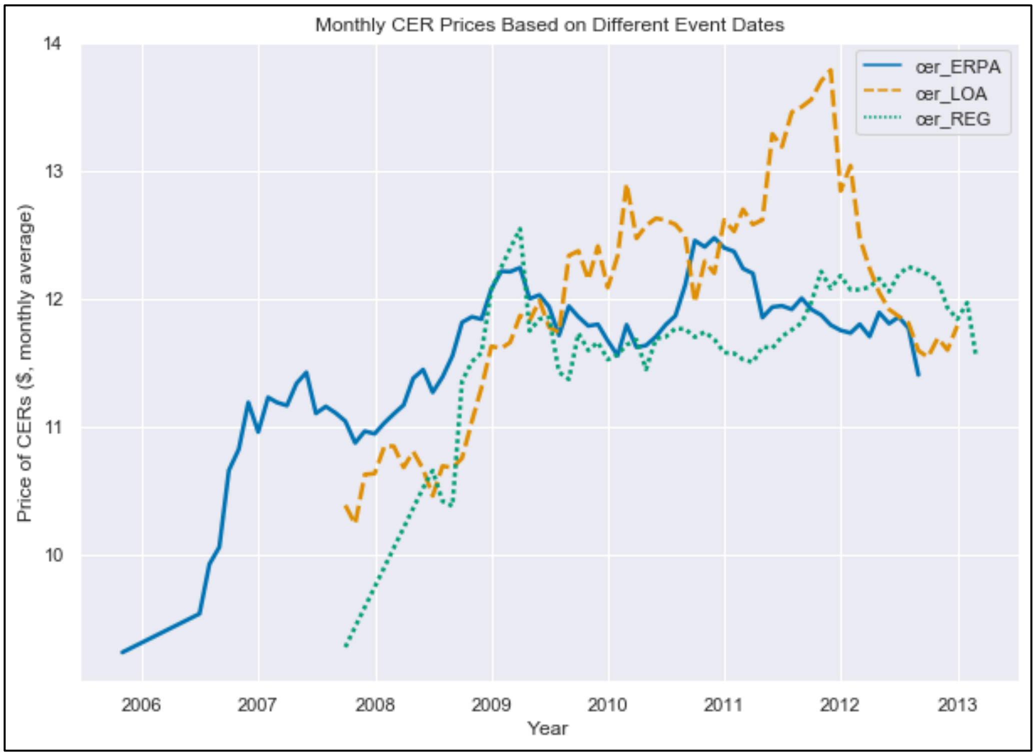
To check the accuracy of the ERPA dates extracted by Python, I adopted two methods to validate the data. First, I plot the monthly average CER prices over the period of April 2005 to February 2013 against the signed dates of ERPA, along with two other event dates (the date of getting the Letter of Approval, and the date that a project get registered) in **Figure 3-2.** I can see that the line of CER prices drawn against the ERPA dates is quite different from the other two lines based on the other two events: Letter of Approval date and project

---

[33] In our paper, I set the assumption is that all the CDM projects in the pipeline are fixed-price contract, since it is the most common contract structure based on UNDP. Based on this assumption, information on the contract date is required in order to control the time variation of the carbon prices.

[34] In our paper, I unify all the currency to U.S. dollars for the purpose of comparison

registration Date. I expect that the date of LOA will be close to the ERPA line, or might be delayed, compared to the ERPA dates, which is confirmed in the figure.



Data is from the CDM project pipelines, with ERPA dates collected by the author.
Note: The three lines are calculated based on a five-year moving average in order to smooth out dramatic price fluctuation. LOA: Letter of Approval. REG: Project Registration Date. Units: US dollar per ton.

Figure 3-2. Monthly CER prices based on different event dates. *The line of CER prices drawn from the ERPA is very different from the other two lines based on the other two events. Normally, the date of LOA will be close (but delayed relative) to the ERPA dates, which is confirmed in the figure. The low price at the early stage is due to the uncertainty of whether or not the Kyoto Protocol would come into force. Thus, it leads to limited demand for CERs with an understandably low price of the CERs (Kamel et al., 2007). The second fall of the CER prices is due to the 2008 economic crisis.*

Second, I compared the overall trend of the monthly average CER prices based on ERPA dates to the spot market price trend. We find that among the three lines, the line of ERPA date fits the spot market trend best in **Figure 3-3.**

Source: Norwegian Ministry of Finance, 2012

Figure 3-3. EU ETS Spot price ("EUA") and price of approved CDM allowances ("CERs") from 1 Januray 2009 to 3 September 2012*. Units: EUR per tonne.*

4.2. Methodology

4.2.1. CER prices

CER prices fluctuate widely and are not closely correlated with traditional macro-economic factors. Although the overall trend of CER prices follows the carbon markets, there are also certain factors that can make the CER prices off the market prices. The determinants of the CER prices can be divided into two major groups: macro- and micro-level determinants (Kamel et al., 2007). The macro-level determinants of CER prices are the carbon markets (including supply and demand), the implementation structure of the global treaties, the expectation of the future market and the whole sector, etc. The micro-level determinants of CER prices are mainly a function of concentrated on the buying and selling parties, and also the project characteristics, such as project duration, investment cost, location, type, etc.

The purpose of this paper is to study the effect of co-benefits (represented by achieving the Gold Standard certification) on the prices of CERs. The first step requires determining the project and extra-project independent variables likely to explain the intrinsic value of the CER as exhaustively as possible while ensuring the robustness of the specifications. I have presented the key factors affecting CER prices along with the supporting literature in Error! Reference source not found.. Variables also cover the two levels of CER price determinants. Buyers, sellers, and project's characteristics, such as duration of the crediting period, project types, project size, project investment, etc. are adopted into the model as the micro-level determinants. In order to count towards the current and future expectations of the market and international reduction commitment, I include the expected CER volum2020 and 2030, plus the crediting period.[35] Additionally, I also use the signed date of ERPA to control for the market spot prices (macro-level) and also variation among buyers and sellers (micro-level).

---

[35] A CDM project can have either a seven-year crediting period, which can be renewed twice to make a total of twenty-one years, or a one-off 10-year period.

Table 3-3. List of key factors affecting CER prices.

Factors	Level	Explanation	Literature	Indicator
Short-term expectation (Volume)	Micro	Phase one and phase two prices	(Meyrick, 2007)	1st period ktCO$_2$e/yr
Credit period	Macro and Micro	Long-term supply; CDM project can have either a seven-year crediting period, which can be renewed twice to make a total of twenty-one years, or a one-off ten-year period	(Nordseth, et al., 2007)	Years of projects
Mid-term expectation (Volume)	Macro and Micro	the likelihood that the project will generate and deliver CERs	(Wilder and Willis, 2007)	Expected accumulated 2020 ktCO$_2$e
Long-term expectation (Volume), and project size	Macro and Micro	The likelihood that the project will generate and deliver CERs	(Bishop, 2007; Wilder and Willis, 2007)	Expected accumulated 2030 ktCO$_2$e
Financing	Micro	production cost	(Gao and Li Liyan, 2007)	Project investment
Seller	Macro	Carbon-related country risks; host country approval risk	(Ascui and Moura Costa, 2007; Bishop, 2007)	Project location
Project type	Micro	The nature of the project; Specific project influences; e.g., limited use of large-scale hydro and exclusion of CERs from forest projects by EU-ETS	(Bishop, 2007; Wilder and Willis, 2007)	Project type
Buyer	Macro	Buyers' level of sophistication, and the extent to which they provide an underlying debt or equity investment.	(Palmisano, 2007; Wilder and Willis, 2007)	Project buyer
Legal contract	Macro and Micro	Contracts for CERs are highly heterogenous.[36]	(Bishop, 2007)	Emission Reduction Purchase Agreement (ERPA)

Note: *Total investment cost

---

[36] Because of the heterogenous of the contract, therefore CER were traded in a wider price range. It is important to include the ERPA data in our model to control for the variability.

4.2.2. Matching

The next step is to find a suitable technique to calculate the price premium effect of obtaining the Gold Standard. Thus, a combined technique of exact matching, propensity score matching, and regression adjustment is applied.

As the literature suggests that combining exact matching on key covariates, such as project types or locations, with propensity score matching is often desirable and possible. Especially when these covariates are categorical variables. Including them into the propensity score might not lead to the expected result of reducing bias. While, the combination of exact matching and propensity score matching can lead to a large reduction in bias (Glazerman et al., 2003) and can result in a design analogous to blocking in a randomized experiment (Stuart and Rubin, 2008). A detailed balancing test is presented in **Appendix A Table 3-12**. After finding good matches for the treatment group, the regression is used to adjust for any small residual biases and to increase efficiency (Stuart and Rubin, 2008). In conclusion, the matching method allows me to reduce large covariate bias between the treated and control groups, then it can be followed by conducting a regression to improve the model accuracy (Glazerman et al., 2003).

In my study, treatment is if a project receives a Gold Standard certification.[37] The control group includes all the regular CDM projects. The rationale behind matching is to identify (based on the available covariates) a control group of projects with similar characteristics to a treated group of projects for comparison. Thus, the selection of covariates should be

---

[37] Since the Gold Standard CDM market and regular CDM market is nonrandomized, so direct comparison between these two markets is meaningless and the results will be misleading. In order to compare these two markets, I need to introduce the technique of propensity scores, with the combination of exact matching.

those variables that thought to be related to the outcome (CER prices), but not the treatment (Garrido et al., 2014). With respect to the covariates, a list of variables selected as covariates for matching is displayed in **Table 3-4**.

Table 3-4. List of covariates.

Variable	Unit	Source	Variable type
1st period $ktCO_2e/yr$	$ktCO_2e/yr$; average over 7/10 years or 20/30 years	CDM/JI Pipeline	continuous
Years of projects	Years	CDM/JI Pipeline	continuous
Expected accumulated 2020 $ktCO_2e$	$ktCO_2e/$	CDM/JI Pipeline	continuous
Expected accumulated 2030 $ktCO_2e$	$ktCO_2e/$	CDM/JI Pipeline	continuous
Project investment*	million USD	CDM/JI Pipeline/ PDDs	continuous
Project region	continent level	CDM/JI Pipeline	categorical
Project type	type level	CDM/JI Pipeline	categorical
Project buyer	company level	CDM/JI Pipeline	categorical
Emission Reduction Purchase Agreement (ERPA)	year level	PDDs and validation reports	categorical

*Total investment cost

Table 3-5 shows that treated and control groups are very different before matching on the CER prices, and a number of covariates, e.g., regions, types, project sizes, years, and even the contract dates of the emission reductions purchase. The differences between the two groups indicate that I cannot compare them directly to get the treatment effect. I need to construct a control group that is similar to the treated group based on the preintervention variables.

Table 3-5. Gold Standard and regular CDM summary by treatment.

	Gold Standard CDM (Treated)					Regular CDM (Control)				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
CER price	64	13.26	6.45	5	38.76	2,195	11.66	2.62	1.31	42.02
Years of projects	64	8.22	1.49	7	10	2,195	7.46	1.18	5	30
1st period ktCO$_2$e/yr	64	79.48	111.48	6.9	736.6	2,195	133.73	210.64	2	3016.7
Expected accumulated 2020 ktCO$_2$e	64	735.58	938.76	60	5612	2,195	1227.70	1995.38	18	30167
Expected accumulated 2030 ktCO$_2$e	64	1267.45	2038.33	98	12983	2,195	2342.52	3582.53	38	54489
Project investment	63	70.85	282.36	1.4	2191	2,188	56.27	84.70	0	1550.5
Methodology	64	0.63	0.49	0	1	2,195	0.25	0.43	0	1
ERPA	64	2008	2.04	2002	2013	2,195	2009	1.71	2003	2012

My strategy is to perform a propensity score matching at the level of five continuous variables. beyond that, I also conduct the exact matching using two scenarios. Scenario 1 performs exact matching at the buyers' country level, and Scenario 2 conducts exact matching at both buyers' country and project location level. After finding good matches for the treatment group, the model will be adjusted by running a regression to control for the fixed effect from contract year, project type, project location, and buyers' location.

Python and Stata are used jointly for data analysis. **Figure 3-4** shows that there is overlap in the range of propensity scores across the treatment and comparison group, which we called the "common support"[38] (Caliendo and Kopeinig, 2008; Garrido et al., 2014). Additionally, diagnostic tests for balancing of covariates are shown in **Figure 3-5.** We can see that matching did a quite good job at balancing the covariates across the treatment and control group, with all (except one) p-values from both the KS-test and the grouped permutation of the Chi-Square distance after matching to be > 0.05.

---

[38] Assessing the common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group.

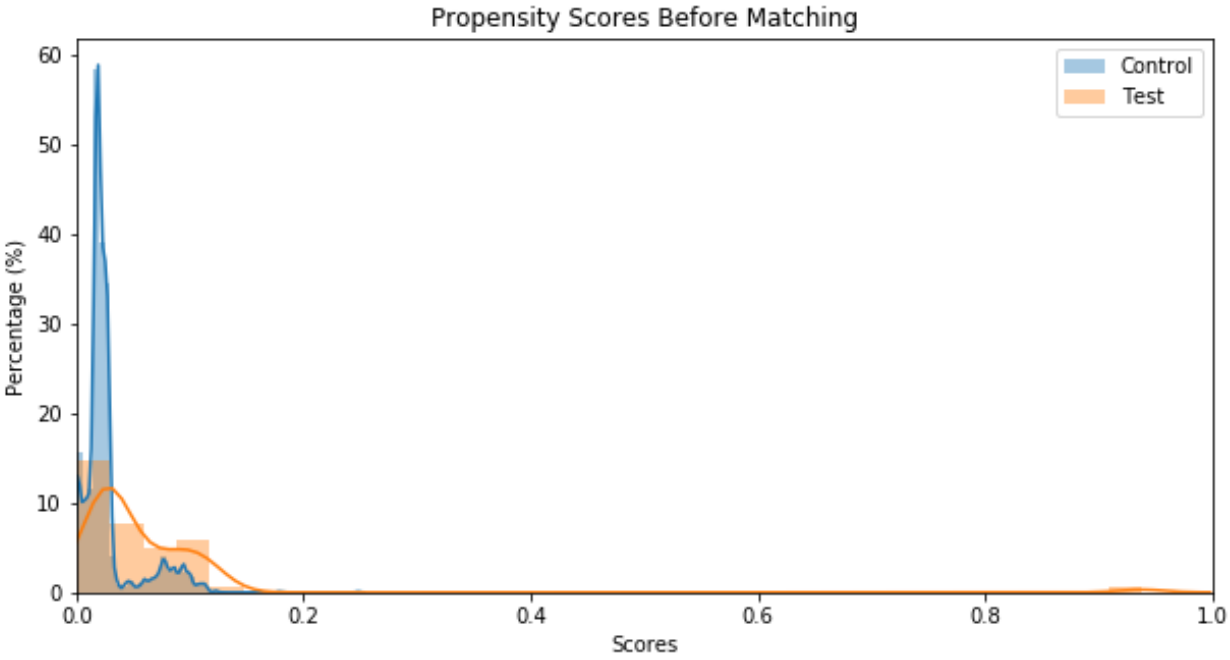
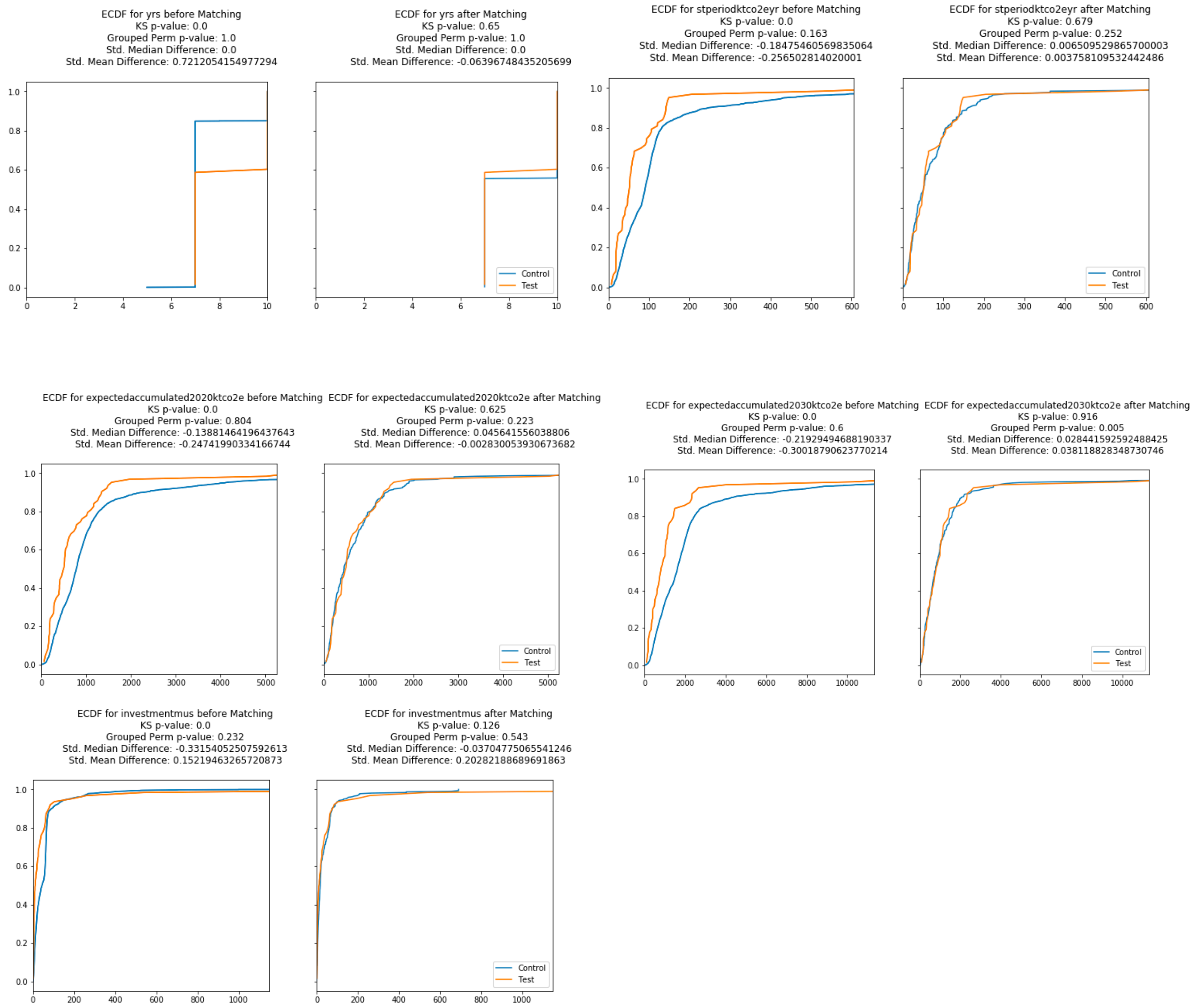


Figure 3-4. Distribution of propensity score across treatment and comparison groups. *This figure shows the "common support" area between the treatment and comparison groups.*



ECDF for yrs before Matching
KS p-value: 0.0
Grouped Perm p-value: 1.0
Std. Median Difference: 0.0
Std. Mean Difference: 0.7212054154977294

ECDF for yrs after Matching
KS p-value: 0.65
Grouped Perm p-value: 1.0
Std. Median Difference: 0.0
Std. Mean Difference: -0.06396748435205699

ECDF for stperiodktco2eyr before Matching
KS p-value: 0.0
Grouped Perm p-value: 0.163
Std. Median Difference: -0.18475460569835064
Std. Mean Difference: -0.256502814020001

ECDF for stperiodktco2eyr after Matching
KS p-value: 0.679
Grouped Perm p-value: 0.252
Std. Median Difference: 0.006509529865700003
Std. Mean Difference: 0.003758109532442486

ECDF for expectedaccumulated2020ktco2e before Matching
KS p-value: 0.0
Grouped Perm p-value: 0.804
Std. Median Difference: -0.13881464196437643
Std. Mean Difference: -0.24741990334166744

ECDF for expectedaccumulated2020ktco2e after Matching
KS p-value: 0.625
Grouped Perm p-value: 0.223
Std. Median Difference: 0.045641556038806
Std. Mean Difference: -0.002830053930673682

ECDF for expectedaccumulated2030ktco2e before Matching
KS p-value: 0.0
Grouped Perm p-value: 0.6
Std. Median Difference: -0.21929494688190337
Std. Mean Difference: -0.30018790623770214

ECDF for expectedaccumulated2030ktco2e after Matching
KS p-value: 0.916
Grouped Perm p-value: 0.005
Std. Median Difference: 0.028441592592488425
Std. Mean Difference: 0.038118828348730746

ECDF for investmentmus before Matching
KS p-value: 0.0
Grouped Perm p-value: 0.232
Std. Median Difference: -0.33154052507592613
Std. Mean Difference: 0.15219463265720873

ECDF for investmentmus after Matching
KS p-value: 0.126
Grouped Perm p-value: 0.543
Std. Median Difference: -0.03704775065541246
Std. Mean Difference: 0.20282188689691863

*distribution function (ECDF) for test vs ECDF for control **before** matching (left), ECDF for test vs ECDF for control **after** matching.*

5. Results

5.1. Main Results: The Effect of Gold Standard on CDM Projects

My main model is expressed in the following regression equation:

$$Y_{it} = \beta_0 + \beta_1(Treat_{it}) + \beta_2 X_{it} + \gamma_i + \delta_i + \varphi_i + \omega_t + \varepsilon_{it}$$

Where, i indicates projects, and t indicates years. In all models, the dependent variable Y_{it} is the CERs price for each project. The variable of interest is $Treat_{it}$, with its coefficient β_1 indicates the effect of Gold Standard on CDM projects. I also control for a group of continuous covariates listed in **Table 3-4**, project location fixed effects (γ_i),[39] credit buyer fixed effects (δ_i), project type fixed effects (φ_i), and year fixed effects (ω_t). Finally, the error term captures unobserved factors affecting our dependent variable that changes over the year.

I conducted the analysis by performing five models, and the final results with absolute terms are presented in ***Table 3-6****. I also present CER price premium in relative (as a % of CER price) terms in*

Table 3-7. Model 1 conducted OLS regression using the nine covariates that used to estimate the propensity to receive the treatment. That is, model 1 displays the difference in being Gold Standard CDM projects and regular CDM projects by controlling for the nine covariates. Model 2 through model 5, show results of estimates by using different matching techniques. Model 2 and model 3 only used propensity score matching, while model 4 and model 5 used the combined exact matching and propensity score matching technique. The

---

[39] Due to the variation of project location and variation of treatment is highly collinear, I do not include project location fixed effects in model 2, 3, and 4.

difference between model 2 and model 3 is the number of covariates used to obtain the results. In model 2, I perform the propensity score technique for all nine covariates, including both continuous and categorical covariates. In model 3, I only conduct the propensity score with the five continuous covariates. The models of interest are model 4 and model 5. In model 4, I perform the exact matching at the credit buyers' country level, in order to obtain the impact of Gold Standard on projects within the same buyers. In model 5, I restricted our model further to conduct exact matching on both credit buyers' country level and also the projects' location level.[40] Model 5 is the most restricted model among these five models. I lost some observations due to model restriction in model 5, and I only obtained 21 projects in the treatment group.

Across the five models, coefficients of treatment effect are all statistically significant at a 90% confidence level. Except the result of model 2, the difference between the CER prices of Gold Standard and regular CDM shows consistent, with model 4 and model 5 yield more conservative estimates, which are expected. Model 1 indicates that statistically controlling for differences in projects' features and sellers' background, Gold Standard projects received a price premium of $1.9/tCO_2e$ (10.3% of CER price increase due to the Gold Standard Certification). Results of model 2 and 3 indicate that when matched on their propensity to receive Gold Standard, projects with Gold Standard displayed a higher price premium. Compared to matched projects that don't have the Gold Stand certification, the price premium is from $4.21/tCO_2e$ (29%) to $2.58/tCO_2e$ (14%). However, due to the

---

[40] I intended not to perform exact matching on buyers' company level due to our small sample of the treatment group. But I clustered our standard error at the company level.

poorly matched results from model 2,[41] estimates from model 2 might overestimate the impact of Gold Standard. Model 4 displays an estimate of the effect of Gold Standard for CDM projects that, within each credit buyer's country, were predicted to have statistically similar propensities of obtaining Gold Standard certification. The price premium from model 4 is \$2.33/tCO_2e (11.2% of CER price increase due to the Gold Standard Certification), which is very close to the results from model 3. Model 5 presents an estimate of the price premium of Gold Standard for CDM projects that, within a narrower range, where each credit buyers' country and project location (country level) should be exactly matched, were predicted to have statistically similar propensities of obtaining Gold Standard certification. The price premium from model 5 is \$1.13/tCO_2e (6.6%), which is also expected. In Model 5, due to our limited number of projects in the treatment group, eventually, I only have two locations of projects left in my model: China and Vietnam.

---

[41] The diagnostic tests for balancing of covariates are very poor in model 2. I can provide detailed information in Appendix.

Table 3-6. Treatment effect of Gold Standard on CDM projects.

Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Full regression	Propensity score matching with all 9 covariates	Propensity score matching at 5 continuous covariates	Exact matching on the credit buyers	Exact matching on the credit buyers and project location
TREAT	1.909**	4.210***	2.581***	2.338*	1.130*
	(0.858)	(1.124)	(0.939)	(1.180)	(0.616)
Year fixed effects (FE)	yes	yes	yes	yes	yes
Type FE	yes	yes	yes	yes	yes
Credit buyer FE	yes	yes	yes	yes	yes
Project location FE	yes	no	no	no	yes
Special cases					
Wind	1.130***	3.426	0.893	2.136**	2.514**
	(0.425)	(2.135)	(1.069)	-0.833	(1.148)
Methane avoidance	-2.715***	-4.546	-1.839*	0.915	0.119
	(0.900)	(6.943)	(1.012)	-1.464	(1.678)
Vietnam	4.417*				13.11***
	(2.360)				(2.436)
F Joint test	6.0***	15.1***	2.9**	5.09***	2.05*
No. of Observation	2251	378	378	294	126
TREAT	64	63	63	49	21
UNTREAT	2187	315	315	245	105
R Square	0.3406	0.9521	0.3404	0.2062	0.8327

Note: The dependent variable in all five models is CER price. Coefficient estimates are reported in this table, with standard errors in parentheses. Standard errors are clustered at credit buyers' company level. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model.

* p<0.10 ** p<0.05 *** p<0.01

Table 3-7. Treatment effect of Gold Standard on CDM projects (LOG)

Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Full regression	Propensity score matching with all 9 covariates	Propensity score matching at 5 continuous covariates	Exact matching on the credit buyers	Exact matching on the credit buyers and project location
TREAT	0.1026***	0.2900***	0.1424***	0.1175*	0.0654*
	(0.0288)	(0.0708)	(0.0553)	(0.0680)	(0.0407)
Year fixed effects (FE)	yes	yes	yes	yes	yes
Type FE	yes	yes	yes	yes	yes
Credit buyer FE	yes	yes	yes	yes	yes
Project location FE	yes	no	no	no	yes
F joint test	4.14***	16.55***	2.9**	5.21***	3.81**
No. of Observation	2251	378	378	294	126
TREAT	64	63	63	49	21
UNTREAT	2187	315	315	245	105
R Square	0.3406	0.9521	0.3404	0.2062	0.8327

Note: The dependent variable in all five models is Log (CER price). Coefficient estimates are reported in this table, with standard errors in parentheses. Standard errors are clustered at credit buyers' company level. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model.

* p<0.10 ** p<0.05 *** p<0.01

5.2. Robustness Check and Supplementary Analysis

First, I replaced the credit buyer's country information with the indicators representing the health of a country's economy, such as GDP per capita, employment rate, government expenditure, and inflation rate. I get very similar results (results are presented in **Table 3-8**) across all five models compared to the results in **Table 3-6**. All coefficient estimates of Gold Standard treatment are statistically significant. This indicates that my models are quite robust.

Table 3-8. Robustness check: treatment effect of Gold Standard on CDM projects.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Models	Full regression	Propensity score matching with all 9 covariates	Propensity score matching at 5 continuous covariates	Exact matching on the credit buyers	Exact matching on the credit buyers and project location
TREAT	2.006**	3.697***	2.713***	2.338*	1.130*
	(0.847)	(1.078)	(0.964)	(1.180)	(0.616)
Year FE	yes	yes	yes	yes	yes
Type FE	yes	yes	yes	yes	yes
Credit buyer FE	no	no	no	no	no
Project location FE	yes	no	no	no	yes
No. of Observation	2251	378	378	294	126
TREAT	64	63	63	49	21
UNTREAT	2187	315	315	245	105
R Square	0.3307	0.9160	0.2996	0.2062	0.8327

Note: The dependent variable in all five models is CER price. Coefficient estimates are reported in this table, with standard errors in parentheses. Standard errors are clustered at credit buyers' company level. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model.
* $p<0.10$ ** $p<0.05$ *** $p<0.01$

Second, I conducted a "placebo" test by randomly selecting 50 percent of the data from our control group and artificially assigning them into the treatment group. By doing that, I created a "fake" treatment group, that is, a group that I know was not affected by the Gold Standard. I estimated the models by using the "fake" treatment, and the results are presented in **Table 3-9.** All the coefficients of treatment effect are not statistically significant. Since I do not find that there is a difference in the absence of the real treatment, Gold Standard certificates, I successfully reject this falsification. This result increases the credibility of our research design.

Table 3-9. Placebo test: treatment effect of Gold Standard on CDM projects.

Models	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Full regression	Propensity score matching with all 9 covariates	Propensity score matching at 5 continuous covariates, combined regression	Exact matching on the credit buyers	Exact matching on the credit buyers and project location
TREAT	0.109	0.0259	-0.0526	-0.0274	-0.0375
	(0.0931)	(0.0982)	(0.120)	(-0.143)	(0.144)
Year FE	yes	yes	yes	yes	yes
Type FE	yes	yes	yes	yes	yes
Credit buyer FE	yes	yes	yes	yes	yes
Project location FE	yes	no	no	no	yes
No. of Observation	2195	378	378	294	126
TREAT	1098	63	63	49	21
UNTREAT	1097	315	315	245	105
R-squared	0.3097	0.3075	0.1863	0.4714	0.4182

Note: The dependent variable in all five models is CER price. Coefficient estimates are reported in this table, with standard errors in parentheses. Standard errors are clustered at credit buyers' company level. I control for project location fixed effects, credit buyer fixed effects, project type fixed effects, and year fixed effects in the model
Standard errors in parentheses
* $p<0.10$ ** $p<0.05$ *** $p<0.01$

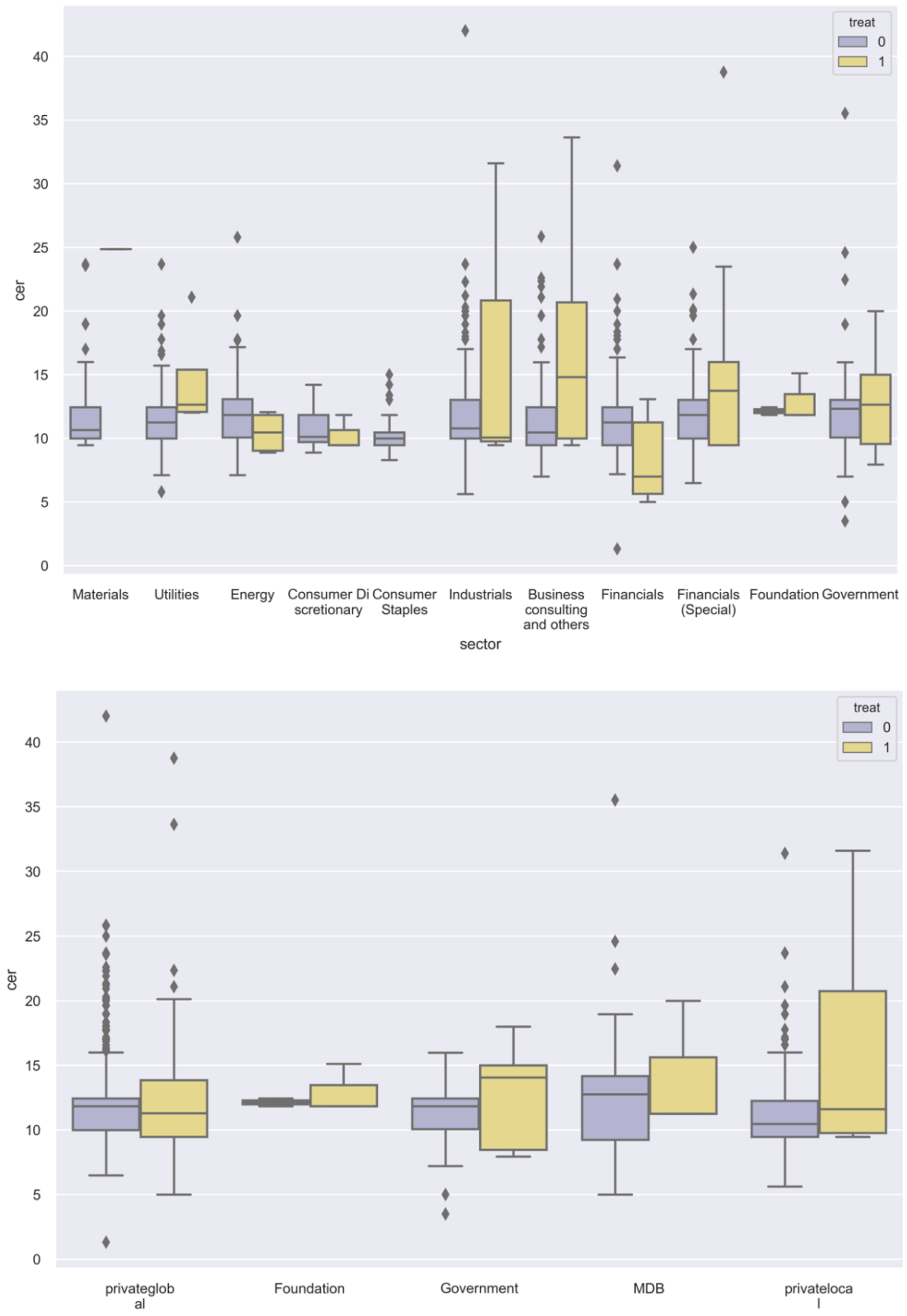
5.3. Sectoral Analysis

CER prices are reported at the buyers' company level in the ERPA. It will be useful to study further the question of what explains the price of CER prices from the buyers' perspective. In this section, I will focus on explaining whether CER prices differ systematically based on the credit buyers' industry, or their profit status, for example, whether the reporting entity is considered a for-profit or not-for-profit enterprise.

In order to do so, I further divide credit buyers into different categories by using different classification systems. First, credit buyers (company level) were classified by their primary business activities using the Bloomberg Industry Classification Systems (BICS). I obtained 11 industries,[42] and the CER prices they paid are plotted in **Figure 3-6 (a)**. Second, credit buyers are also categorized into five categories of profit status, including local private companies, global private companies, government entities, Multilateral Development Banks (MDBs), and foundations. **Figure 3-6** shows that there is variation among buyers' preference towards paying a price premium for the Gold Standard CDM. To explore the variation, I adopt the hedonic price method. The model behind this analysis is the hedonic price method (Conte and Kotchen, 2010; Freeman et al., 2014), where CER prices can be explained as a function of credit buyer and project characteristics. Because I am interested in the general characteristics of credit buyers after I run our preliminary model, and because the prices for carbon credits are provided at the credit buyer level, it makes sense to use a hedonic function to study whether the location and profit status of these credit buyers (private, government, MDB) or industries of these buyers will consistently present a different attitude towards the impact of the Gold Standard certification on the CER prices. In applying the hedonic function analysis, I estimate linear and log-linear specifications using ordinary least squares (OLS).

---

[42] We later aggregate these 11 industries into 7 industries based on some of their similarity.



(a)

(b)

Figure 3-6. Box plot for CER prices based on credit buyers across treatment and control group*. The left figure(a) is the CER price plot among different industries of these companies. Figure (b) is the CER plot by more broad classification as their status as for-profit or not-for-profit.*

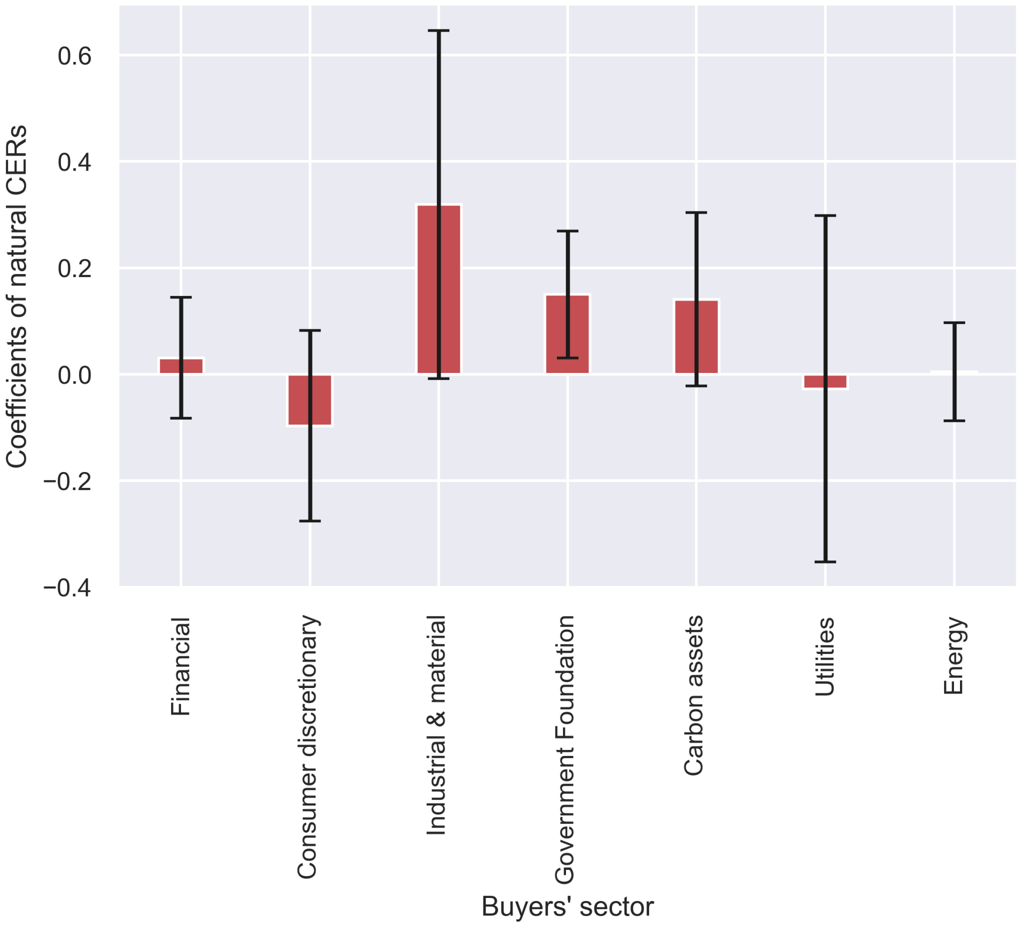
Model 1 and model 2 in **Table 3-10** are conducted to analyze the different preferences over Gold Standard-certified CDM projects and regular CDM projects, based on buyers' industry. Estimates from **Table 3-10** show that the results of the analysis comparing the Gold Standard CDM projects and regular CDM projects are statistically significant in the following industries: industrial and material, carbon-related (including carbon assets management, carbon consulting management, etc.), and government and foundation. If these buyers operate in the industrial and material sector, the results indicate that the price premium of Gold Standard CDM projects paid by credit buyers is \$6.5/tCO_2e or 32 percent more, compared to those regular CDM projects. If business activities of credit buyers are primarily focused on carbon-related asset management, the price premium paid was \$2.9/tCO_2e or 14 percent more if the projects obtained Gold Standard certification. Buyers from government entities and foundations are willing to pay \$1.6/tCO_2e or 15 percent more if the projects are certified by the Gold Standard. The rest of the coefficient estimates of interest are not statistically significant. I find no price difference between Gold Standard certified projects and regular CDM projects in other industries, such as utilities, energy, financial (except for carbon asset management), and consumer discretion. To our standpoint of view, it can be explained that Gold Standard was initiated by the WWF in 2003. During the time of the CDM, it is still quite a new idea in the market. Only experts in the carbon market, such as companies dealing with carbon asset directly are fully aware of the add-on value that the Gold Standard provides to the projects at that time.

Table 3-10. Company-level regression results A.

Sectoral Analysis		
	Model 1 (linear)	Model 2 (log-linear)
TREAT	0.0262	0.0045
	-0.588	(0.047)
TREAT & Financials	0.549	0.0310
	(0.721)	(0.058)
TREAT & Consumer discretionary	-1.080	-0.0967
	(1.024)	(0.0912)
TREAT & Industrial & material	6.496**	0.319*
	(3.261)	(0.167)
TREAT & Government Foundation	1.578**	0.150**
	(0.798)	(0.061)
TREAT & Carbon related	2.916**	0.141*
	(1.477)	(0.083)
TREAT & Utilities	-0.643	-0.0273
	(2.329)	(0.166)
TREAT & Energy	0.0262	0.0045
	-0.588	(0.047)
No. of Observation	2251	2251

Note: The dependent variable in model 1 is CER price and in model 2 is natural log of CER price. Coefficient estimates are reported in this table, with Standard errors in parentheses. Standard errors are clustered at credit buyers' company level.

* p<0.10 ** p<0.05 *** p<0.01



Note: Error bars indicate 95-percent confidence interval.

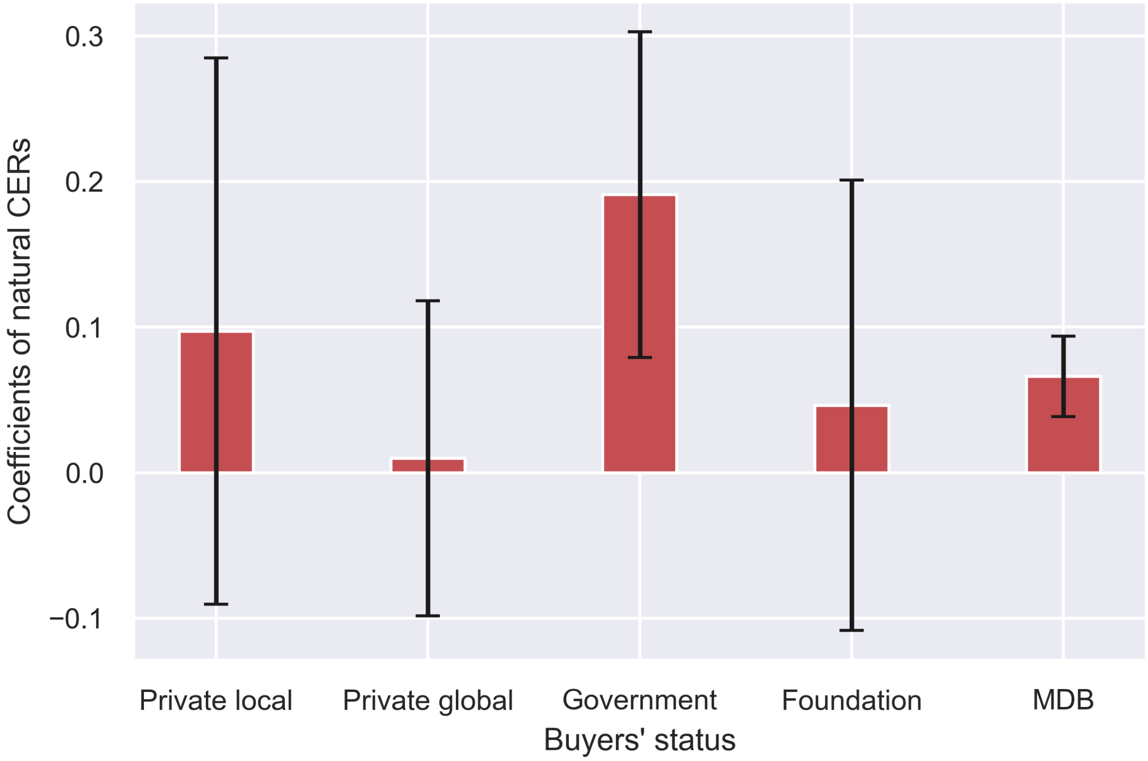
Figure 3-7. Coefficients of interaction between buyer's sector and treatment. *It shows that the treatment effects differ across buyer's sectors.*

Model 1 and model 2 in **Table 3-11** are performed to analyze the different preferences over Gold Standard-certified CDM projects and regular CDM projects based on broader buyers' status as for-profit and not-for-profit. The results from the for-profit entities have no statistical significance, while the results from non-for-profit (government and MDBs) entities continue to have statistical significance. The price premium for Gold Standard CDM projects is \$2.3/tCO$_2$e or 19 percent more from government entities and is \$0.6/tCO$_2$e or 7 percent more from MDB respectively. The rest of the coefficient estimates of interest are not statistically significant. I find no price difference for local for-profit and global for-profit companies in terms of purchasing Gold Standard CDM projects and regular CDM projects. The results deliver an important messages that non-for-profit organizations value co-benefits more, and they are pushing the assessment of the co-benefits in the local communities by purchasing the Gold Standard-certified CERs with a price premium. From the climate policy perspective, it is important to set a framework that can place a high strategic value on delivering local co-benefits to receiving communities through climate investment, where public funding can play an enabling role at the early stage. The results show that organizations supported by the public funding are willing to pay a price premium for projects with higher co-benefits. However, I do not see the same willingness from the private sectors. Thus, I might still face the challenge: How to mobilize for-profit entities to engage into the climate finance and optimize the value of climate investment and to achieve real and lasting sustainability.

Table 3-11. Company-level regression results B.

Sectoral Analysis: Buyer Profit Status		
	Model 1 (linear)	Model 2 (log-linear)
TREAT	0.625***	0.0661***
	(0.176)	(0.0141)
TREAT & Private Local	2.687	0.0972
	(1.809)	(0.0957)
TREAT & Private Global	0.909	0.00992
	(0.960)	(0.0552)
TREAT & Government	2.260**	0.191***
	(0.919)	(0.0571)
TREAT & Foundation	0.613	0.0462
	(1.140)	(0.0789)
TREAT & MDB	0.625***	0.0661***
(Omitted)	(0.176)	(0.0141)
No. of Observation	2251	2251

Note: The dependent variable in model 1 is CER price and is model 2 is natural log of CER price. Coefficient estimates are reported in this table, with Standard errors in parentheses. Standard errors are clustered at credit buyers' company level.
* p<0.10 ** p<0.05 *** p<0.01



Note: Error bars indicate 95-percent confidence interval.

Figure 3-8. Coefficients of interaction between buyer's profit status and treatment. *It shows that the treatment effects differ across buyer's Profit status.*

6. Discussion

I base my analysis on projects, buyers and sellers listed on a refined CDM pipeline database, to which I contribute by adding ERPA dates and also the buyers' sectoral information. It is the most comprehensive listing of buyers and sellers in the CDM and Gold Standard CDM market.

Among the robust findings of our analysis is that the Gold Standard has a significant effect on CER prices. The price premium is in the range of \$1.13/tCO$_2$e (6.6% increase in CER prices due to the Gold Standard certification) to \$4.2/tCO$_2$e (29%) based on the models I estimated from. I am comfortable to use the premium of \$2.23/tCO$_2$e (11.8%) because this is the most fitted model among the five models I used in this study. The price premium is quite sizable because the average CER price is \$11.7/tCO_2e of 2259 projects.

Another robust finding is that certain project types affect CER prices, such as wind and methane avoidance projects. I find that wind projects overall are significantly more expensive than the average price of all the project types. Methane avoidance projects are cheaper than the average price of all the project types. Because these two project types have a large influence on the treatment group (representing 31 percent and 20 percent of the treatment sample respectively), I can conclude that wind projects may be suitable to get Gold Standard certificates. By earning a Gold Standard certification for a wind project might generate a larger price premium than it would for some other type of project, such as a methane-capture project. It implies that the extra money makes it worth the extra effort that it takes the CDM project developer to earn Gold Standard Certification.

Somewhat surprising is that sectors, such as carbon-related asset management, are willing to pay more if a CDM project is Gold Standard certified. One possible explanation of carbon-related asset management paying more for Gold Standard projects is that they are the experts in the carbon market. They are fully aware of the add-on value that the Gold Standard provides to the projects. Thus, they are willing to pay a premium at nearly \$3/tCO_2e.

Despite my robust finding, I have to acknowledge some limitations of this analysis. First, I am only able to use a small example of Gold Standard CDM projects due to a lack of complete information for the rest of the Gold Standard CDM projects. Small sample size leads us to draw the conclusion in a limited way, even though the coefficient of the study of interests is quite sizeable. Second, data quality in the original CDM pipeline is poor, although I have manually improved it substantially. The consequences of the CDM pipeline being poor is that I have to drop half of the projects in the original dataset due to missing information. Although it will not affect my estimates of the impact of treatment in general, I can get a more accurate estimation if I can use the full dataset.

This study also points to some potential area for future research. First, it points to a potential value for additional research on the voluntary carbon market. It would be valuable to see the impact of the Gold Standard in the voluntary carbon market, where I expect the price premium will be higher. Because buyers from the voluntary markets are largely motivated to purchase offsets by their social responsibility and concerns about climate change to reduce their emission (Anja, 2007; Goldstein, 2016). The Gold Standard is widely used in the voluntary carbon market, where its market share is roughly 20 percent (Hamrick and Gallant, 2018). Second, it also shows the importance of deeper assessments of diverse buyer groups because they might drive premiums differently and show divergent levels of willingness to pay a premium price for high-quality CERs. Our findings indicate that the majority volume of CER credits were purchased by the for-profit private sectors (96 percent), and our analysis shows no statistical difference among this group in paying more for the Gold Standard projects at the aggregated level. However, if I further break this group into the more industries, I see two industrial categories, industrial & material and carbon-related management, that represent 31 percent of the total market share, are paying a price premium for the Gold Standard CERs. The result indicates that there is a large price variability in the CER prices paid by for-profit sectors within and between Gold Standards projects and regular CDM projects.

7. Conclusion

The area of local co-benefits analysis has been a topic of great interest, but most of the previous studies focused on evaluate co-benefits on projects per se, but not from the market segments perspective. The motivation for studying the CER market and the price premium earned by projects with higher co-benefits inspires us to look at the market segments for different buyers and examine this topic from a broader perspective.

The primary aim of this paper is to investigate whether there is a price premium delivered by the Gold Standard-certified CDM projects compared to the regular CDM projects. Using the combined technique of exacting matching and propensity score matching, I am able to separate the impact from the co-benefits feature of the Gold Standard. My results show that there exists a small, albeit statistically significant premium earned by the Gold Standard CERs compared to standard CERs. I estimate that this price premium to be between \$1.13/tCO$_2$e to \$2.58/tCO$_2$e. The finding presented in this paper suggests that the market in general recognizes the added value of the Gold Standard CDM certification.

The secondary aim of this paper is to explore factors that help explain the variation in the CER prices from the credit buyers' perspective. I use the buyer-level characteristics as explanatory variables in the hedonic price model, and I find that when I only look at the buyers' for-profit and not-for-profit status, MDBs and government are willing to pay an average price premium of \$0.63/tCO$_2$e and \$2.3/tCO$_2$e for Gold Standard CDM projects, By contrast, for-profit companies show no difference in willingness to pay for the Gold Standard CDM and the standard CERs produced by regular CDM projects. When I review the buyers' business activities, industrial & material and carbon-related management companies are paying an average price premium of \$6.5/tCO_2e and \$2.9/tCO_2e respectively.

In conclusion, I emphasize that Gold Standard-certified CDM projects are associated with guaranteed co-benefits in local communities, and there is a price premium from the buyers' side for these projects. I also emphasize that buyers' willingness to pay more for projects associated with co-benefits can drive the implementation of co-benefits into the local communities more effectively and efficiently.

The case study of Gold Standard demonstrates the value proposition of "branding", and I should recognize that the value proposition is substantiated by the underlying link between the Gold Standard brand and higher co-benefits in projects acquired by the buyers, the "value", of the Gold Standard are the benefits beyond emission reductions. Gold Standard estimated that the issued 669 projects have created nearly 5.5 billion dollars of value benefits beyond carbon (Gold Standard, 2019).

As I mentioned at the beginning of this paper, making the global financial flow to projects that reduce greenhouse gas emissions has a foundation tension. What I learned from the study is that financial flow can be jointly achieved with projects with better quality, such as those that deliver on higher co-benefits in local communities. Although these co-benefits are difficult to be monetized into every dollar sign, they are the real impact on the local communities. There is a potential to generate even more financial flow into the project level if the co-benefits can be captured and visualized by the design of the project and monetarized at the buyers' side.

Appendix A Balancing Test

I adopted the standardized differences (SD) technique, which is the standardized difference of means, to assess the differences between multiple variables of the treatment and control groups (Lunt, 2014). If there is no big difference between these two groups, I can conclude that there is adequate balance between these two groups of observations. Before matching (a), the treated and untreated groups are unbalanced. When I do propensity score matching at both categorical and continuous covariates level (b), I still didn't get balanced groups. However, in the last test (b), when I only conduct propensity score matching at the continuous covariates level, I get balanced groups.

Table 3-12. Covariate balancing check between the control group and the treatment group.

(a) Before matching

	Mean in treated (GS projects)	Mean in Untreated (Regular projects)	Standardized diff.
1st period $ktCO_2e/yr$	80.28	133.87	-0.317
Years of projects	8.24	7.45	0.608
Expected accumulated 2020 $ktCO_2e$	739.63	1228.90	-0.313
Expected accumulated 2030 $ktCO_2e$	1278.00	2345.72	-0.365
Project investment	70.85	56.27	0.070

(b) Matching at both categorical and continuous covariates

	Mean in treated	Mean in Untreated	Standardized diff.
1st period $ktCO_2e/yr$	80.28	64.13	0.194
Years of projects	8.24	8.57	-0.223
Expected accumulated 2020 $ktCO_2e$	739.63	546.63	0.274
Expected accumulated 2030 $ktCO_2e$	1278.00	961.94	0.206
Project investment	70.85	26.88	0.219

(c) Matching at continuous covariates

	Mean in treated	Mean in Untreated	Standardized diff.
1st period $ktCO_2e/yr$	80.28	79.88	0.004 **
Years of projects	8.24	8.33	-0.064 *
Expected accumulated 2020 $ktCO_2e$	739.63	742.55	-0.003 ***
Expected accumulated 2030 $ktCO_2e$	1278.00	1202.95	0.037 **
Project investment	70.85	42.38	0.136

Note: Standardized differences (SD) are the standardized difference of means. *** SD <0.001, **SD<0.05, and *SD<0.1

Chapter 4 Paper Three: How are Corporate Motivations for Voluntary Carbon Offset Investments reflected in how they value Project Co-benefits?

Abstract

Companies can prioritize sustainable investment finance flows to reflect their concerns about climate change and carbon emissions. One type of climate finance flows is that companies decide to invest relevant significant funds in voluntary carbon offset projects. Despite growing research into what and how these companies are doing in the voluntary carbon offset markets, much remains to be learned about why companies are investing in this market. There might be diverse motivations that drive companies to choose what they purchase and how they finance in carbon offsets. A mixed-method analysis based on a group of 186 companies with 534 carbon offset projects is conducted to explore the motivations that drive companies to invest in the offset projects, and how motivations map on to specific purchase behavior, such as project types, offset standards. I identified four corporate motivations for carbon offset investment and the criteria they use to evaluate offset investment. The growing prevalence of companies using carbon offset to realize carbon neutrality has been coupled with an increasing number of companies recognizing the importance of using offsets to contribute to the so-called "company values" and "market competitiveness." Our study reveals that companies of offset investment represents a unique class of companies that are willing to pay more for projects with higher co-benefits.

1. Introduction

We are in a world facing a suite of climate-related risks that are not new to the global community. The significant and growing risks cause numerous organizations, including government, investors, private companies, to think about their strategies to tackle climate change issues. Companies, as the major players in this battle, are looking at how they can respond to climate change and think about the ways they can invest in specific opportunities to offset their emissions.

Companies pursue these goals in many different ways. One of the strategies that haven been used over the past couple of decades is to offset their emissions via purchases of carbon credit certificates in the carbon markets.[43] In the carbon markets, a rising number of companies take action on supporting sustainable projects. Their efforts cover identifying suitable projects, applying sustainability insights, and eventually navigating the flow of climate finance. One of the signals of companies directing the climate finance flow as a result of concerns about climate change and their carbon emissions is that companies decided to invest significant funds in voluntary carbon offset projects.

This paper focuses on studying several issues at the convergence of corporate decision-making, co-benefits of climate finance projects, carbon offsets, and sustainability research. Moreover, I examine these critical issues through the lens of the voluntary carbon offset markets for insight into how they can help inspire and reform corporate practice on climate change for a sustainable low-carbon society. The voluntary carbon offsets markets offer an interesting lens for me to study corporate social responsibility and the reason why the selected companies value the sustainable benefits in their decision-making process. First, corporates are the primary buyers in the voluntary markets.[44] Secondly, the voluntary carbon markets landscape changes rapidly year by year, which reflects buyers' preference among different projects. Over the course of its 13 year history,[45] the cumulative volume

---

[43] Currently, there are two markets for carbon offsets to be exchanged on, the compliance and voluntary markets. The market settings are different for the two markets.

[44] Individual consumption of carbon offset is very limited compared to the corporate consumption. Individuals only made up 5 percent of the voluntary offset consumers while 80% were companies (Bergqvist and Lindgren, 2014).

[45] The first market available data for voluntary carbon markets can be traced back to 2006 when the Ecosystem Marketplace (EM) teaming up with New Carbon Finance launched the first-ever EM report through surveys and interviews in the voluntary carbon markets.

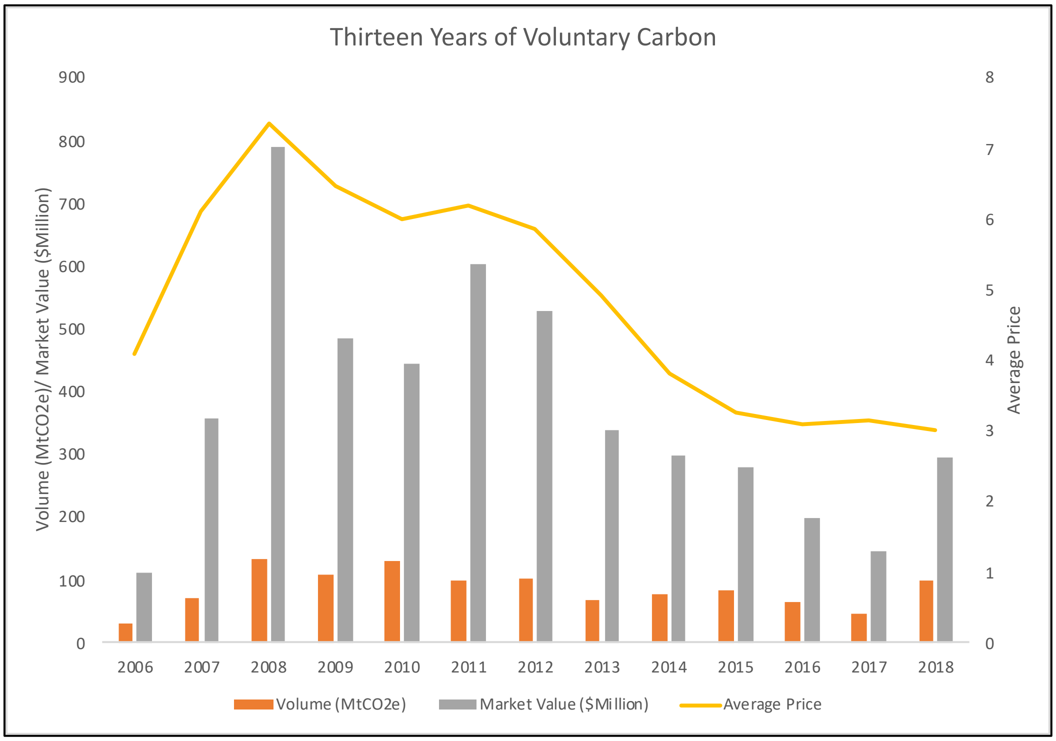
of pure[46] transacted voluntary carbon offsets has exceeded 1.2 billion metric tons ($GtCO_2e$) with a total market value of $5 billion as showed **Figure 4-1.**

The bulk of voluntary offset purchases by volume are made by private, for-profit companies and multi-national institutions. In 2017, available data shows that private sector purchased 88 percent of offsets by volume and 61 percent by count of transactions. A figure shows the share of different types of buyers is presented in **Figure B 4-1**. Especially the private companies, encouraged by the Paris Agreement, are more aware of the impacts of climate change on their business and increase their commitments to reduce emissions as their pressing activities than they were before. In 2017, the number of private companies purchasing carbon offsets to reduce their emissions voluntarily was 314, which presents 17 percent of the total companies that disclosed their information to the Carbon Disclosure Project (CDP).[47] This number reached 422 in 2018 (CDP).

---

[46] This number excludes these offsets used for the pre-compliance purpose. Pure transacted offsets are offsets that not used to fulfill the pre-compliance purpose.

[47] There were 314 corporates purchased carbon offsets voluntarily in 2017, while the total number of corporates reporting to the CDP is 1896.



Data source: Forest Trends' Ecosystem Marketplace, *State of the Voluntary Carbon Markets 2019*

Figure 4-1. Voluntary carbon markets between 2006-2018. *Year 2018 had the highest volume ever tracked (98.4 MtCO*$_2$*e). Although between 2008 and 2012, the transacted volumes were high, these included the volume that count towards "pre-compliance" or transacted under the Chicago Climate Exchange (CCX), which exited the market in 2012. Carbon prices were dropped from 2008 due to reasons such as the 2008 global economic recession, oversupply increased in 2014.*

In contrast to the compliance markets, buyers in the voluntary markets are largely motivated to purchase offsets by their social responsibility and concerns about climate change to reduce their emission (Anja, 2007; Goldstein, 2016). Thus, although companies are initially driven to reducing emissions in order to achieve their voluntary commitment, their motivations to offset investment evolve over time. During this process, companies face a wide variety of choices not only on price but also on technologies, locations, standards, and potential social impacts, when facing an offset purchase decision.

This research serves the purposes of (1) identifying motivation for corporates to purchase offsets; (2) examining what is essential for corporates when evaluating which offset projects to invest in/support/purchase; (3) recognizing the role of co-benefits in the corporate decision-making process; and (4) gaining a better understanding of how non-market characteristics like social value are being demanded by these investors.

Methodologically, this paper used a mixed-method research design, evaluating 534 offset projects purchased by 186 companies globally during 2017. Companies have different motivations for investing in voluntary carbon offsets. These motivations translate directly to their choice of purchase. Through the analysis, I intend to answer the research question: how do diverse corporate motivations to invest in offset projects affect their choices with respect to co-benefits for local communities?

To answer the questions, I will take the following three steps. First, I need to understand the motivations that drive companies to invest in offset projects. Second, I should have these motivations map on to the specific choices of projects and offset standards. Different project types and offset standards can generate different levels of co-benefits in the local communities, and they are also transacted on the market with different prices. Thus, it allows me to elucidate the research question further. Third, I should examine whether specific motivation has an impact on corporate preference on bringing co-benefits to local communities.

In 2018, the global market capitalization of listed domestic companies was about $68 trillion,[48] the $3 trillion asset value of 186 corporates represented about 4 percent of the market capitalization. This paper believes that channeling available finance to offset

---

[48] World Bank Data, Market capitalization of listed domestic companies (current USD).

projects that benefit local communities is a must. I need new courses of action that deliver on the ground.

The remainder of this paper is organized as follows: Section 2 provides a review of the literature on the previous studies on motivations of offset investment. Section 3 describes the mythological approaches and data used for this paper. Section 4 presents the Analysis of the mixed-method analysis. Discussion and conclusions are summarized in sections 5 and 6 respectively.

2. Voluntary Carbon Markets and Corporate Motivations

This essay is tackling the question of how corporate motivations map on their decision to support voluntary carbon offset projects. To better understanding the question, I have to go all the way back and answer why companies engage in voluntary initiatives for their environmental performance in the first place, including setting voluntary emission reductions targets, committing to carbon neutrality, or creating eco-labelling projects, etc.

Companies use voluntary initiatives to address environmental performance. Voluntary programs by definition are initiatives that are not driven by regulatory compliance. They are voluntary because they do not need to be ordered by the government in order to be undertaken (Gibson, 1999). Voluntary initiatives originate from the limits of regulation and the search for alternative political means to improve corporate environmental performance (Gibson, 1999; Weizsäcker et al., 2005). Current environmental regulation works reasonably well to control harmful behavior, but it is a blunt and imperfect tool when used to inspire and motivate creative responses that lead to greener products and processes

(Strasser, 2008). Thus, voluntary initiatives are believed to push innovation and fund creative solution ahead of regulations (Bayon et al., 2009; Gibson, 1999).

Voluntary program can be grouped in to three big categories: government-sponsored, international voluntary standards, and corporate efforts undertaken by individual companies committing themselves to a specific environmental performance target (Strasser, 2008). Thus, voluntary carbon offsetting can be one of the initiatives to improve corporate performance. It touch upon on many dimensions of voluntary initiatives, such as CSR, eco-labelling, green products, zero emissions, etc.(Lozano, 2012).

Currently, there are two kinds of markets for carbon offsets, compliance markets and voluntary markets. The market settings are different for the two kinds of markets. In compliance (mandatory) markets, buyers are primarily motivated to purchase offsets that can provide a more cost-effective mechanism to fulfill their lawful requirement, such as in a cap-and-trade regime. In a compliance market, assessments of co-benefits are primary focused on the outcome of the Clean Development Mechanisms (CDM) by using a common methodology called multiple-dimension-multiple-indicator to evaluate co-benefits of carbon offset projects. The most convenient and generally adopted rule of dimension/criteria is based on a social-economic-environmental framework comparison (Disch, 2010; Hultman et al., 2019; Olsen and Fenhann, 2008; Spalding-Fecher et al., 2012; Subbarao and Lloyd, 2011a; Sutter, 2003; Sutter and Parreño, 2007; UNFCCC, 2012; Watson and Fankhauser, 2009). Most of the studies agreed that the CDM has not consistently delivered significant co-benefits to local communities. As a result, the current compliance markets still represent a small share of the in terms of combating climate change. The need for increased action should be taken by more institutions and individuals. That’s where voluntarily carbon markets enter onto the stage.

Compared to the regulatory compliance, voluntary carbon markets provide a channel of participating in the fight against climate change in a way that the compliance market does not (Bayon et al., 2009). Because some companies or individuals are unable to access the compliance carbon markets. Second, voluntary carbon markets can be a critical tool for education the public about climate change. Third, the voluntary carbon markets do not have coercive enforcement, which make it a better indicator to understand the corporate motivation. As a result, voluntary carbon markets actually reflect a signal of corporate preference to financing for specific types of projects and support specific co-benefits, because companies are facing a more complex situation compared to just avoid producing carbon.

In voluntary carbon markets, buyers (for example, companies) are largely motived by their social responsibility and concerns about climate change to reduce their emission (Anja, 2007; Goldstein, 2016). However, there is limited literature addressing corporate motivations for investing in offset projects voluntarily or how companies prioritize local co-benefits in their decisions to invest in carbon offsets.

Motivations for offsetting are profiled for collective decisions from companies and individual decisions from regular consumers, mainly in the sector of passenger transportation, such as airlines.

With the potential growth in international aviation in the coming years, studies on co-benefits and customers' willingness to pay for these offset carbon credits become urgent (Araghi et al., 2016; Blasch, 2013; Hinnen et al., 2017; Jou and Chen, 2015; MacKerron et al., 2009). Studies of offset purchases in the aviation sector shows that there may be substantial consumer WTP in the aviation sector through revealed and stated choice (Choi and Ritchie, 2014; MacKerron et al., 2009; Roberts et al., 2018). Some airline passengers are even willing to pay substantially more for certified offsets, which manifests the value of certification of these carbon offsets, and underlines the importance of market-existing co-benefits standards, such as Gold Standard, Verified Carbon Standard (VCS), etc.

Research on motivations for offsetting at corporate level can be categories into two groups. The first group of studies focus on the motivations for offset investments by major players in the voluntary offset markets, such as private companies, governments, offset project developers, etc. The most common methodologies used in these studies are surveys and interviews. Through market surveys, general motivations for offset investments are discussed, and a list of diverse motivations are revealed from the analysis of the survey responses.

There are also two attributes of motivations discussed in aligned with the multi-stage decision process. The first attribute of motivations is studied from the perspective of reducing GHG emissions and the second attribute of motivations is discussed beyond emission reductions.

Anderson and Bernauer studying corporate motivation through interviews and online surveys found that if only from reducing GHG emissions' perspectives, companies were motivated by the economic efficiency offset projects, which deliver cheaper carbon credits at a lower cost (Anderson and Bernauer, 2016). The ecosystem Marketplace conducts an annual series market surveys with a focus on corporate voluntary carbon offset activities using the CDP database. They found that offsetting investments primarily served the purpose of companies choosing to meet a voluntary emission reduction target. Beyond that, it could also help companies to derive value from their offset portfolio through offset purchases. Especially when companies were looking to bring in "beyond climate" benefits, such as co-benefits to the society. (Goldstein, 2016, 2015).

Lovell et al. identified three narratives to explain why offset organizations purchase voluntary offset credits: "quick fix for the planet" is based on the science of climate change, "global-local" connections focus on side benefits, and "avoiding the unavoidable" is based on drivers of increasing greenhouse gases (Lovell et al., 2009). Two of the three motivations are derived from the logic of emission reductions.

International Carbon Reduction & Offset Alliance (ICROA) also conducted market surveys by working with a group of selected universities. They found that 94 percent of respondents felt that organizations should voluntarily reduce their GHG emissions. Beyond that, they also found that companies engaged in offset investments for a variety of other reasons, including sense of responsibility, reputation, market differentiation, and risk management. Among all these reasons, "a sense of responsibility" was ranked by most to be their primary motivation for offsetting. (ICROA and Imperial College, 2016, 2014; ICROA and University of Bristol, 2015)

Forest Trends' Ecosystem Marketplace conducted another series of annual surveys, collecting data from offset project developers, wholesalers, brokers, and retailers. Over 13 years, they found that the main motivations for offset purchases are corporate social responsibility and combating climate change. Additionally, they agreed that "offset buyers have varied motivations and preferences when it comes to choosing the projects or portfolio of projects they buy from." They found these motivations for offsetting were as varied as the buyers themselves over the years (Forest Trends' Ecosystem Marketplace, 2019; Goldstein and Hamrick, 2015; Hamrick, 2017, 2016; Hamrick and Gallant, 2018). For example, the survey conducted right before the Paris Agreement showed that "demonstrating climate leadership with industry" ranked as the top reason for offsetting. Although, their studies of corporate motivations relied on the secondary information from project providers, not from companies directly, they still provide a useful insight into corporate motivations.

Carbon offsetting has the potential to contribute to a range of side benefits that meet the demand for corporate social responsibility. A number of studies in the literature have investigated companies using voluntary carbon offset projects to deliver certain sustainable development benefits, beyond the general motivation. They identified this phenomena as a sustainability sweet spot, where business interest overlap with environmental and social interests (Bergqvist and Lindgren, 2014; Savitz and Weber, 2014). Co-benefits were used to add value in areas such as branding, public relations (Bayon et al., 2009), and corporate reputation (Pohl and Tolhurst, 2012; Tolhurst and Embaye, 2010). Additionally, some companies were willing to pay an additional premium for independent verification of the co-benefits derived from activities generating emissions offsets (ICROA and Imperial

College, 2014). Another study conducted interviews among one carbon offset consulting firm with four of its customers, and it provided great insights into the “sustainability sweet spot”. However, the data limitation constrained them from drawing a broader conclusion on the motivations of these corporate buyers (Bergqvist and Lindgren, 2014).

However, literature derived from market surveys (such as the annual survey conducted by the forest trend) has its own limitations. Conclusions from these surveys are very scattered and lack a systematical structure due to lack of first-hand responses from companies actually purchasing the offsets. There is no research systematically studying corporate motivations of offset investment, and deciding across different project options, and no evidence can be found in terms of which factors determine corporate willingness to pay for carbon offsets. Thus, there is an extensive large gap in what motivates companies to purchase offsets.

To fill the gap in literature, this research on corporate motivations attempts to: (1) Utilize secondary data from corporate CSR reports and combine it with data from the CDP Climate Change Questionnaire. This study seeks to fill a gap in the corporate responsibility strategy research and provide insight into why corporates purchase carbon offset credits voluntarily. (2) It looks at the interface between the strategies for reducing emissions that corporates emphasize in CSR reports and their carbon offset activities. (3) Using a mixed-method approach, contrast to the qualitative method in the conventional studies of motivations.

Despite limited research from the literature and growing academic and practitioner attention to the co-benefits of climate investment, several foundational issues remain unaddressed. Challenges include the lack of research on the topic of interplay between motivations and co-benefits. This study aims to fill these gaps in the literature by examining our research question.

Furthermore, emission offsets have two embedded features when they are traded in the form of carbon credits. First, carbon offsets are a commercial good that can be purchased in the voluntary carbon markets. Consumer behavior can play an important role in the purchasing process. Second, carbon offsets are also an uncommon intangible good, which means that consumer behavior differs from behavior in relation to conventional goods under certain circumstances. Due to the dual features of carbon offsets, I developed our hypotheses as follows:

Hypothesis 1: Companies whose primary motivation is to cut emissions will prioritize purchasing cost-effective offset projects (cheaper projects at a lower cost).

Hypothesis 2: Companies whose primary motivations arise from non-emissions-related impacts (i.e., company values, company market competitiveness) place a higher value on co-benefits, and they are willing to pay a premium on the standard offset price to achieve these impacts.

3. Data and Methodology

3.1. Operationalizing the Research Question.

Corporate investment decisions on the purchase of emissions offsets from the voluntary markets are private and not subject to disclosure to governments or the public. Thus, it is always challenging to understand why corporates do what they do. Discussions over the decision making are not documented nor are they accessible for public review. Due to privacy considerations, the price information for projects is admittedly a big factor in decisions and could be the only determining factor for all we know. It is likely that offset purchasing decisions are multi-stage within a corporate entity (Bergqvist and Lindgren, 2014), involving different levels of hierarchy and different offices. But we don't have visibility into that process.

However, I do have some options on how to conduct this research. I am able to gain some insight via companies' published CSR reports, and self-reported data (from CDP). Many companies publish annual CSR reports in order to communicate the activities and strategies being used to address social and environmental issues. These reports are often referred to as sustainability reports. They normally serve as a "barometer" of a company's attitudes toward social and environmental responsibility, strategic planning, and the level of integration in the corporate's business strategic plans (Tate et al., 2010). Additionally, CDP, acting as a not-for-profit organization, has requested that the largest corporates globally to participate an standard annual questionnaire (Ben-Amar and McIlkenny, 2015). Companies reported their emissions and strategies to address climate change directly through the questionnaire, including the information on offset projects they invested in during the reporting year. I believe both pieces of information can provide a practical window into studying the interplay between corporate motivations and decisions on offset purchases.

There are many ways of studying corporate motivations, such as interviews, social media, or corporate communications. I chose to use corporate social responsibility (CSR) reports as my primary research sources for the following reasons. First, CSR reports per se are one kind of corporate communication, where I am able to hear the voice of the companies to their internal and external audiences. Second, purchasing voluntary carbon credits is part of corporates' CSR strategy. As a result, using CSR reports as the secondary sources will serve our research interests, since the intention of studying the corporates' purchasing behavior of voluntary carbon credits is their motivation, instead of what have they done.

Despite interest from both academicians and practitioners, there is limited research to understand how corporates communicate carbon offsets and emission reductions through CSR reports. Furthermore, there is rarely published research exploring how companies position CSR reports as a way to voluntarily commit to reduce carbon emissions. CSR reports can be used as a rich source of secondary data to better understand corporate motivations, intentions, strategies, and activities of carbon offsets behavior, as well as the results of corporate social and environmental responsibility at the corporate level.

3.2. Data

As a multi-stage process, studying offset purchasing decisions requires us to have a dataset with settings that explain the process. This study has been conducted using a comprehensive dataset compiled by the author from different data sources. The dataset includes corporate offset investment decisions[49] and the offset projects they purchased. I constructed the primary dataset using corporate CSR reports and the CDP Climate Change

---

[49] The information I extract from corporate CSR reports describes how and why companies purchase offsets, and for what purposes in particular. As a result, this information is not just the outcome of the decision process, but actually reflects the actually decision process.

Questionnaire. I also put considerable effort into composing data of corporate characteristics and sectoral data from the Bloomberg Company Profile.

Company selection. This research focused on companies that have engaged in carbon offsets activities. Companies were first identified from the CDP Climate Change Questionnaire 2018, Question C11.2 and C11.2a.[50] I got 414 candidates from this effort. I then filtered out those companies purchasing offset credits to meet the requirements of a compliance regime or acting as the originators[51] of carbon offsets. This left me with a group of 306 companies total.

CSR reports. Once the target set of corporates were identified, I verified the availability of the CSR reports (free-standing or published jointly with annual reports) using the Corporate Register[52] and the Sustainability Disclosure Database.[53] After the list of companies was finalized, the most recent CSR report was downloaded from corporateregister.com or directly from the companies' websites. Finally, I obtained 306 CSR/sustainability reports and corporate annual reports. However, after having reviewed all 306 reports, only 186 reports were retained in the final sample. I had to drop 120 companies from my sample because their CSR report didn't mention any related

---

[50] C11.2 asks companies to answer the question of "Has your organization originated or purchased any project-based carbon credits within the reporting period?". C11.2a asks companies to provide details of the project-based carbon credits originated or purchased by their organization in the reporting period.

[51] Originators of carbon offsets are those companies who produce offset credits.

[52] The Corporate Register is the global online directory of corporate responsibility reports, including tens of thousands of reports past and present. More information can be found at: https://www.corporateregister.com/.

[53] The Sustainability Disclosure Database is a free online database that provides users with all types of sustainability reports. More information can be found at: https://database.globalreporting.org/.

information about purchasing carbon offsets. A detailed comparison table between these two groups can be found in appendix **Table B 4-1.**

Sectoral data: These companies were then classified by industry using the Bloomberg Industry Classification Systems (BICS). Additionally, corporate characteristic information, such as headquarters location, primary working currency, number of employees, annual revenue, net income, total assets, operating, and investing, was also obtained from Bloomberg Company Profile 2018.

Project characteristics: Within 186 corporates, I identified from the CDP data 534 projects executed in 28 countries, 12 sectors, 39 industries, and 73 sub-industries. I presented the distribution of project types aggregated at country or regional level in **Figure 4-2**. These 534 projects accounted for 16.2 $MtCO_2e$, which is about one third of the total volume of transactions in the voluntary market of that year.[54]

---

[54] In 2017 and 2018 the total volume of transaction in the voluntary market is 46.2 $MtCO_2e$ and 98.4 $MtCO_2e$ respectively (Forest Trends' Ecosystem Marketplace, 2019).

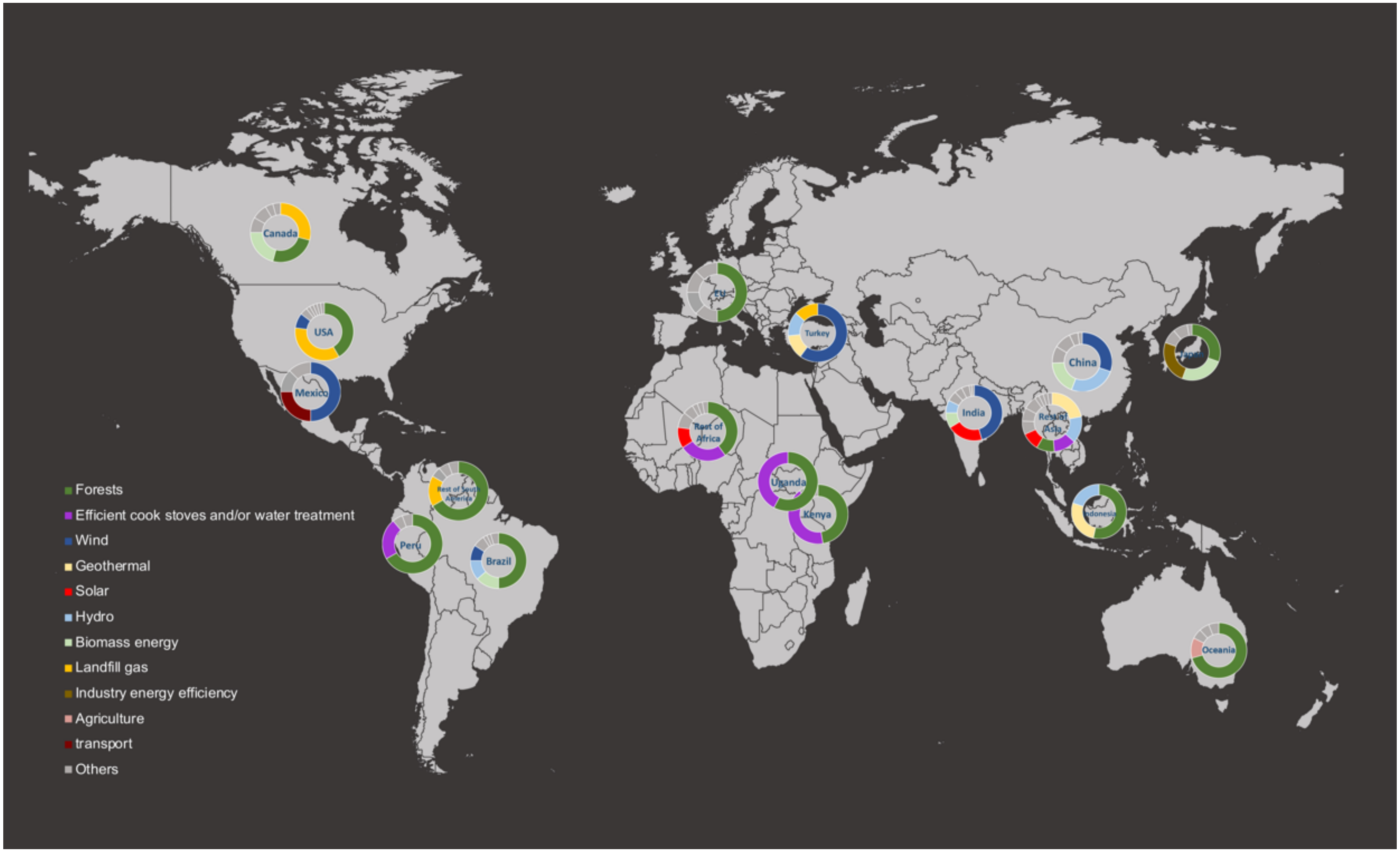


Figure 4-2. Distribution of project types by project locations. *Different project types happen in different place. That tells us that there may be gaps in the types of benefits accruing in places that need them.*

Table 4-1 lists the descriptive statistics of the 186 companies in our dataset. In aggregate, these companies represent \$3.5 trillion in revenue, and \$0.4 trillion in profits, \$3.1 trillion in total assets, and a workforce of 9 million people worldwide. When I compared the data to the list of global Fortune 500,[55] these 186 companies represent one third of the value created by the Fortune 500 companies in the year of 2018. In conclusion, companies in our sample are quite significant offset buyers, and they can be a representative sample to study corporate investment decisions.

Table 4-1. Descriptive statistics of the 186 companies.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
EMPLOYEES	186	48,391.32	76,127.74	0	540,779
Annual Revenue	186	18,974.62	25,908.28	0	146,537.3
Net Income	186	2,104.588	4,691.6	-6,837	39,240
Total Assets	186	17,1053.3	398,532.6	0	2,622,001
Operating	186	3,100.763	9,636.763	-36,241.36	71,884.71
Investing	186	-3,501.9	16,270.41	-197,993	12,121.2

Data source: Bloomberg Company Profile 2018
Units: USD in millions

3.3. Methods

3.3.1. "Mixed Methods" Research

Methodologically, I adopted the mixed-method research design by combining the inputs of corporate's CSR reports, and CDP offsets projects to assess the underlying motivations and decisions for corporates to invest in offset projects. "Mixed methods" is a research approach of using both quantitative and qualitative data collectively within the same study to conduct analysis (Creswell and Clark, 2017; Shorten and Smith, 2017). The essential

---

[55] In 2018, Fortune 500 companies represent two-thirds of the U.S. GDP with \$12.8 trillion in revenues, \$1.0 trillion in profits, \$21.6 trillion in market value, and employ 28.2 million people worldwide (https://fortune.com/fortune500/2018/).

element of this method is data linkage, or data integration at an appropriate stage (Ivankova et al., 2006; Shorten and Smith, 2017).

This paper fulfills the precondition of data linkage and data integration. First, there was a natural linkage between the CSR reports and the CDP Climate Change Questionnaire. They were the same groups of companies reporting different aspects of the offset investment to different audiences and stakeholders. As a result, corporate-level data was constructed from the CSR reports studying the motivations of investment behavior through a defined coding strategy. Meanwhile, the project-level data was extracted from the self-reported CDP data to study the project-specific issues. Second, the two sets of data were integrated into Nvivo 12[56] through the "case" function. In this function, each individual company was treated as one "case" in the software. It allows me to study the interaction between the specific motivations and specific project characteristics.[57] Additionally, sectoral data from the Bloomberg Company Profile and the Bloomberg Industry Classification Systems (BICS) is applied to study corporate aggregated behavior. In conclusion, qualitative data was collected and analyzed first, then quantitative data was collected and used to test findings empirically.

3.3.2. Coding Strategy

The first part of my study focuses on underlying motivations behind corporate offset investment behavior, and I have chosen to do a qualitative study using the content analysis.

---

[56] Nvivo is a qualitative data analysis (QDA) computer software package produced by QSR International. Primarily, it is designed for qualitative analysis, but the additional "case" function enables researchers to conduct mixed-methods research.

[57] In this circumstance, corporate CSR reports act as interviews, and CDP data acts like survey responses. I combined these two datasets based on individual corporate.

Content analysis is a common method used in qualitative analysis, which comprises a set of methods for systematically coding and analyzing qualitative data for examining trends and patterns in documents (Goldstein et al., 2019; Stemler, 2001). Originally taken from the consumer behavior and marketing field, this approach was later widely adopted in the social and anthropology field (Kolbe and Burnett, 1991). Recently, content analysis has been used in several studies that examined corporate environmental and social disclosures, as well as corporate risk disclosures (Goldstein et al., 2019).

I conducted the content analysis of the 186 CSR reports by using a coding strategy to extract corporate motivations for offset investment. To create the coding strategy, I first compiled a wide-ranging set of motivations (I called them metrics in our coding strategy) based on the literature. I began with a deductive content analysis of a pilot study of 20 companies to see whether motivations from the pilot study were closely aligned with those from the literature. I found that most of these motivations would fit under the list I compiled, whereas one motivation that relates to Sustainable Development Goals (SDGs) was not on the list. I agreed that the motivation of supporting SDGs, although not mentioned in the literature, was an essential piece that can perhaps describe the current trend of corporate motivations. Thus, I added it to the coding strategy. Later on, when reviewing the CRS reports from the pilot sample, I started to see these motivations could be aggregated into three main themes to describe the underlying motivations behind corporate investment behavior. As a result, I identified three main themes of motivations, namely "company carbon management and efficiency," "company values," and "company market competitiveness." At this point, the preliminary coding strategy was eventually defined as in **Table 4-2.** Once the coding strategy was defined, the coding was applied to the full sample. I made small revisions during the coding process.

By using the technique of content analysis, I am able to create a realm of research opportunities to access the frequency with which companies undertake different motivations and sub-motivations to invest in offset projects. I am also able to understand corporate strategies to enhance the quality and impacts of the projects that they have invested in.

Table 4-2. Coding Strategy.

Main theme	Metric	Indicator	Description of indicators	Source
Corporate Management and efficiency	Carbon management strategy	Carbon emission reduction strategy	Offset as one of important pillars of the whole strategy	Tolhurst and Embaye 2010, Goldstein 2016
	Corporate voluntary mitigation commitment	Carbon neutrality	Offset as one of the strategies for fulfil carbon neutrality	Goldstein 2015
		Meeting a voluntarily established emissions reductions target/goal	Corporates aim to cut emissions by a certain percentage below a baseline year, or Corporates aim to cut emissions per a certain unit of output, such as electricity per kWh of generated, or products produced	Goldstein 2016, 2015
		General emission reduction		Goldstein 2015
	Efficiency (Economic Efficiency)	Unavoidable emissions	The most cost-effective way, because these emissions are difficult to reduce (offsets are a way to neutralize the carbon footprint of a product after exhausting all other means of cutting emissions)	Anderson and Bernauer 2016, OCROA and Imperial College 2014, Goldstein 2015, Zeppel and Beaumont 2013
Corporate Market Competitiveness	Global-local connection	Key regions for business	Invest in projects in the areas where corporates operate, obtain raw material, conduct business or have strategic partners.	Lovell et at. 2009
	Reputation/brand image/Market differentiation	Customer awareness (public-facing programs)	"Linking carbon credits with customer purchase, which encourage customer action (Offset buyers commonly engage their customers or employees in their programs in order to reap the reputational benefits they hope will be associated with a proactive stance on climate change.)"	OCROA and Imperial College 2014, Goldstein 2016, 2015
		Reputational risks from customers and stakeholders	Pressure from clients, employees, shareholders, and customers to be on the “right side” of climate change and to take proactive, voluntary action even in absence of carbon regulation.	Goldstein 2016, 2015
		Uniqueness	By offsetting, corporates can differentiate themselves from their competitive in this industry as a market branding strategy	Author's own expertise Bayon 2009
Corporate Values	Corporate culture	Internal and external communication	Employee communication and stakeholder engagement	Bayon 2009
	Supporting SDG goals	Supporting SDG goals	Achieve SDGs along with carbon neutrality	Author's own expertise
	Philanthropy	Philanthropy	Donate carbon credits to other parties or donate money in investing carbon offset projects	OCROA and Imperial College 2014
	Sense of "responsibilities" (environmental sustainability)	Business impact on the local community	Business areas that affect the environment (climate risks), Risk mitigation	OCROA and Imperial College 2016; Bergqvist and Lindgren 2014, Zeppel and Beaumont 2013
		Supporting vulnerable regions	Invest projects that benefit vulnerable populations or communities	OCROA and Imperial College 2016; Bergqvist and Lindgren 2014, Zeppel and Beaumont 2013

4. Results

4.1. Corporate Motivation Results: Aggregated Results for All Companies

The primary objective of our qualitative analysis is to determine the underlying motivations behind corporate offset investment decisions. Through the coding strategy, I am able to identify 14 indicators, nine metrics, and three primary motivations. I present the results in **Figure 4-3**. I will go over each motivation in detail in this section.

Motivation 1: Company carbon management and efficiency. 155 companies investing in carbon offsets have treated offsets as an effective way to cut carbon emissions and meet their voluntary mitigation commitments. The number of companies acting on this motivation was expected to be higher compared to the other two motivations. Because it confirms the relevance of motivations for the environmentally responsible actions described in the literature (Anderson and Bernauer, 2016; Goldstein, 2016; Goldstein and Hamrick, 2015; ICROA and Imperial College, 2016, 2016; ICROA and University of Bristol, 2015; Lovell et al., 2009). Although there is large variability in using offset credits to neutralize a corporate's carbon emissions at scale or from the scope, the primary purpose is to meet the voluntarily established emission reduction targets set by these companies, followed by the purposes of efficiency and carbon management.

With the recognition that human activities drive global warming, more and more companies have pursued a voluntary commitment to curb the carbon emissions that result their business activities. A key component of their commitments for most of this period has been to become carbon neutral through carbon offset projects. Companies seem to have moved beyond the general commitment to cutting emissions into more concrete discussions about how to use carbon management strategies to cut emissions in a more efficient way under a given set of technological and resource limitations, as described in many of the corporate CSR reports. Carbon offsets normally serve as the last step in the carbon management strategy.

Some issues remain surrounding the corporate commitment of carbon neutrality, such as whether they are ambitious enough, or whether they represent real carbon neutrality at the company level, value chain level, or just only a very small portion of the total emissions. But this kind of discussion is beyond the scope of this paper. The main message from this motivation is clear, which is that emissions offsets can be used to cut emissions further after cost-effective internal efforts have been exhausted.

Motivation 2: Company market competitiveness. Approximately 60 companies use offset projects as a branding tool to gain a competitive advantage in the market and bring their global and local markets into closer alignment. In brief, companies in this group invested in carbon offsets as a branding strategy to interact with their customers and as an outreach strategy to engage their strategic partners in their value chain. As a branding strategy, most of the companies are from the following sectors: consumer discretionary, industrials, financials, utilities, and technology. Especially for the companies whose primary business activities are passenger transportation, transportation, and logistics, followed by retail, software, and home and office products, their investing in offset projects can increase their customers' awareness of the impact of climate change. Thus, shifting corporate brand and marketing to climate positive products will engage consumers to be part of the agents of solution actively (New Climate Economy, 2018). The detailed distribution based on sector and industry can be found in **Figure B 4-3** in Appendix B.

Advertising the offset activities enabled these companies to be strong competitors by introducing a public-facing carbon offset program to their customers or launching an ambitious offset purchasing plan in their local market at the upstream or downstream end of the value chain. An example of advertising for local markets in the upstream sector of the value chain was the Tiffany & Co., an American luxury jewelry and specialty retailer, which:

> invested in carbon offsets from Kenya's Chyulu Hills to help meet our climate goals and promote sustainable development in an area of the world where we source colored gemstones and where we support wildlife conservation (Tiffany & Co., 2017).

Example of both upstream and downstream value chain advertising was Marui Group Co., Ltd, a Japanese retail company, indicated that:

> Since 2014, we have been conducting carbon offset initiatives in disaster-stricken areas as well as in the areas that produce material for our shoes, the areas in which we open new stores, and other areas that benefit local customers"(Marui Group Co., Ltd., 2017).

Motivation 3: Company values. There are 59 companies in our sample that claimed to have invested in carbon offsets in order to enhance and live out their corporate values. The ability to deliver on company values through offset investment relies on the following four pillars: supporting SDGs, taking the responsibilities, strengthening public relations, and committing to philanthropy. The first three of these pillars had 25, 24, and 22 companies undertaking the claims, whereas the latter one only had three companies.

Under the pillar of public relations, companies used carbon offsets to serve the two key functions: effective employee communication and stakeholder engagement to raise their awareness of the environmental impact within the whole company:

> To raise employee awareness of the environmental impact of business travel, Cogeco Connexion voluntarily purchased carbon offsets corresponding to the GHG emissions resulting from business travel in fiscal 2016 and 2017—a total of 584 metric tons."(Cogeco Inc., 2018)

The impact of climate change increasingly becomes a clear threat to corporate development and their core value of contributing to society and demonstrating corporate social responsibility. The pillar of taking "responsibility" through investing in carbon offset project, such as supporting vulnerable regions as a result of global climate impact, or local communities as a result of corporate local business operations, helping to address the aforementioned concerns at scale. Companies became active in identifying offset projects for addressing their corporate values and are instrumental in linking co-benefits from projects to local communities. Examples can be found:

> The selection of these projects took into account the fact that they were located near the Pelotas Road Pole, which was admitted by Ecosul, a major concessionaire of the Ecorodovias Group, the main channel for the disposal of

> commodities produced in Rio Grande do Sul to the port of Rio Grande" (EcoRodovias Infraestrutura e Logística SA, 2019).

Overall, the motivation to engage in carbon management and efficiency is often driven by a belief that market-based solutions can be practical in addressing environmental problems. The motivations to engage in company values and market competitiveness are often encouraged by a theory that the sustainability sweet spot can be effective in addressing social problems.

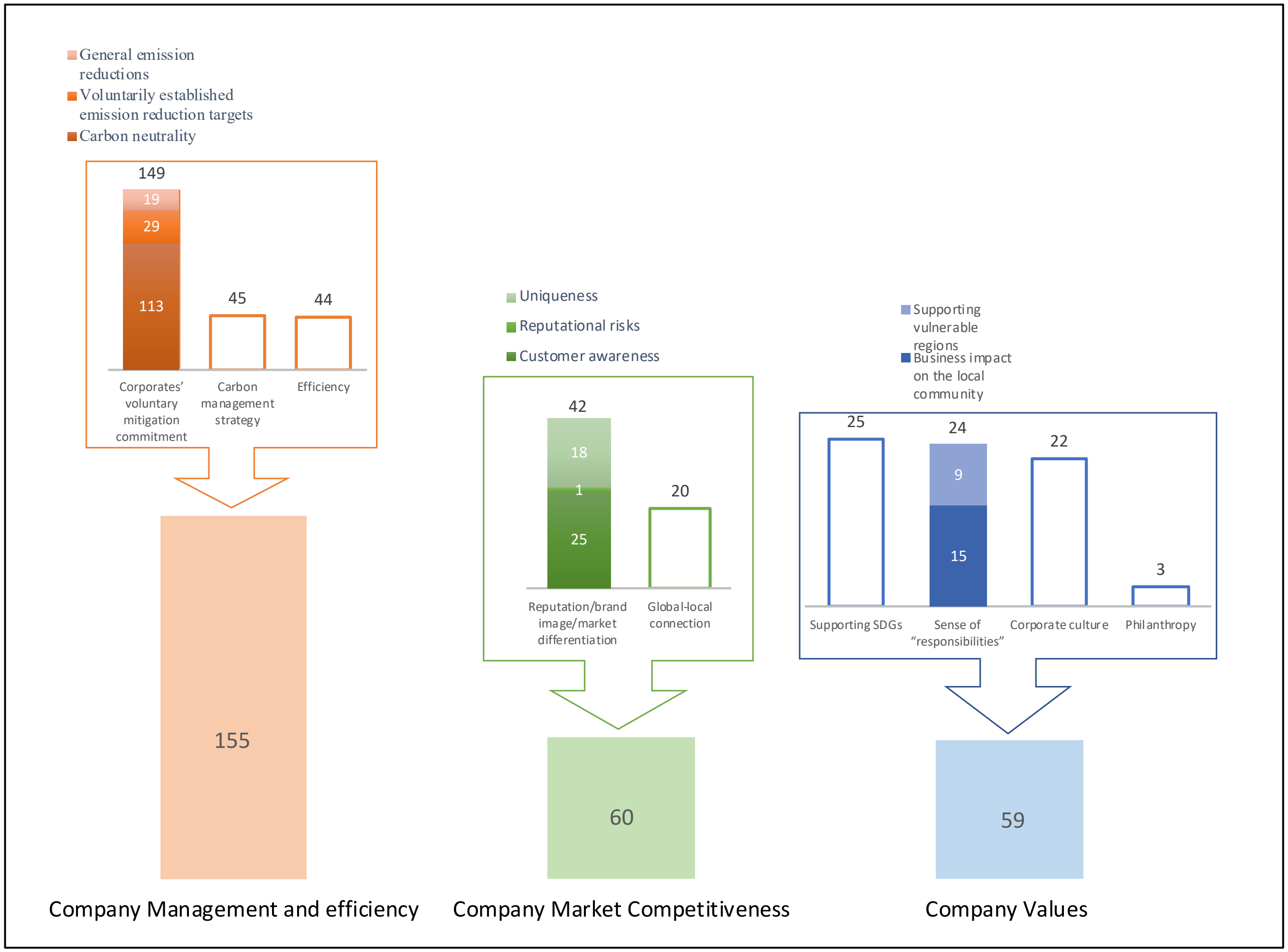


Figure 4-3. Three motivations by counts among corporates (based on case). *Our data covers a total 186 companies. 155 companies investing in carbon offsets have treated offsets as an effective way to cut carbon emissions and meet their voluntary mitigation commitments. 60 companies using offset projects as a branding tool to gain a competitive advantage in the market and bring their global and local markets closer. 59 companies have invested in carbon offsets to enhance and live out their corporate values.*

4.2. Motivations and Purchasing Behaviors are Linked with Local Co-benefits

Co-benefits can be viewed as the value proposition of offset projects. If motivation 1 for investing a carbon offset project is primarily to drive carbon reductions, then motivation 2 and motivation 3 as the secondary motivations are to finance some form of value creation. My strategy to explore the value proposition is a three-fold effort. First, I look at the corporate-level data and evaluate how companies committed to contribute to the local communities by the realization of a variety of co-benefits indicated in their CSR reports. Second, I conduct analytic virtualization to explore the project-level data and examine the role of local co-benefits played in this domain. Third, I connect the corporate commitment and project-level data to validate the value proposition of offset projects through corporate motivations.

4.2.1. Corporate Commitment

In this section, my primary goal is to study corporate commitment to delivering on co-benefits generated from offset projects in local communities. Companies make their offset investment decisions and deliver benefits of these projects based through several channels: by establishing rigorous criteria for project selection, by choosing the focus of the projects, and by looking at specific benefits of that project.

4.2.1.1. Corporate Criteria for Project Selection

Figure 4-4 lists the criteria for project selection cited from corporate CSR reports. Among all the criteria mentioned by companies, benefitting local communities is ranked as the first criterion, followed by the quality of the offset certificates. Additionality and location got the same ranking by counts. Moreover, four companies emphasized their commitment to using offset projects to bring a positive impact to poor rural communities.

Criteria for project selection is used in a targeted manner to spur the offset investment flow towards the course as companies expected. It is the first step after the general offset decision was made. **Figure 4-4** clearly states that the constructive role of local co-benefits can play in bringing out the corporate vision towards the offset projects.

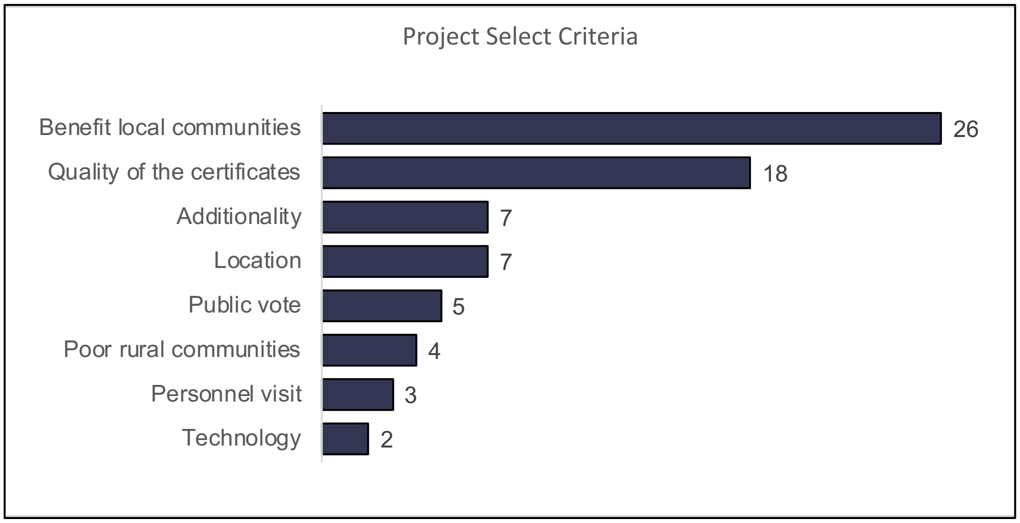


Figure 4-4. Corporate carbon offset criteria for project selection. *Benefitting local communities is the most mentioned criterion. (Based on 47 companies)*

4.2.1.2. Focus of Projects ("Local" vs "General")

Community-based projects were heavily weighted in the frequency count compared to the commercial-based projects when companies described their preferences of project focus. 37 companies mentioned 43 times that their offset projects were community-based, while only six companies mentioned their offset projects were commercial-based (see **Figure**

4-5). The word "community" was central to the reason companies gave for their preference in the focus of investing offset projects.

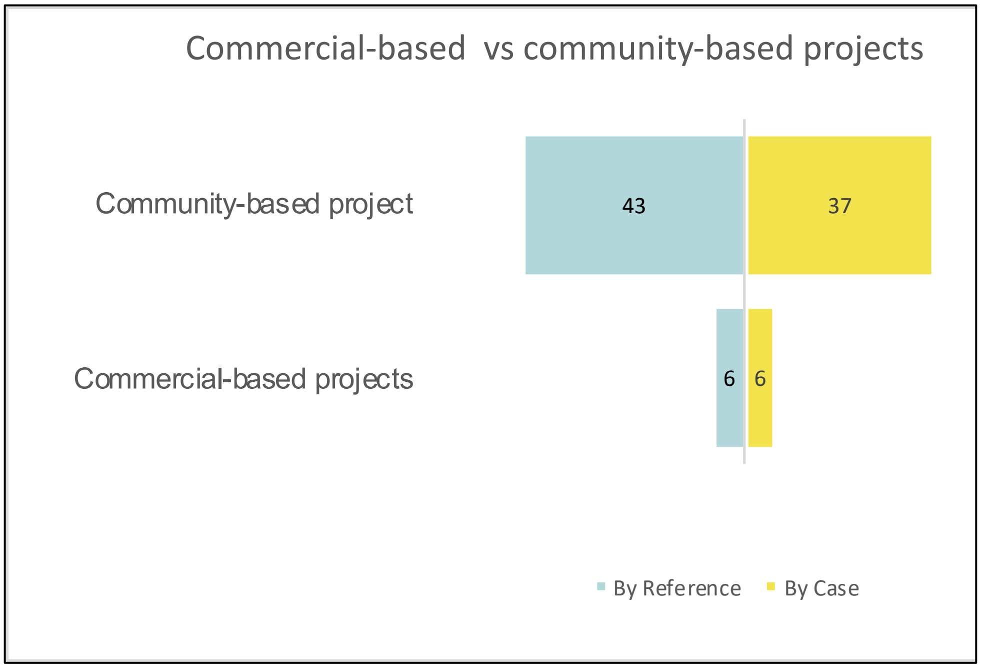


***Figure 4-5. Focus of offset projects**. Community-based projects were heavily weighted in the frequency count compared to the commercial-based projects when companies described their preferences of project focus.*

The majority of companies focused on describing specific benefits that offset projects can bring into the local communities. A variety of co-benefits were mentioned 103 times by 57 companies, compared to 27 companies used the general term such as social, economic or environmental benefits (see **Figure 4-6**). Specific benefits, instead of the general benefits, were central to the outcomes that companies cited as being important.

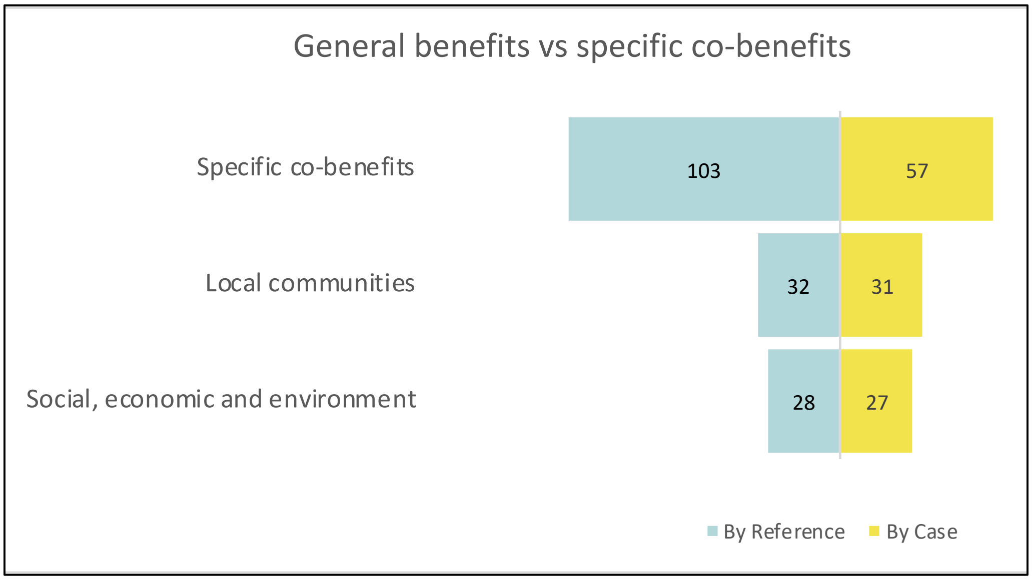


Figure 4-6. Number of companies describing "general" benefits or "specific" benefits*. The majority of companies were focusing on describing specific benefits that offset projects can bring into the local communities.*

4.2.1.3. Preference of Specific Co-benefits

Companies depicted various expected benefits of the project in CSR reports. I plotted the results in **Figure 4-7**. Improved quality of life was the leading descriptor for how companies expected their investment of offset projects to contribute to local communities and bring real impact to society. Other benefits that were heavily weighted in the frequency count included (in order of frequency): improved health, local job creation, improved biodiversity, prevention of deforestation, education, access cleaning energy, gender equality, cleaner air, etc. This list of specific co-benefits covered a wide range of dimensions of the conceptualization of well-being and well-being outcomes in local communities.

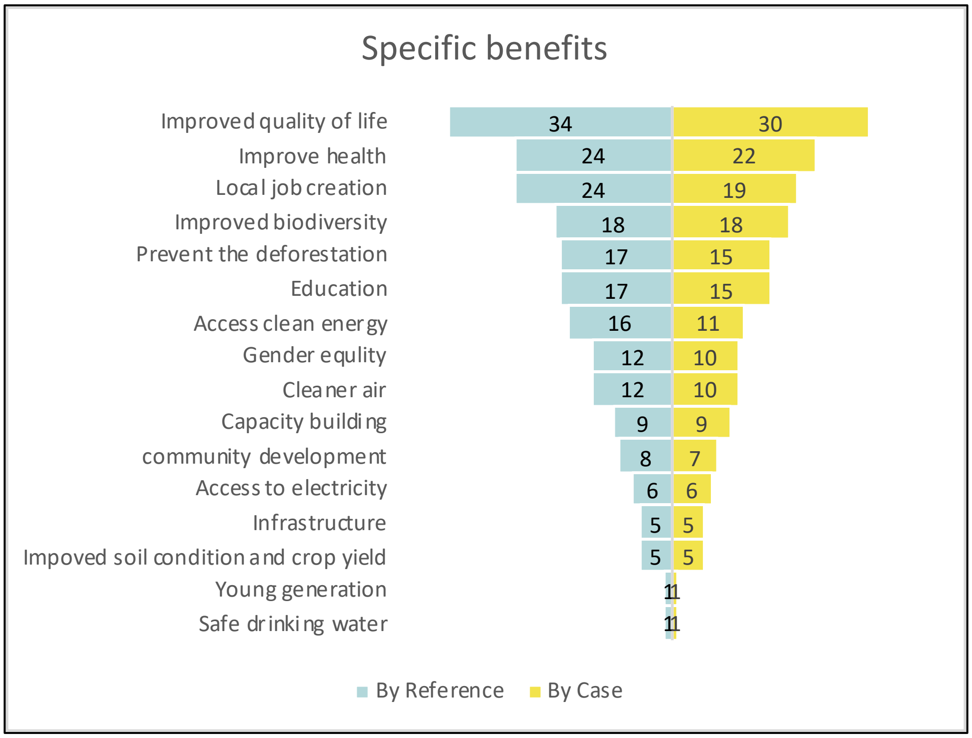


Figure 4-7. Specific benefits mentioned by companies. *Improved quality of life was the leading descriptor for how companies expected their investment of offset projects to contribute to the local communities and brings real impact to society. (The total number of companies mentioned specific co-benefits are 57 companies with 209 references from NVivo.)*

Overall, I noticed that companies mentioned quite frequently the focus on the project with its associated benefits in the local dimension. Their perspectives reflected a range of consentient from companies being responsive to a positive impact from offset investment. These aforementioned findings might be more indicative of the role of co-benefits in general within companies.

4.2.2. Projects' Perspective of Co-benefits in Local Communities

In this section, my focus is to explore the interplay of co-benefits and local communities by using data from the projects' level. I adopted two visual analytic approaches in this section to demonstrate the depth and breadth of my findings.

I enhanced the breadth of our findings by looking at data horizontally. Compared to other words used in project narratives, I explored how frequently "local" showed up and at what scale using a "word cloud" tool. I further developed the depth of our findings by focusing on the content surrounding the "local" and see how "local" penetrated to the project context vertically by the "word tree" tool.

4.2.2.1. "Local" Showed Up More Than Expected

I utilized the data visualization tool to help us explore the words most frequently used by corporates to report purchased offset projects to the CDP (survey response). A word frequency counts documented over 534 project narratives, and the term "local" played a relatively big role in narratives about projects,[58] as shown in **Figure 4-8.** This could be seen as quite significant relating to the local impact from offset projects because companies appeared to be impact-driven decision-makers that outlined the linkage between the project and where the project is located.

---

[58] Although "local" ranked as the 14th among the 100 most frequent words, it is the first adjective word showed up in the list.

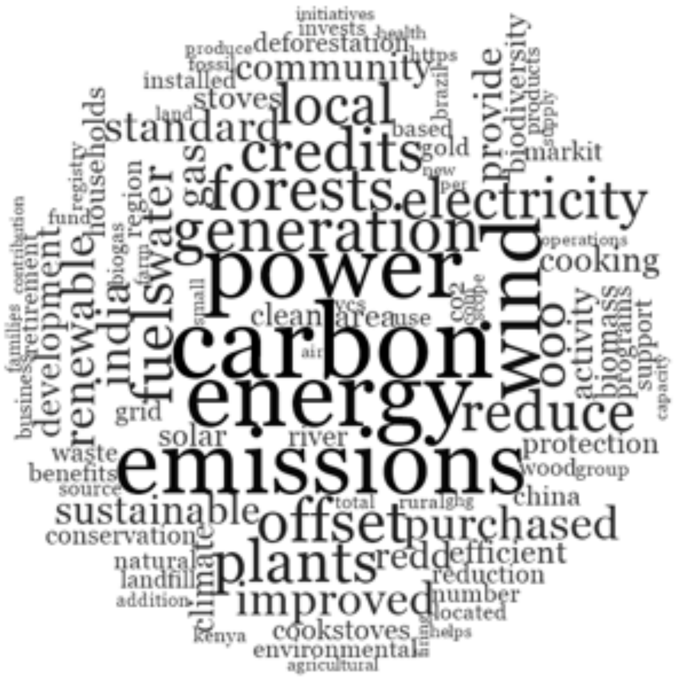


Figure 4-8. Word cloud based on NVivo analysis of CDP project description. *"Local" plays a big role in narratives about projects. The word "local" was mentioned 79 times, ranked as the 14th among the 100 most frequent words.*

4.2.2.2. "Local" Context and Dimensions

I used another data visualization tool, "word tree" to analyze word or word combinations in their respective contexts. A full list of the results can be found in **Figure B 4-7.** The results show that "local" had many links to community concepts, with projects described many dimensions of "local" benefits. Because a word tree often follows or precedes a target word, which is "local" in my study. I summarized the information from the complex figure into a three-category table in **Table 4-3,** with each column to elaborate our main argument as below.

The links to community concepts can be traced through a group of beneficiaries that follow our target word. Among all the beneficiaries, community/communities were the two most cited words, accounted for one-third of the group of beneficiaries. Vulnerable and disadvantaged groups, such as small landholders, farmers, women, etc., were also emphasized in the project narrative. This case illustrated the crucial role of rooting projects with the local circumstance.

The dimensions of “local” benefits from the projects were presented directly in the middle column of the table. These benefits also followed my targeted word directly. Among these benefits, job creation was the most mentioned benefit, followed by an improved environment and biodiversity. By closely linking a variety of co-benefits to the local circumstance, benefits became self-described as being given the local benefits.

Finally, benefits should be delivered to the beneficiaries through the action word, which normally preceded the targeted word. The right column of the table listed all the words that preceded the word “local.” These words factored in the positive effects of the projects and the thriving effects of enabling environment whereby offset investment contributes to the local communities.

Table 4-3. Key summaries of the word tree. *Words in the first two columns are sorted from largest to smallest based on the counts of how many times that word appears in the word tree. While action words are ordered alphabetically.*

Group of beneficiaries	**Benefits**	**Action**
Community(ies)	employment/job	carry out
population(s)	environment and biodiversity	conserve
residents	Infrastructure	create
families	forests	enable
farmers	economy	engage
landholders	consumption	ensure
people	schools	fed into
towns	education	foster
experts	air quality	fund
worker	climate change effect	generate
area	grid	improve
entities	livelihood development	increase
manufacturers		protect
organizations		provide
women		train

4.2.3. Role of Project Benefits for Serving Specific Corporate Motivations

The limitation of visualization analysis in the previous section is that it can tell me what the projects were relevant for (both from horizontally and vertically) but does not tell me about outcomes. Thus, I need to close the gap by linking what the companies committed to doing, and whether the intended outcomes resulted from the actions taken.

One of the advantages of using mixed methods is the embedded linkage between my two datasets. By linking corporate commitment from the CSR report, to the projects' characteristics from the CDP data, I can validate the outcome from offset investment to some extent.

4.2.3.1. Going Beyond SDG 13

One of the levels of motivation 3 is supporting UN SDGs through offset investments. In this level, I found 25 companies made commitments in their CSR reports to support a variety of SDGs. I grouped these 25 companies and their supporting SDGs into two figures based on the number of SDGs and examined the interplay between the number of SDGs and co-benefits. The results are plotted in **Figure 4-9**.

In general, the most common SDG that companies used offsets for is SDG 13, "taking urgent action to combat climate change and its impacts." With companies committing to more SDGs, the benefits of supporting SDGs were increasing from the description of these companies.

The rationale behind the analysis follows a two-pronged approach. In group one **Figure 4-9 (a)**, I was looking at companies that only supported one or two SDGs, where the common SDG was SDG 13. Six out of 12 companies claimed that their purchasing offset credits were to support SDG 13, and seven companies supported the other two SDGs, which are SDG 7 or SDG 12. The second group **Figure 4-9 (b)** shows companies that hosted a higher number of SDGs than the first group, where SDG 13 worked in unison with the other SDGs to develop a joint strategy to generate more co-benefits from offset projects.

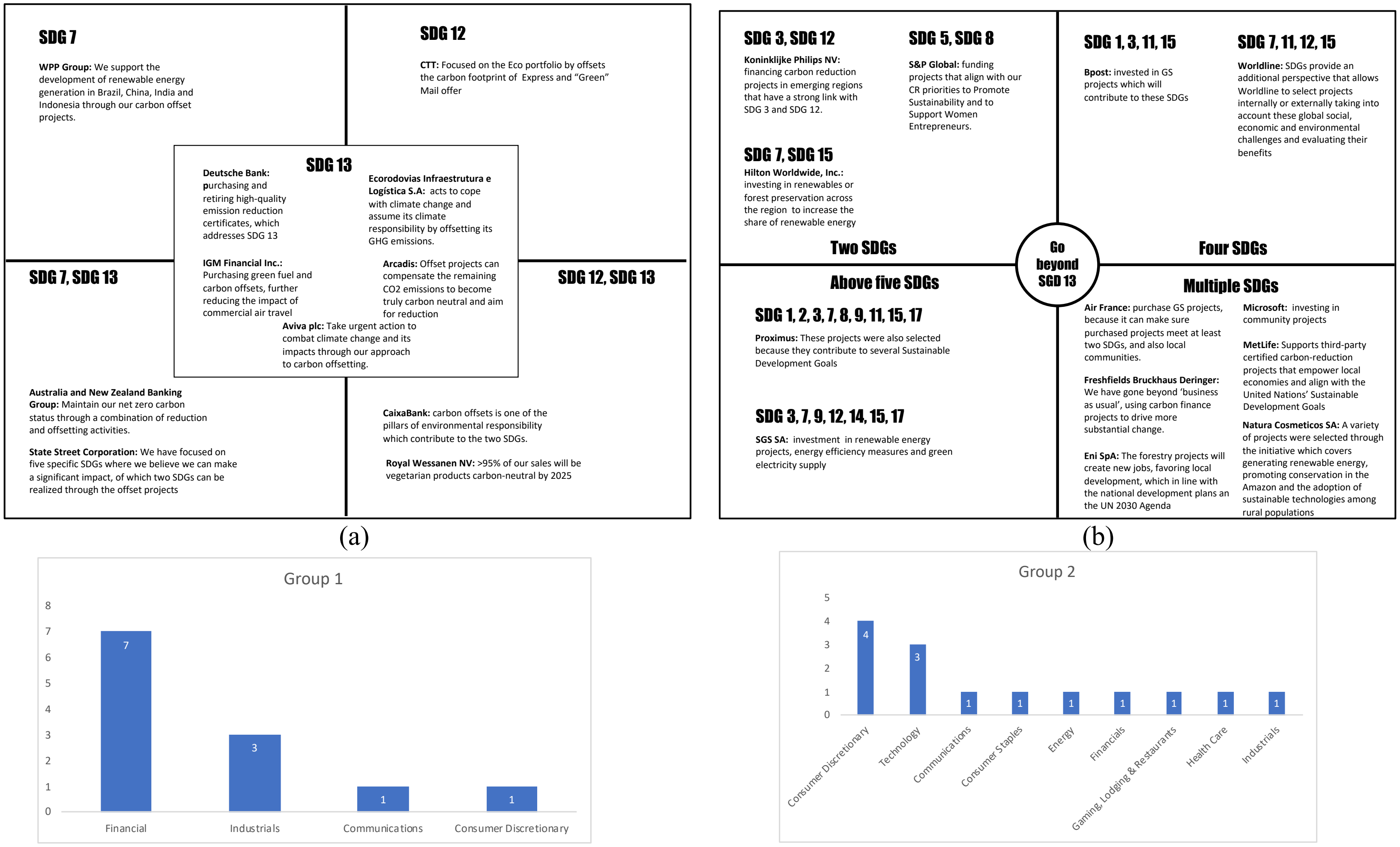
Implementing SDG 13 in concert with contributing to the other SDGs by companies to use a specific group SDGs for offset project offered the potential to tap a source of corporates for achieving the company values. Taking Koninklijke Philips NV for example, a health technology company focusing on improving people's health used offset investment to support SDG 3 ("Ensure healthy lives and promote well-being for all at all ages") and SDG 12 ("Ensure sustainable consumption and production patterns"):

> In 2017, we kicked off our carbon neutrality program by compensating 220 kilotonnes of carbon emissions. In 2018, we increased this to 330 kilotonnes, equivalent to the annual uptake of approximately 9 million medium-sized oak trees. This covers the total emissions of our direct emissions in our sites, all our business travel emissions and all our ocean and parcel shipments within logistics. We do so by financing carbon reduction projects in emerging regions that have a strong link with SDG 3 and SDG 12. (Koninklijke Philips NV, 2019)

S&P Global used SDGs to accomplish its CR priority, which was women entrepreneurs:

> Launched in 2017, the initiative reduces our operational climate footprint while funding projects that align with our CR priorities to Promote Sustainability and to Support Women Entrepreneurs (S&P Global, 2018).

Figure 4-9 (b) shows companies from the industrial sector spoke more frequently about using the offset investment to contribute to SDG13, while the financial sector had a higher number of companies in using offsets to contribute to SDG 13, SDG 12, and SDG 7. Sectors, such as technology, consumer discretionary (mainly passenger transportation, such as airlines), and consumer staples spoke most frequently about covering multiple SDGs from investing offset projects.



SDG 7

WPP Group: We support the development of renewable energy generation in Brazil, China, India and Indonesia through our carbon offset projects.

SDG 12

CTT: Focused on the Eco portfolio by offsets the carbon footprint of Express and "Green" Mail offer

SDG 13

Deutsche Bank: **p**urchasing and retiring high-quality emission reduction certificates, which addresses SDG 13

Ecorodovias Infraestrutura e Logística S.A: acts to cope with climate change and assume its climate responsibility by offsetting its GHG emissions.

IGM Financial Inc.: Purchasing green fuel and carbon offsets, further reducing the impact of commercial air travel

Arcadis: Offset projects can compensate the remaining CO2 emissions to become truly carbon neutral and aim for reduction

Aviva plc: Take urgent action to combat climate change and its impacts through our approach to carbon offsetting.

SDG 7, SDG 13

Australia and New Zealand Banking Group: Maintain our net zero carbon status through a combination of reduction and offsetting activities.

State Street Corporation: We have focused on five specific SDGs where we believe we can make a significant impact, of which two SDGs can be realized through the offset projects

SDG 12, SDG 13

CaixaBank: carbon offsets is one of the pillars of environmental responsibility which contribute to the two SDGs.

Royal Wessanen NV: >95% of our sales will be vegetarian products carbon-neutral by 2025

(a)

Two SDGs

SDG 3, SDG 12

Koninklijke Philips NV: financing carbon reduction projects in emerging regions that have a strong link with SDG 3 and SDG 12.

SDG 5, SDG 8

S&P Global: funding projects that align with our CR priorities to Promote Sustainability and to Support Women Entrepreneurs.

SDG 7, SDG 15

Hilton Worldwide, Inc.: investing in renewables or forest preservation across the region to increase the share of renewable energy

Four SDGs

SDG 1, 3, 11, 15

Bpost: invested in GS projects which will contribute to these SDGs

SDG 7, 11, 12, 15

Worldline: SDGs provide an additional perspective that allows Worldline to select projects internally or externally taking into account these global social, economic and environmental challenges and evaluating their benefits

Go beyond SGD 13

Above five SDGs

SDG 1, 2, 3, 7, 8, 9, 11, 15, 17

Proximus: These projects were also selected because they contribute to several Sustainable Development Goals

SDG 3, 7, 9, 12, 14, 15, 17

SGS SA: investment in renewable energy projects, energy efficiency measures and green electricity supply

Multiple SDGs

Air France: purchase GS projects, because it can make sure purchased projects meet at least two SDGs, and also local communities.

Freshfields Bruckhaus Deringer: We have gone beyond 'business as usual', using carbon finance projects to drive more substantial change.

Eni SpA: The forestry projects will create new jobs, favoring local development, which in line with the national development plans an the UN 2030 Agenda

Microsoft: investing in community projects

MetLife: Supports third-party certified carbon-reduction projects that empower local economies and align with the United Nations' Sustainable Development Goals

Natura Cosmeticos SA: A variety of projects were selected through the initiative which covers generating renewable energy, promoting conservation in the Amazon and the adoption of sustainable technologies among rural populations

(b)

(c)

(d)

Figure 4-9. Supporting SDGs through carbon offsets. *Corporates use offsets to contribute to the UN SDGs. The most common SDG is SDG 13. With corporates contributes more SDGs, the benefits from supporting SDGs are increasing from the description of these corporates.*

4.2.3.2. “Global-local” Investment Flow

One of the categories of motivation 2 is supporting key regions for corporate business through offset investments. In this global-local investment flow, companies claimed in their CSR reports that they have invested in offset projects in the areas where corporates operate, obtain raw material, conduct business, or have strategic partners. Detailed commitments from these 20 corporates can be found in **Appendix B Figure B 4-8.** To validate these commitments, I draw investment flow maps based on the data from the projects' level.

Example one: Australia and New Zealand Banking Group, whose operations span Australia, New Zealand, and a number of countries in the Asia Pacific region, the United Kingdom, France, Germany, and the United States. The investment flows in ***(a)*** showed that the location of the projects that matched to the markets of business operation.

Example two: Enagás, S.A., a Spain Utility Company, invested in emissions reduction projects in the countries where it operates. ***(b)*** validated the two investment flows from Spain to Chile and Peru.

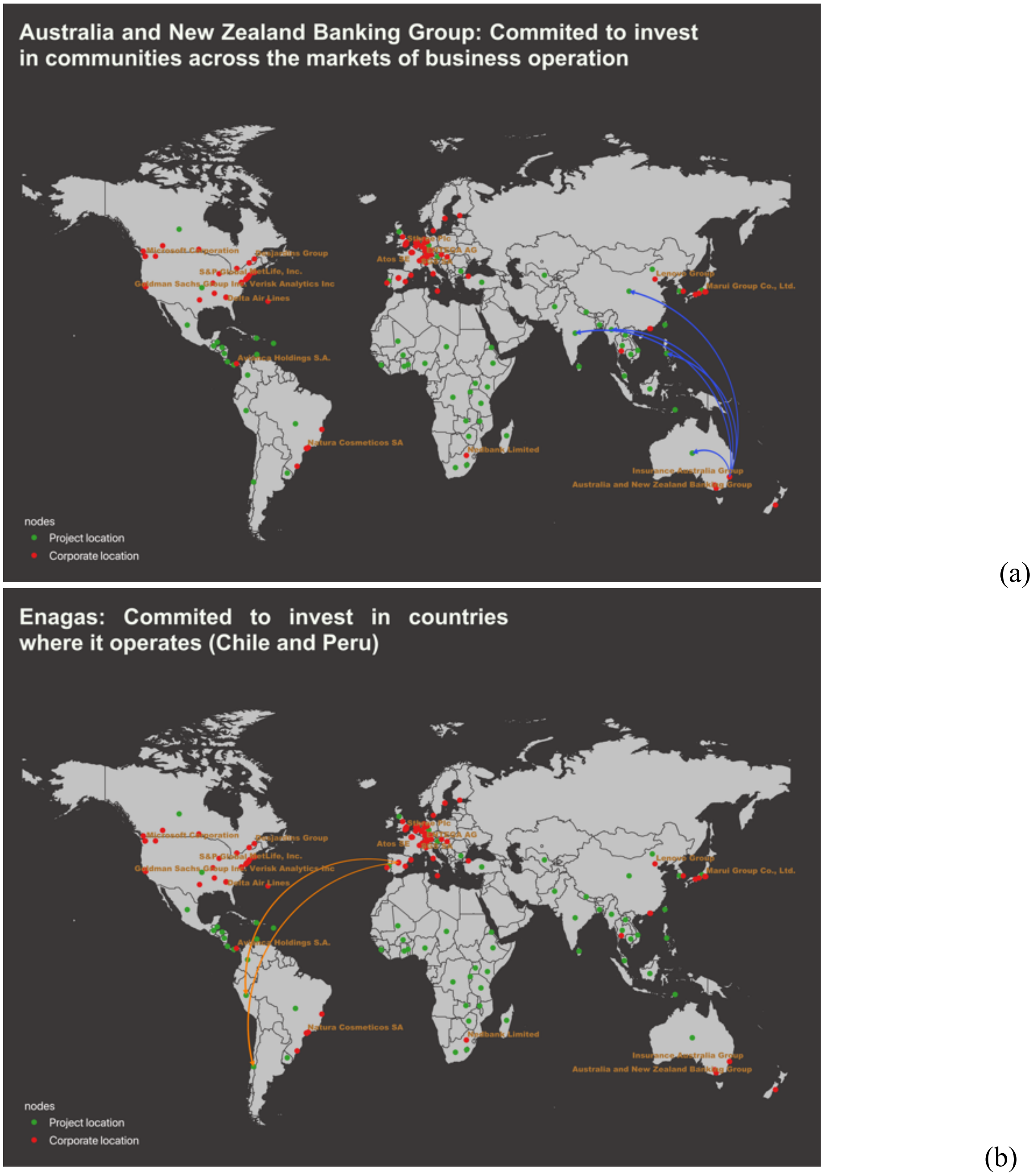


Figure 4-10. Global-to-local offset investment flows.

I plotted the investment flows for all 20 companies, and the full map can be found in appendix **Figure B 4-8.** The finding in **Figure B 4-8** mirrors that of corporate commitment in their CSR reports. It should be considered as solid evidence that offset investment flows were happening thought the global-local direction. It further emphasizes the impact of offset projects in the "local" dimension.

4.3. Mapping Motivations on to Purchasing Behaviors

Investment in carbon offset projects in the long- and short-term will be driven by the interplay of corporates motivations, project characteristics, such as project types, offset standards, and the quality of the projects. These project characteristics are the essential determinants of whether co-benefits in the local communities are real or not. In this section, our primary objective is to answer the second part of the research question: does the specific motivation affect the specific choices for investment? If yes, how specific motivation affects purchasing behaviors, including project typed and standards.

Before I moved into the discussion of results from my analysis, I want to make some clarification about the four motivations used in this section. Companies in each motivation are mutually exclusive with no overlaps. The final list of motivations is as follows:

Motivation 1: Company carbon management and efficiency (93 companies)

Motivation 2: Company market competitiveness (34 companies)

Motivation 3: Company values (33 companies)

Motivation 4: Company values and market competitiveness (26 companies)

Companies in the four motivations add up to 186.

4.3.1. Motivations and Project Types

Regardless of project type, as long as certain projects meet the eligibility requirement of offset standards, these projects can create carbon offsets. From the perspective of reducing emissions, buyers should be comfortable purchasing offsets from any types of project as long as these offsets are verified because there is no difference in using offsets to reduce emission reductions. But there still might be some variability in choosing certain project types. Especially, some projects have the potential to generate a more positive, immediate local sustainable development impact, and buyers would purchase these projects by adding a price premium to these offsets. Currently, different project types are sold at different prices in the market. The information on the average prices by project type can be found in **Appendix Figure B 4-5.** I am exploring the interaction between the corporate purchasing decision and project types to see if there is a trend to indicate buyers' preferences.

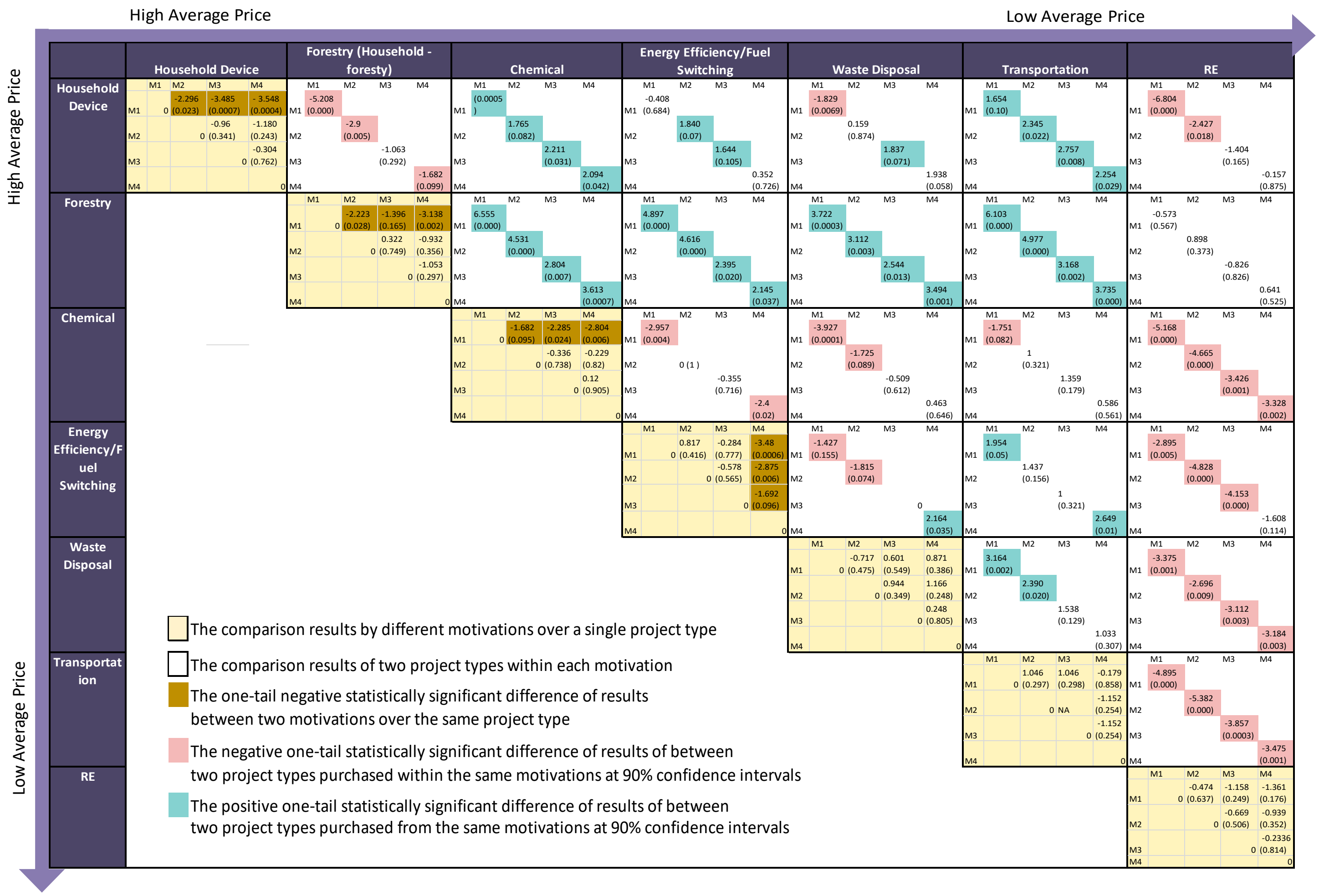
Table 4-4. Pearson Chi-squared test between motivations and project types.

Project Types	Company Management and Efficiency	Company Market Competitiveness	Company Value	Company Value and Market	P-Value	Pearson chi2
Forestry	57	36	32	37	0.000***	17.958
Household Devices	9	11	19	17	0.000***	31.967
Energy Efficiency/Fuel Switching	10	1	0	11	0.000***	26.686
Waste Disposal	20	10	5	3	0.415	2.851
s	3	0	0	1	0.515	2.288
RE (with Hydro)	80	34	35	47	0.001***	17.425
RE (without Hydro)	63	27	20	44	0.000***	28.016
Wind	30	12	13	16	0.199	4.658
Solar	15	7	2	7	0.241	4.198
Hydro	17	7	15	3	0.020***	9.872
Biomass	17	8	4	20	0.000***	30.180

Note:
1. The number of corporates in each motivation category is: "company management and efficiency": 93, "company market competitiveness: 34; "company value": 33; "company value and market: 26.
2. Overall Pearson chi2(108) = 166.8649 Pr = 0.000***
3. ***Significant at 0.1% level

The overall relationship among different motivations that taking different project types was significant and the p-value of the Pearson correlation was 0.000. To explore where the significance came from, either within the motivation or within project types, I further conducted Pearson correlations between each project type and motivations. The results are listed in **Table 4-4.** From the results, I can see that the main source of the significance stemmed from certain project types, such as forestry, household devices, efficiency/fuel switching, and renewable energy. Within these four project types, there were significant differences in attitudes towards different project types based on different motivations. Thus, I further performed a statistical analysis to see the preference among project types based on different motivations, and also preference between projects within the same motivation. Detailed results are presented in **Figure 4-11.**

I acknowledged that corporate features, such as size, revenues, net income, total emission status, etc., might have influence in their decision of offset investments. Simply looking at the correlation might miss these factors. However, I conducted some tests to assessing balance of two different groups of companies (group based on our hypothesis) before I further calculate the t-test in Appendix A. I present the results of the standardized differences in **Table 4-7.** Overall, these two groups are quite balanced, especially in the following three areas: annual revenue, net income, and operation of year 2018. I can conclude that there is adequate balance between these two groups of companies. I also conducted a hedonic model with 37 companies who reported the purchased prices of offsets in 2018. I report the results in **Table 4-8**. I also found that these corporate features do not statistically have an impact on the offset prices.



Household Device	Household Device M1	M2	M3	M4	Forestry (Household - foresty)	Chemical	Energy Efficiency/Fuel Switching	Waste Disposal	Transportation	RE
M1	0	-2.296 (0.023)	-3.485 (0.0007)	- 3.548 (0.0004)	-5.208 (0.000)	(0.0005)	-0.408 (0.684)	-1.829 (0.0069)	1.654 (0.10)	-6.804 (0.000)
M2		0	-0.96 (0.341)	-1.180 (0.243)	-2.9 (0.005)	1.765 (0.082)	1.840 (0.07)	0.159 (0.874)	2.345 (0.022)	-2.427 (0.018)
M3			0	-0.304 (0.762)	-1.063 (0.292)	2.211 (0.031)	1.644 (0.105)	1.837 (0.071)	2.757 (0.008)	-1.404 (0.165)
M4				0	-1.682 (0.099)	2.094 (0.042)	0.352 (0.726)	1.938 (0.058)	2.254 (0.029)	-0.157 (0.875)

Forestry	Forestry M1	M2	M3	M4	Chemical	Energy Efficiency/Fuel Switching	Waste Disposal	Transportation	RE
M1	0	-2.223 (0.028)	-1.396 (0.165)	-3.138 (0.002)	6.555 (0.000)	4.897 (0.000)	3.722 (0.0003)	6.103 (0.000)	-0.573 (0.567)
M2		0	0.322 (0.749)	-0.932 (0.356)	4.531 (0.000)	4.616 (0.000)	3.112 (0.003)	4.977 (0.000)	0.898 (0.373)
M3			0	-1.053 (0.297)	2.804 (0.007)	2.395 (0.020)	2.544 (0.013)	3.168 (0.002)	-0.826 (0.826)
M4				0	3.613 (0.0007)	2.145 (0.037)	3.494 (0.001)	3.735 (0.000)	0.641 (0.525)

Chemical	Chemical M1	M2	M3	M4	Energy Efficiency/Fuel Switching	Waste Disposal	Transportation	RE
M1	0	-1.682 (0.095)	-2.285 (0.024)	-2.804 (0.006)	-2.957 (0.004)	-3.927 (0.0001)	-1.751 (0.082)	-5.168 (0.000)
M2		0	-0.336 (0.738)	-0.229 (0.82)	0 (1)	-1.725 (0.089)	1 (0.321)	-4.665 (0.000)
M3			0	0.12 (0.905)	-0.355 (0.716)	-0.509 (0.612)	1.359 (0.179)	-3.426 (0.001)
M4				0	-2.4 (0.02)	0.463 (0.646)	0.586 (0.561)	-3.328 (0.002)

Energy Efficiency/Fuel Switching	Energy Efficiency/Fuel Switching M1	M2	M3	M4	Waste Disposal	Transportation	RE
M1	0	0.817 (0.416)	-0.284 (0.777)	-3.48 (0.0006)	-1.427 (0.155)	1.954 (0.05)	-2.895 (0.005)
M2		0	-0.578 (0.565)	-2.875 (0.006)	-1.815 (0.074)	1.437 (0.156)	-4.828 (0.000)
M3			0	-1.692 (0.096)	0	1 (0.321)	-4.153 (0.000)
M4				0	2.164 (0.035)	2.649 (0.01)	-1.608 (0.114)

Waste Disposal	Waste Disposal M1	M2	M3	M4	Transportation	RE
M1	0	-0.717 (0.475)	0.601 (0.549)	0.871 (0.386)	3.164 (0.002)	-3.375 (0.001)
M2		0	0.944 (0.349)	1.166 (0.248)	2.390 (0.020)	-2.696 (0.009)
M3			0	0.248 (0.805)	1.538 (0.129)	-3.112 (0.003)
M4				0	1.033 (0.307)	-3.184 (0.003)

Transportation	Transportation M1	M2	M3	M4	RE
M1	0	1.046 (0.297)	1.046 (0.298)	-0.179 (0.858)	-4.895 (0.000)
M2		0	NA	-1.152 (0.254)	-5.382 (0.000)
M3			0	-1.152 (0.254)	-3.857 (0.0003)
M4				0	-3.475 (0.001)

RE	RE M1	M2	M3	M4
M1	0	-0.474 (0.637)	-1.158 (0.249)	-1.361 (0.176)
M2		0	-0.669 (0.506)	-0.939 (0.352)
M3			0	-0.2336 (0.814)
M4				0

🟨 The comparison results by different motivations over a single project type

☐ The comparison results of two project types within each motivation

🟫 The one-tail negative statistically significant difference of results between two motivations over the same project type

🟥 The negative one-tail statistically significant difference of results of between two project types purchased within the same motivations at 90% confidence intervals

🟦 The positive one-tail statistically significant difference of results of between two project types purchased from the same motivations at 90% confidence intervals

Note: t-test results are from comparing the difference of the average number of projects (number of transactions) within the respective project types, invested by companies driven by separate motivation

Figure 4-11. T-test results of voluntary carbon offset project types and corporate motivations. *Green cells indicate that buyers purchase more from projects with a higher average price. Rose-colored cells show that the preference over projects fits the assumption that buyers buy more projects due to the low price of the products.*

Figure 4-11 delivers three important messages for this study. First, motivations of company values and company market competitiveness drove companies to purchase more offset projects with a higher offset price, compared to companies under the motivation of carbon management and efficiency. In the boxes (yellow) of the four highest priced project types (household devices, forestry, chemical process, and energy efficiency), there is a statistically significant difference at the number of projects being purchased by motivation-1 companies and the group of companies from motivation 2, motivation 3, and motivation 4. When project types moved towards the right corner of the diagonal line (offset credits became cheaper), there is no statistically significant difference among these four motivations towards project types.

Second, companies with the motivation of carbon management and efficiency were attracted by the low prices of certain project types, and they tended to purchase more projects from this group of projects. In the boxes (white) that have only one or two rose-colored cells,[59] at least one of the rose-colored cells resided in the motivation-1 companies. Under this circumstance, project type with a lower price had a higher chance to be chosen by motivation-1 companies, when motivation-1 companies were facing the investment decision between two project types.

Third, renewable energy projects were favored by all companies except when companies compared renewable energy projects with household device projects or forestry. When facing the decision of investing between renewable energy projects and projects such as

---

[59] Rose-colored cell indicates that a lower-priced project was chosen; green-colored cell indicates that a higher-priced project was chosen.

chemical processes, energy efficiency/fuel switching, waste disposal, or transportation, companies showed a very strong preference for purchasing renewable energy projects. One reason to explain the situation is that the average offset price of renewable energy is the lowest as shown in **Figure B 4-5.** Another possible explanation besides the low price of renewable energy offset credits was that there were better co-benefits from renewable energy projects compared to projects such as chemical processes, energy efficiency/fuel switching, waste disposal, or transportation. Because when corporates facing the investment choice between renewable energy projects and forestry, or household device projects, the low-priced factor no longer works, and I started to see less impact, or no impact.

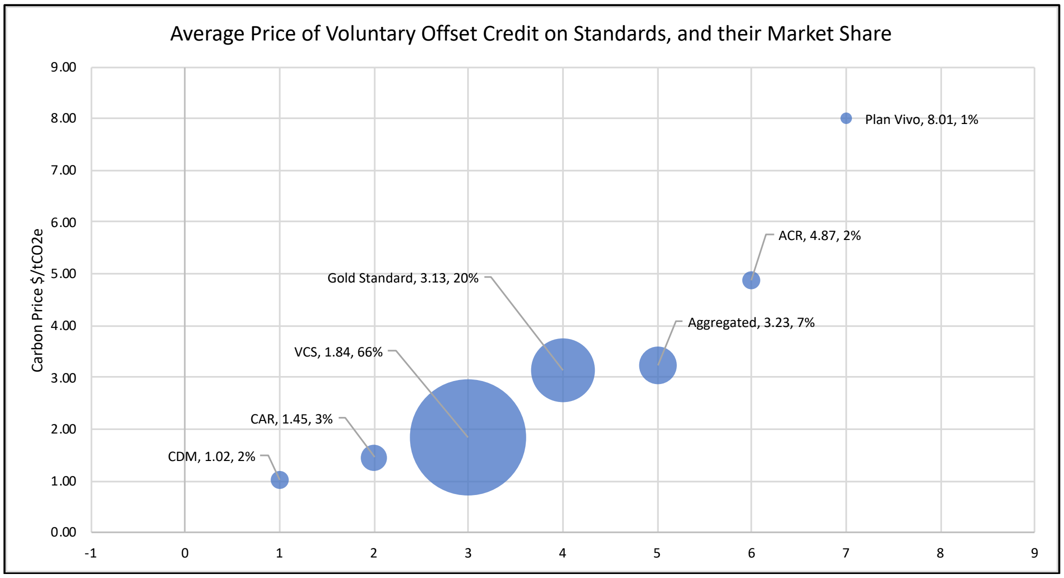
In conclusion, there are two opposite trends of offset investment due to the pricing signals. One trend is from the high-priced signal. Companies in motivations, such as company value and company market competitiveness were willing to invest more in projects with a higher offset cost, especially in household device projects and forestry projects, which could potentially yield a higher local co-benefit due to the nature of the projects. By contrast, the other trend is from the low-priced signal. Companies, especially those inspired by the motivation of carbon management and efficiency, intended to invest more in renewable energy projects, along with other project types such as chemical processes, energy efficiency/fuel switching, waste disposal, or transportation. Not only did these projects yield a cheaper carbon offset cost, but potentially some of the project types can also yield good local co-benefits, such as renewable energy projects.

4.3.2. Motivations and Voluntary Carbon Offsets Standards and Registry Infrastructure

In this section, I explore the interaction between corporate purchasing decisions and offset standards. The standards and registry infrastructure are an essential piece of voluntary offset markets in standardizing carbon credits and proving the legitimacy of these credits by third-party verification. Additionality has been an ongoing concern from environmentalists and some buyers who hold skeptical attitudes towards carbon offsetting. To address the concerns, companies purchase the carbon offsets that meet the highest possible standards to avoid criticism from the media and environmentalists (Bayon et al., 2009).

Currently, there are five common voluntary carbon offsets standards in the market, where the Verified Carbon Standard (VCS) and the Gold Standard got the lion's share of the market by taking roughly 66 percent and 20 percent (**Figure 4-12**) of the transacted offset volumes respectively based on a market survey (Hamrick and Gallant, 2018). Standards serve the purpose of issuing offsets to a voluntary carbon offset project if the general criteria set by the standards are met, mainly refer to the qualification of validation and verification. On top of these two-primary qualifications, a few standards will issue add-on certification to offer buyers "charismatic" offsets that emphasize co-benefits (Conte and Kotchen, 2010). For example, Gold Standard certifies positive co-benefits, and the Climate, Community & Biodiversity Standard (CCBS) certifies positive social and biodiversity impacts. Additionally, the American Carbon Registry (ACR), listed as the highest priced standard, is recognized for environmental integrity and innovation (Forest Trends' Ecosystem Marketplace, 2019).

As a result, I have standards that only focus on GHG reduction attributes, which do not require additional environmental or social benefits, such as VCS (Dhanda and Hartman, 2011; Forest Trends' Ecosystem Marketplace, 2019). I also have standards that focus on demonstrating social and environmental benefits, such as the Gold Standard, and CCBS, Plan Vivo. By mapping the motivations on to these standards, I can identify some trends.



Note: 1. Average Price is calculated based on transactions between January-March 2018 2. Source: Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends

Figure 4-12. Average price of voluntary offset credit on offset standards.

Table 4-5. Pearson chi-squared test between motivations and carbon credit standards.

Standard	**Company Management and Efficiency**	**Company Market Competitiveness**	**Company Value**	**Company Value and Market**	**P-Value**	**Pearson chi2**
ACR	3	2	1	4	0.112	5.998
CAR	11	5	2	4	0.695	1.444
CCBS	0	3	13	3	0.000***	37.114
CDM	25	12	21	4	0.005**	12.804
Gold Standard	46	28	32	37	0.000***	25.435
Miscellaneous standards	24	10	4	27	0.000***	42.760
Not yet verified	6	5	1	3	0.310	3.586
VCS	64	38	28	44	0.000***	23.473
VER+ (TÜV SÜD standards)	13	0	1	0	0.014*	10.545
Total Observation	192	103	103	126		

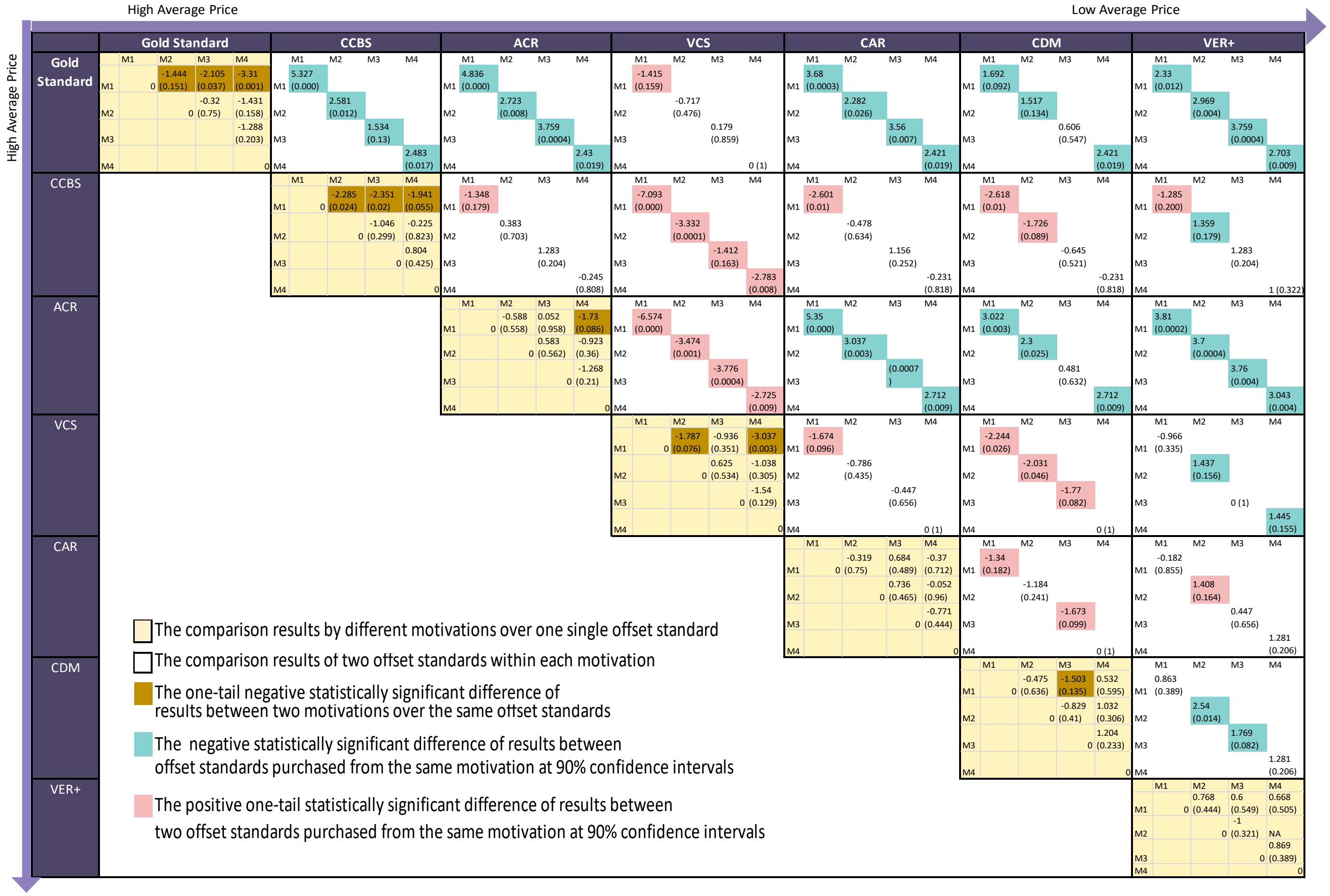
Note:

1. The number of corporates in each motivation category is: "company value": 33; "company market competitiveness: 34; "company management and efficiency: 93; "company value and market: 26.
2. Pearson chi2(24) = 89.8673 Pr = 0.000***
3. *Significant at 5% level, **Significant at 1% level, ***Significant at 0.1% level

The overall relationship among different motivations that purchase different offset standards is significant with the p-value of the Pearson Chi-Squared Test was 0.000. In order to explore where the significance comes from, either within the motivation or within offset standards, I further conducted the chi-squared test between each offset standard and motivations.

Figure 4-12. Average price of voluntary offset credit on offset standards.

Table 4-5 shows that that significance is primarily from the variation in attitudes towards a few offset standards due to different motivations of purchasing offset credits. These offset standards are Gold Standard, CCBS, CDM, VCS, etc. Taking the Gold Standard as an example, there are statistically significant differences in attitudes towards purchasing Gold Standards among the four groups of companies. I further performed a statistical analysis to explore the variation in purchasing motivation towards the same offset standards, and the preference between offset standards within the same motivation. Detailed results are presented in **Figure 4-13.**



		Gold Standard				CCBS				ACR				VCS				CAR				CDM				VER+			
		M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4
Gold Standard	M1	0	-1.444 (0.151)	-2.105 (0.037)	-3.31 (0.001)	5.327 (0.000)				4.836 (0.000)				-1.415 (0.159)				3.68 (0.0003)				1.692 (0.092)				2.33 (0.012)			
	M2		0	-0.32 (0.75)	-1.431 (0.158)		2.581 (0.012)				2.723 (0.008)				-0.717 (0.476)				2.282 (0.026)				1.517 (0.134)				2.969 (0.004)		
	M3				-1.288 (0.203)			1.534 (0.13)				3.759 (0.0004)				0.179 (0.859)				3.56 (0.007)				0.606 (0.547)				3.759 (0.0004)	
	M4				0				2.483 (0.017)				2.43 (0.019)				0 (1)				2.421 (0.019)				2.421 (0.019)				2.703 (0.009)
CCBS	M1					0	-2.285 (0.024)	-2.351 (0.02)	-1.941 (0.055)	-1.348 (0.179)				-7.093 (0.000)				-2.601 (0.01)				-2.618 (0.01)				-1.285 (0.200)			
	M2						0	-1.046 (0.299)	-0.225 (0.823)		0.383 (0.703)				-3.332 (0.0001)				-0.478 (0.634)				-1.726 (0.089)				1.359 (0.179)		
	M3							0	0.804 (0.425)			1.283 (0.204)				-1.412 (0.163)				1.156 (0.252)				-0.645 (0.521)				1.283 (0.204)	
	M4								0				-0.245 (0.808)				-2.783 (0.008)				-0.231 (0.818)				-0.231 (0.818)				1 (0.322)
ACR	M1									0	-0.588 (0.558)	0.052 (0.958)	-1.73 (0.086)	-6.574 (0.000)				5.35 (0.000)				3.022 (0.003)				3.81 (0.0002)			
	M2										0	0.583 (0.562)	-0.923 (0.36)		-3.474 (0.001)				3.037 (0.003)				2.3 (0.025)				3.7 (0.0004)		
	M3											0	-1.268 (0.21)			-3.776 (0.0004)				(0.0007)				0.481 (0.632)				3.76 (0.004)	
	M4												0				-2.725 (0.009)				2.712 (0.009)				2.712 (0.009)				3.043 (0.004)
VCS	M1													0	-1.787 (0.076)	-0.936 (0.351)	-3.037 (0.003)	-1.674 (0.096)				-2.244 (0.026)				-0.966 (0.335)			
	M2														0	0.625 (0.534)	-1.038 (0.305)		-0.786 (0.435)				-2.031 (0.046)				1.437 (0.156)		
	M3															0	-1.54 (0.129)			-0.447 (0.656)				-1.77 (0.082)				0 (1)	
	M4																0				0 (1)				0 (1)				1.445 (0.155)
CAR	M1																	0	-0.319 (0.75)	0.684 (0.489)	-0.37 (0.712)	-1.34 (0.182)				-0.182 (0.855)			
	M2																		0	0.736 (0.465)	-0.052 (0.96)		-1.184 (0.241)				1.408 (0.164)		
	M3																			0	-0.771 (0.444)			-1.673 (0.099)				0.447 (0.656)	
	M4																				0				0 (1)				1.281 (0.206)
CDM	M1																					0	-0.475 (0.636)	-1.503 (0.135)	0.532 (0.595)	0.863 (0.389)			
	M2																						0	-0.829 (0.41)	1.032 (0.306)		2.54 (0.014)		
	M3																							0	1.204 (0.233)			1.769 (0.082)	
	M4																								0				1.281 (0.206)
VER+	M1																									0	0.768 (0.444)	0.6 (0.549)	0.668 (0.505)
	M2																										0	-1 (0.321)	NA
	M3																											0	0.869 (0.389)
	M4																												0

🟨 The comparison results by different motivations over one single offset standard

☐ The comparison results of two offset standards within each motivation

🟫 The one-tail negative statistically significant difference of results between two motivations over the same offset standards

🟩 The negative statistically significant difference of results between offset standards purchased from the same motivation at 90% confidence intervals

🟥 The positive one-tail statistically significant difference of results between two offset standards purchased from the same motivation at 90% confidence intervals

Note: t-test results are from comparing the difference of the average number of projects (number of transactions) within the respective project offset standards, invested by companies driven by separate motivations.

Figure 4-13. T-test results of voluntary carbon offset standards and corporate motivations. *When we compare the differences of standards purchased, I always subtract the lower-priced offset standard from the higher-priced standard. Green cells indicate that corporates purchase more from offset standards with a higher average price. Rose-colored cells show that the preference over offset standards fits the assumption that buyers buy more offset standards due to the low price of the standards.*

Figure 4-13, again with similar trends as in the previous section, delivers four important messages for our paper.

First, motivations of company values and company market competitiveness drove companies to invest in offset standards either with a higher offset price or having more "charismatic" features, compared to companies with the motivation of carbon management and efficiency. In the boxes (yellow) of the three highest-priced offset standards with add-on co-benefits (Gold Standard, CCBS and ACR), there is a statistically significant difference at the number of offset standards being purchased by motivation-1 companies and motivation-2, motivation-3, motivation-4 companies. Companies were indifference in preference for offset standards when moving towards the right corner of the diagonal line (offset credit became cheaper with no add-on features are attached, and there is no statistically significant difference among these four motivations towards offset standards.)

Second, companies with the motivation of carbon management and efficiency were attracted by the low-priced offset standards, and they tended to purchase more offsets from this group of standards, namely VCS, CAR, and CDM. The average price of offset credits from this group is below \$2/tCO_2e. In the boxes (white) that only one or two rose-colored cells,[60] at least one of the rose-colored cells resided in the motivation-1 companies. Thus, when motivation-1 companies faced the investment decision between two offset standards, the one with a lower price had a higher chance to be chosen by motivation-1 companies.

---

[60] Rose-colored cell indicated that the lower-priced standard was chosen.

Third, Gold Standard offset credits were favored over other standards by all types of companies, with only one exception, when Gold Standard was compared to VCS by motivation-1 companies. There were two explanations. First, VCS is the most common standard in the voluntary carbon markets with a market share of 66 percent of total transacted credit volumes. Second, lower-priced VCS credits were favored by motivation-1 companies, and they intended to make a significant purchase.

Fourth, ACR, offering offset credits with environmental integrity and innovation at a higher price in the voluntary carbon markets, had an advantage in offset project investing, except when competing against more market-recognized standards, namely the Gold Standard and VCS.

Generally, corporate motivations show a large degree of consistency and orientation, which was aligned with the findings of the purchasing behavior on offset standards. Motivation-2, motivation-3, and motivation-4 companies were willing to invest more on offset projects with better add-on features, and willing to pay these offset credits at a higher price. While the investment decision of the motivation-1 companies was driven primarily by the low-priced factor. However, when facing the choice of a specific project type, they intend to invest in renewable energy projects, which are not only cheap but also can deliver on potential local co-benefits. Based on the observations from this sector, I believe that co-benefits might be woven into the fabric of corporate social responsibility and the decision-making process of offset projects.

5. Discussion

Table 4-6. Summary of findings.

Methods	Topic	Key finding
Qualitative	Motivation	Through the coding strategy, I was able to identify three primary motivations: Motivation 1: Company carbon management and efficiency (155 companies): Motivation 2: Company market competitiveness (60): Motivation 3: Company values (60):
	Corporate commitment	Corporates made their offset investment decisions and delivered benefits of these projects based through several channels: by establishing rigorous criteria for project selection, by choosing the focus of the projects, and by looking at specific benefits of that project. in these channels, a wide range of dimensions of the conceptualization of well-being and well-being outcomes are captured in local communities.
	Projects' Prospects	In the project narratives, "local" plays an essential role both from the breadth and depth of our findings.
	Role of project benefits for serving specific corporate motivations	I am able to close the gap by linking what the companies committed to doing, and whether it turned out to be the outcomes by how they support SDGs and how to make the global-to-local offset investment flows.
Quantitative	Motivation and project types	There are two opposite trends of offset investment due to the pricing signals. One trend is from the high-priced signal. By contrast, the other trend is from the low-priced signal. Corporate motivations show a large degree of consistency and orientation, which was aligned with the findings of the purchasing behavior on offset standards. Motivation-2, motivation-3, and motivation-4 companies were willing to invest more on offset projects with better add-on features, and willing to pay these offset credits at a higher price. While the investment decision of the motivation-1 companies was driven primarily by the low-priced factor. However, when facing the decision of choosing a specific project type, they tend to invest in renewable energy projects, which are not only cheap but also can deliver on potential local co-benefits.
	Motivation and project standards	

I have summarized our key findings in **Table 4-6**.

At the core of this analysis lies concerns of whether the offset investment will result in real and impactful co-benefits as companies claims in their CSR reports. The validation process made the flow from the claim-outcome possible. Results of corporate preference towards project types such as household device and forests, and offset certificates such as Gold Standard, were consistent with the literature.

However, it is somewhat surprising that renewable energy projects were not the favored when counting towards improving corporate values and market competitiveness. Additionally, the “local” dimension shows up in many aspects, both from corporate reports and CDP surveys. While it could be considered as an unexpected finding, I do not consider this finding conflicted with our main argument. On the contrary, the unexpected finding help perfecting our storytelling from different perspectives, and making the story with a strong, dynamic, three-dimensional feature.

Co-benefits of the offset investment have come to the fore as a key sustainable development topic. Looking forward, there are several trends and unresolved questions that will impact the investment decisions in the voluntary offset markets.

The findings from this study have some implications for corporate decision-makers, practitioners, and academicians. So far as I know, there is no known published research specifically studying the corporate motivation on offset investment through a deep-dive readout of CSR reports, and validating their behavior through the self-report CDP survey.

Nevertheless, my study has several limitations due to data constraints. My qualitative approach of the mixed method relied solely on corporate CSR reports. Although I used the project-level data to validate the quality of information companies have claimed in CSR reports on certain aspects, I have to acknowledge that the results from this study could be biased. It cannot deliver a full picture of the corporate offset investment decision. This is because our assessment only relied on the self-reported information provided by companies. For those companies that chose not to provide information on their offset purchases, I was not able to access and evaluate their motivations. Additionally, there is no standardized format for CSR reports, which might cause some assessment errors during the coding process. However, regardless of these aforementioned limitations, I am confident that the findings are still rigorous and generalizable to the offset investment market.

Findings from this study show several focal areas for future research and benefit corporate decision-makers and academicians. Studies on corporate motivations can be conducted through interviews with a group of targeted companies from our three motivation categories will reveal insights into their behavior directly. Or a study of those companies who didn't mention their offset investment in their CSR reports might add some new information that I am not able to identify from my studies. Additional research can study corporate choices through a choice model to generalize the traditional used discrete choice model, with quantitative statistical models employed to explain corporate offset investment decisions

For corporate CSR strategists, there may be gaps in the types of benefits accruing in places that need them. **Figure 4-2** shows the global distribution of project types, which tells us that regions such as Africa, might need a diversity of project types to further assist their sustainable development. Regardless of how household device projects can bring better co-benefits to local communities, projects such as renewable energy projects are still needed in this region. With the willingness to pay from companies towards projects with higher co-benefits, and lower prices of offset credits from renewable energy projects, companies can shift the courses of their investment strategy but still obtaining a similar positive impact contributing company values and market competitiveness.

6. Conclusion

In this paper, I presented a full set of motivations for corporate offset project investments. All of the four motivations revolve around their underlying desire to receive both financial and social returns on their investments. The findings from our paper confirmed the two hypotheses at the beginning of this paper. Companies with incentive simply to cut emission reductions are motivated to purchase cost-effective offset projects. While companies with motivations from non-emission impacts value co-benefits more, and they are willing to pay more to fulfill these impacts. Additionally, this paper demonstrates that companies with additional motivations (motivation 2, 3, 4) placed a high value on offset projects or offset certificates with more co-benefits in local communities.

The mixed-method approach provides a valid tool to study the motivations for corporate offset investment decisions and interaction between motivations and specific characteristics of purchasing behaviors. The results from our analysis further accomplish our original assumption that corporates with motivations from non-emission impact values co-benefits more, and they are willing to pay more for certain project types or offset certificates.

Another theme of this paper touches on many aspects of corporate investment behavior towards project benefits and is significant for the incorporation of co-benefits in local communities into the offset investment strategy. Given the huge amount of finance available, this study shows that understanding how corporate motivations could potentially support better policy design is a useful approach to encouraging additional investment in those kinds of areas.

Appendix A Assessing Balance of Two Different Groups of Companies

Group 1: Motivation 1

Group 2: Motivation 2, 3, and 4

I adopted the standardized differences technique, which is the difference in terms of standard deviations (SD), to assess the difference between these two groups (Lunt, 2014). if there is no big difference between these two groups, I can conclude that there is adequate balance between these two groups of companies.

Table 4-7. Checking balance of confounders between group 1 and group 2 (year of 2018).

	Mean in Group 1	Mean in Group 2	Standardized diff.
Employees	36356.97	60816.61	-0.325
Total Assets	243376.22	101344.96	0.360
Annual Revenue	19087.94	19063.61	0.001*
Net Income	2310.24	1923.35	0.082*
Operation	3088.30	3145.80	-0.006*
Credits (sum)	44562.79	193160.56	-0.323
Target dummy	0.92	0.96	-0.139
Carbon pricing dummy	0.41	0.56	-0.294
Number of Projects	2.10	3.40	-0.545
Investing	-5049.74	-2008.19	-0.186
Total emission*	1561738.95	4530981.14	-0.315

*Standardized differences < 0.1 indicate adequate balance. Standardized differences are the standardized difference of means.

I ran the standardized differences test and present the results in **Table 4-7**. The test results show us that group 1 and group 2 differ by less than 0.1 SD in Annual Revenue, Net Income, and Operation of year 2018.

Table 4-8. Regression results of offset prices.

Regression results: Internal Carbon Price for Offsets of 2018

	Model 1 (Linear)	Model 2 (Log)
Number of Projects	-1.071	-0.243
	(0.612)	(0.172)
Total Assets	-0.00000176	-0.000000619
	(0.00000601)	(0.00000169)
EMPLOYEES	-0.0000372	-0.0000101
	(0.0000376)	(0.0000106)
Annual Revenue	-0.0000688	-0.00000542
	(0.000149)	(0.0000420)
Net Income	0.000100	0.0000674
	(0.000769)	(0.000217)
Operating	-0.000149	-0.0000271
	(0.000153)	(0.0000431)
Investing	-0.000258	-0.0000421
	(0.000215)	(0.0000605)
Credits Purchased	-0.00000221	-0.000000828
	(0.00000316)	(0.000000892)
Total Emission	0.000000212	1.60e-08
	(0.000000370)	(0.000000104)
Country FE	Yes	yes
Sector FE	Yes	yes
Observations	37	37
R-Square	0.2482	0.2149

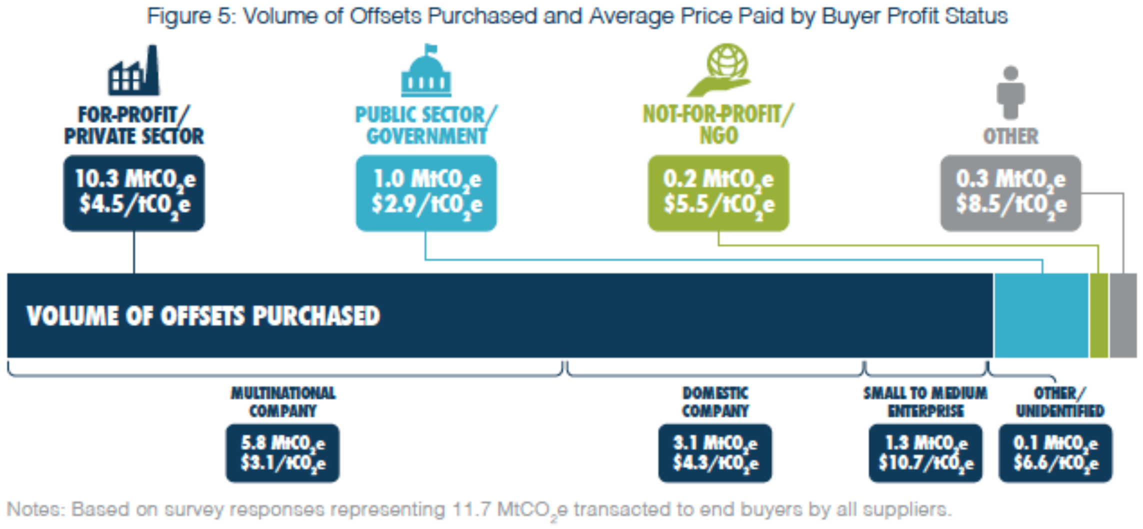
Note: The dependent variable in is Offset price in Model 1 and is natural log of offset price in Model 2. Offset prices are available at the corporate level. They are average offset prices of different projects in each company. Coefficient estimates are reported in this table. I control for company location fixed effects, company sector fixed effects.

* p<0.10   ** p<0.05   *** p<0.01

Table 4-9. Summary of offset price and shadow price of carbon.

Variable	Obs	Mean	Std. Dev.	Min	Max
Offset price ($US)	37	4.085115	2.95946	.304	13.1307
Shadow price ($US)	40	311.6317	1453.178	6.08	9100

Appendix B Supporting Material



Source: State of the Voluntary Carbon Markets 2017 Buyers Analysis

Figure B 4-1. Volume of offsets purchased, and average price paid by buyer profit status.

Table B 4-1. Comparison of the purchased offset volumes between the final sample and deleted sample.

Corporate Number	***186 (sample of interest)***	***120 (deleted)***
Mean	32,798.66	9,932.23
Standard Error	3,969.20	2,245.83
Median	8,204.00	629.65
Standard Deviation	88,309.18	26,477.91
Sample Variance	7,798,510,594.72	701,079,680.54
Minimum	-	0.30
Maximum	1,269,582.00	167,097.00
Sum	16,235,337.22	1,380,579.62
Projects	534.00	139.00

Units: metric tons CO_2e

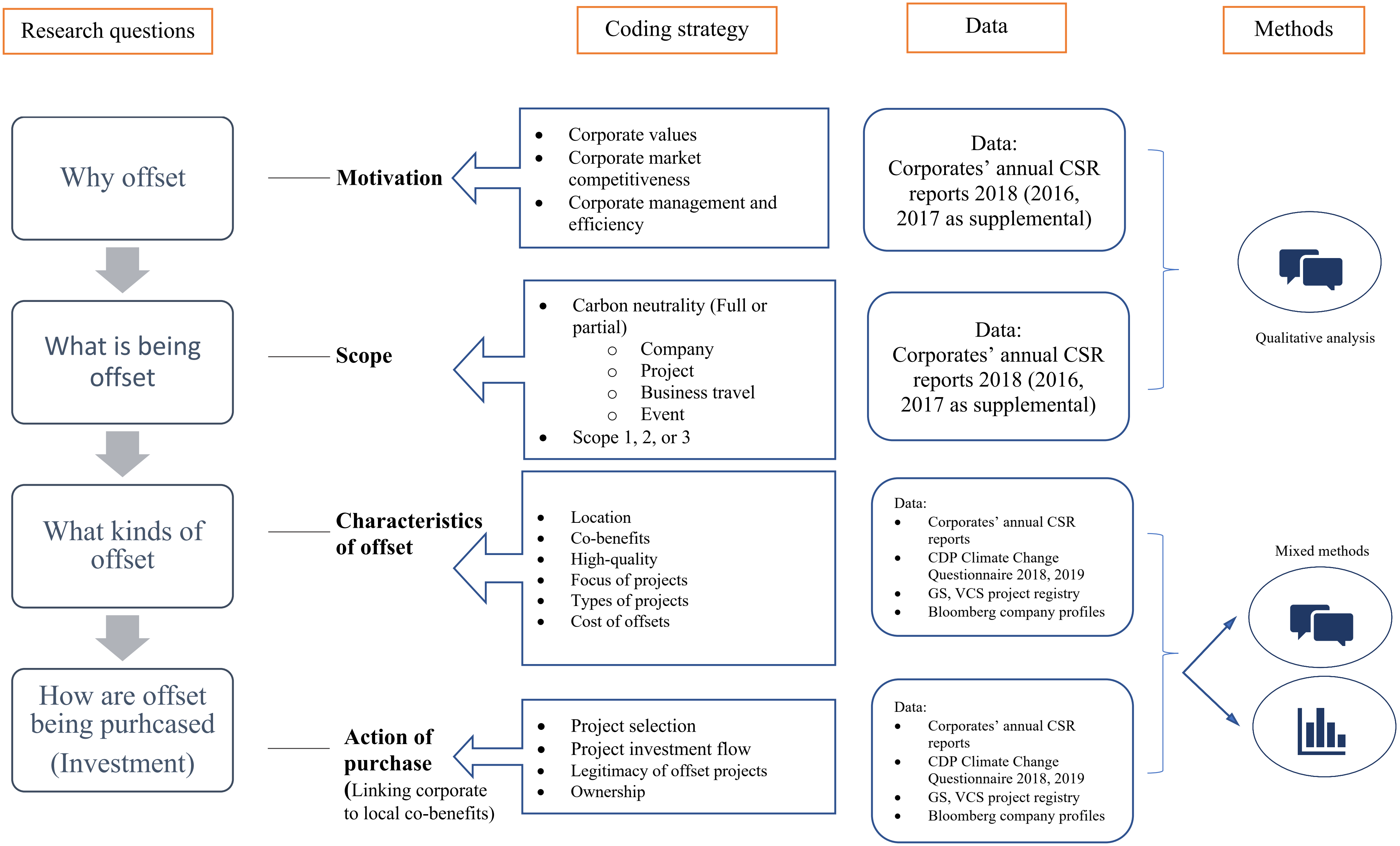


Figure B 4-2. Content analysis approach for evaluation of CSR carbon offset.

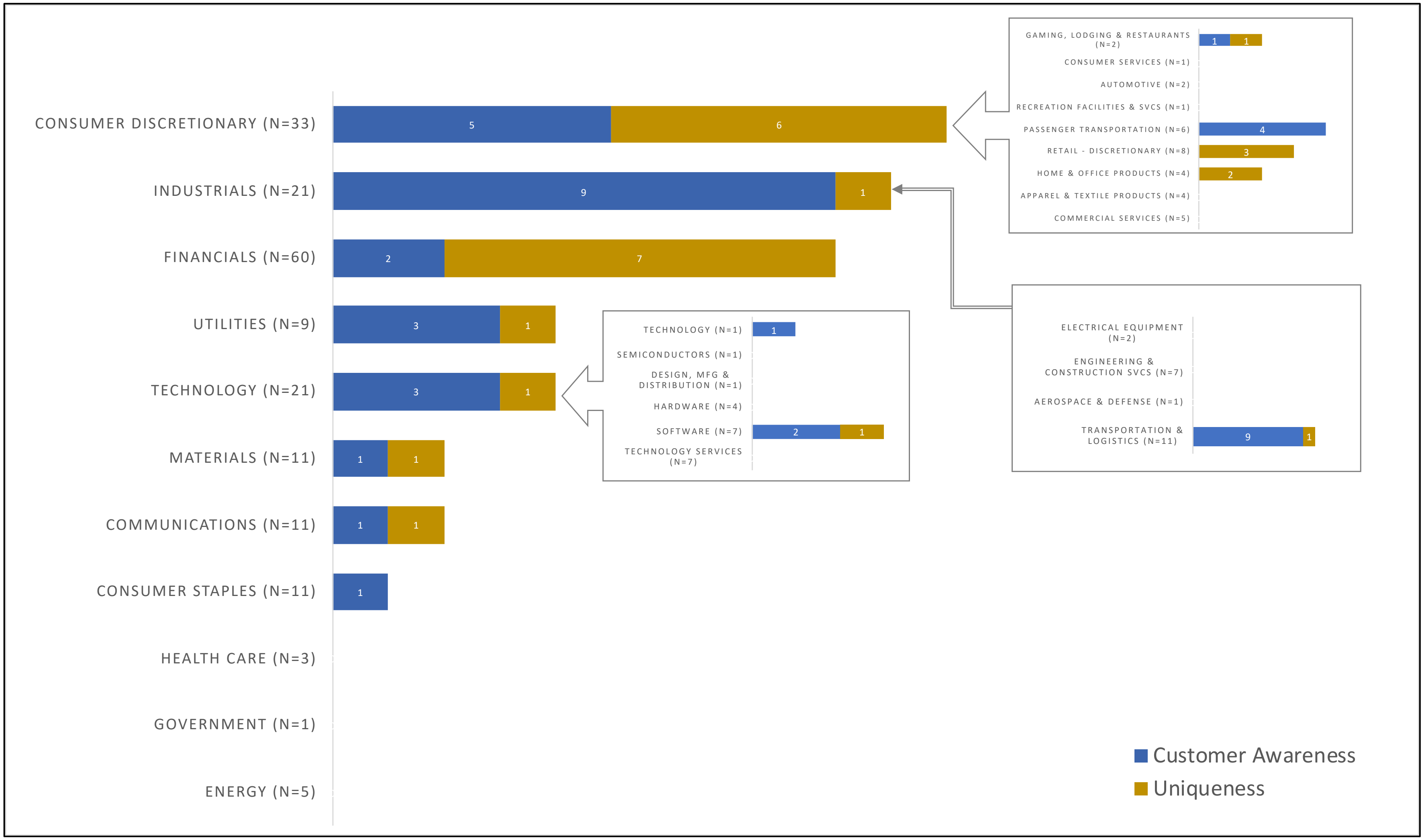


Figure B 4-3. Taking voluntary offset programs as corporate branding strategy (by sector and by industry). *Different industries brand differently and participate at different levels.*

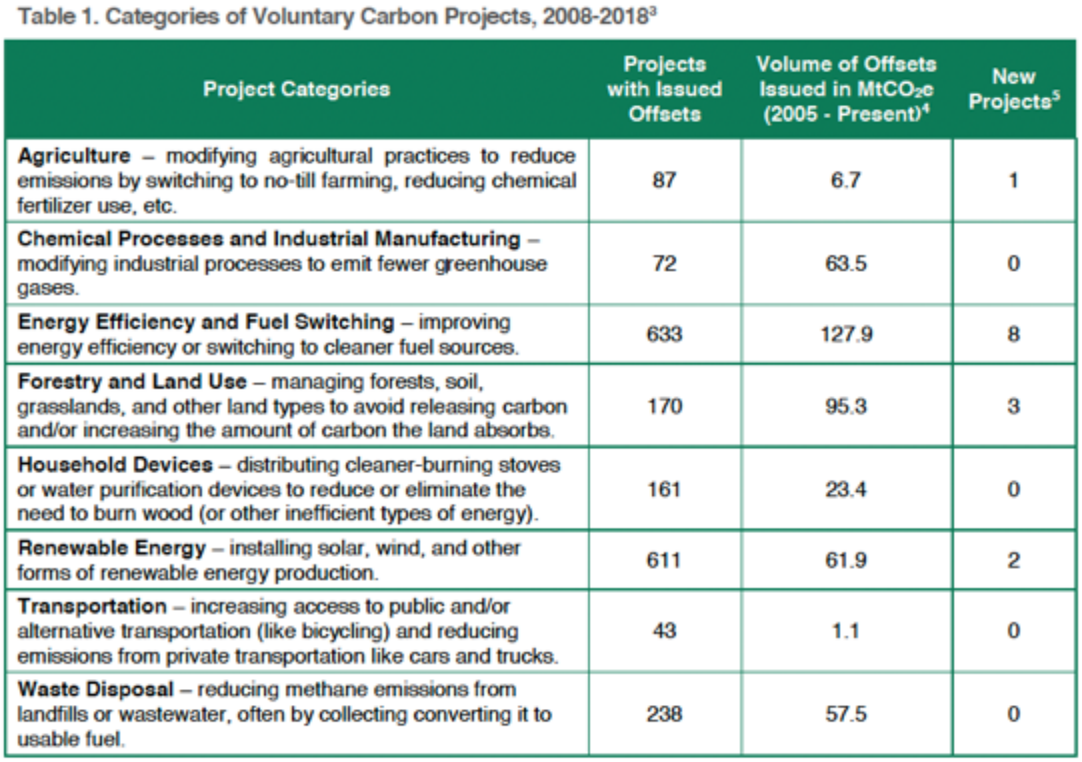
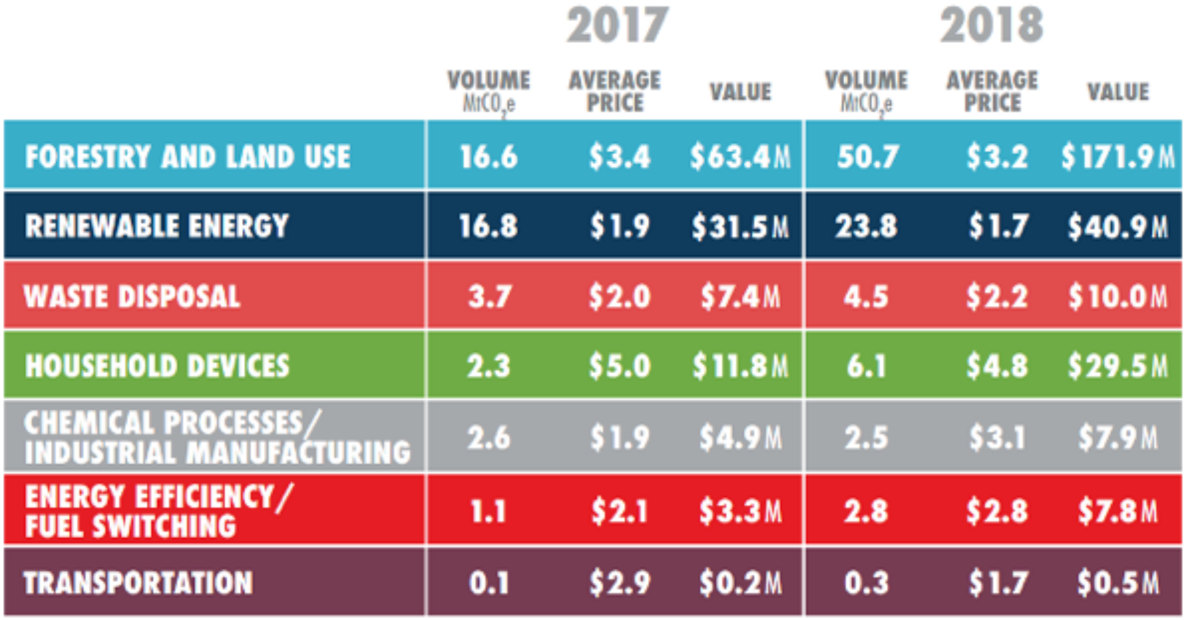


Table 1. Categories of Voluntary Carbon Projects, 2008-2018[3]

Project Categories	Projects with Issued Offsets	Volume of Offsets Issued in MtCO$_2$e (2005 - Present)[4]	New Projects[5]
Agriculture – modifying agricultural practices to reduce emissions by switching to no-till farming, reducing chemical fertilizer use, etc.	87	6.7	1
Chemical Processes and Industrial Manufacturing – modifying industrial processes to emit fewer greenhouse gases.	72	63.5	0
Energy Efficiency and Fuel Switching – improving energy efficiency or switching to cleaner fuel sources.	633	127.9	8
Forestry and Land Use – managing forests, soil, grasslands, and other land types to avoid releasing carbon and/or increasing the amount of carbon the land absorbs.	170	95.3	3
Household Devices – distributing cleaner-burning stoves or water purification devices to reduce or eliminate the need to burn wood (or other inefficient types of energy).	161	23.4	0
Renewable Energy – installing solar, wind, and other forms of renewable energy production.	611	61.9	2
Transportation – increasing access to public and/or alternative transportation (like bicycling) and reducing emissions from private transportation like cars and trucks.	43	1.1	0
Waste Disposal – reducing methane emissions from landfills or wastewater, often by collecting converting it to usable fuel.	238	57.5	0

Source: Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends

Figure B 4-4. Categories of voluntary carbon projects (external source from forest trend report).



	2017			2018		
	VOLUME MtCO$_2$e	AVERAGE PRICE	VALUE	VOLUME MtCO$_2$e	AVERAGE PRICE	VALUE
FORESTRY AND LAND USE	16.6	$3.4	$63.4M	50.7	$3.2	$171.9M
RENEWABLE ENERGY	16.8	$1.9	$31.5M	23.8	$1.7	$40.9M
WASTE DISPOSAL	3.7	$2.0	$7.4M	4.5	$2.2	$10.0M
HOUSEHOLD DEVICES	2.3	$5.0	$11.8M	6.1	$4.8	$29.5M
CHEMICAL PROCESSES/ INDUSTRIAL MANUFACTURING	2.6	$1.9	$4.9M	2.5	$3.1	$7.9M
ENERGY EFFICIENCY/ FUEL SWITCHING	1.1	$2.1	$3.3M	2.8	$2.8	$7.8M
TRANSPORTATION	0.1	$2.9	$0.2M	0.3	$1.7	$0.5M

Sources: Forest Trends' Ecosystem Marketplace, State of the Voluntary Carbon Markets 2019

Figure B 4-5. Offset prices vary among project types.

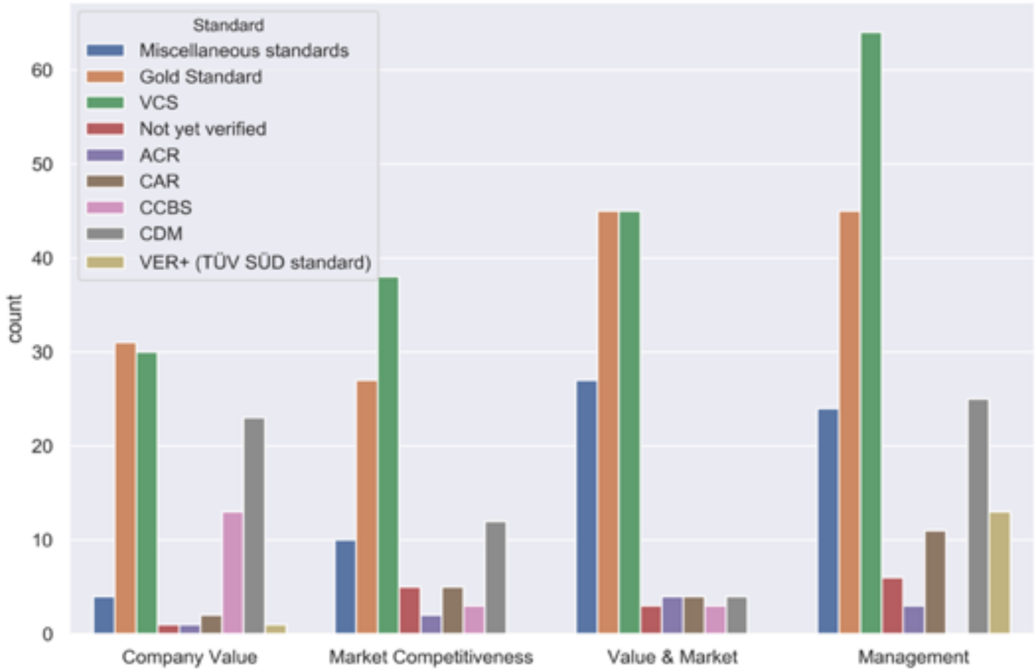


***Figure B 4-6. Distribution of voluntary carbon offset standards by motivations**. Gold Standard (certifies positive co-benefits) and CCBS (certifies positive social and biodiversity impacts) appear more in the motivation of "company value", while in "management" where VCS is the dominant standard.*

Figure B 4-7. Tree map of "local". *"Local" places a big role in narratives about projects.*

Table B 4-2. ***Corporate commitment of global-to-local offset investment.***

Corporate	Commitment	Area
Atos SE	The investments made by Atos every year since 2014 contribute to the reduction of greenhouse gases emissions from the electricity mix in India, a key region for Atos.	key region (India)
Australia and New Zealand Banking Group	We continue to invest in carbon offset projects which deliver meaningful and positive environmental and social impacts and improve the lives of people living in communities across the markets in which we operate.	Markets in which we operate
Avianca Holdings S. A.	In 2018, we offset the impact of the emissions generated by our operations in Colombia, through the purchase of carbon credits, involving certified high impact social and environmental investment projects in the country.	Key region (Colombia)
Delta Air Lines	For our carbon offset portfolio, we ensure that these offsets not only have verified emissions reduction, but also advance the United Nations Sustainable Development Goals in areas that Delta serves.	Areas that Delta serves
Desjardins Group	We've been carbon neutral since 2017, through our purchase of carbon offset credits in several provinces. These carbon credits have been verified by a third party. We carefully vetted these offsets to make sure that they benefit the environment, local communities, young people, as well as our members and clients.	Members and clients
ENAGAS	For the first time, Enagás has offset part of its 2017 footprint emissions with credits generated by emissions reduction projects developed in the countries where it operates, Peru and Chile, which also involve an improvement of environmental and social impact on local communities.	Countries where it operates (Chile and Peru)
Goldman Sachs Group Inc.	In 2018, we again achieved our carbon neutrality commitment through the implementation of our Carbon Reduction Framework, …high-quality certified carbon offsets that support the growth of renewable energy markets where we operate.	Markets in which we operate
Insurance Australia Group	We remain carbon neutral by purchasing offsets from projects in our markets that help us make communities safer and more resilient. Information is available on our website.	Projects in our markets
Lenovo Group	In FY 2017/18, Lenovo partnered with ClimeCo and purchased 10,000 MT CO_2 e of carbon offsets, 35,000 MWh of Green-e Energy certified RECs, 45,000 MWh of I-RECs and 6,500 MWh of GOs, which supported 100 percent renewable energy projects in China (wind), Europe (wind) and the U.S. (wind). These renewable commodities were in addition to local purchases by Lenovo's sites.	Lenovo's local sites
Marui Group Co., Ltd.	Since 2014, we have been conducting carbon offset initiatives in disaster-stricken areas as well as in the areas that produce material for our shoes, the areas in which we open new stores, and other areas that benefit local customers.	Areas that provide raw material
MetLife	To offset the greenhouse gas emissions that we cannot reduce in the short term, we support a diverse portfolio of emissions-reduction and renewable energy generation projects in countries where we operate around the world.	Countries where it operates
Microsoft	Carbon offset community project investment criteria: Geographical coverage—We prioritize investments in projects with local proximity to our datacenter.	local proximity to our datacenter
Natura Cosmetics SA	Six calls for proposal were issued from 2007 to 2018, resulting in the contracting of 38 projects, of which 32 were in Brazil and six in the countries in which we operate in Latin America: Argentina, Chile, Colombia, Mexico and Peru.	Brazil and Latin America
Nedbank Limited	We seek to offset the remaining carbon through carbon credits from projects that demonstrate the biggest potential to benefit the natural heritage and social structure of Africa.	Africa

S&P Global	Through a new program to offset our GHG emissions, S&P Global is supporting these efforts toward a low-carbon economy in emerging countries where we do significant business. Channeling renewable energy into India's vast national grid. Replacing traditional cook stoves to improve living conditions in Kenya.	Countries where we do significant business
SGS SA	The associated economic benefit of our carbon neutrality approach. Any carbon that we cannot eliminate from our operations is offset through investments in clean energy projects that deliver both social and environmental benefits in communities where SGS operates.	Communities where SGS operates
Sthree Plc	Through carbon offsetting we have a positive environmental, economic, health and education impact in a community where we are already empowering change through STEM education. We have offset our 2018 carbon emissions with two projects, one of which is in Ghana close to our strategic partner the African Science Academy.	Strategic partner
Tiffany & Co.	In 2017, we invested in carbon offsets from Kenya's Chyulu Hills to help meet our climate goals and promote sustainable development in an area of the world where we source colored gemstones and where we support wildlife conservation.	Where we source colored gemstones
Verisk Analytics Inc	Verisk's greenhouse gas emissions were balanced 100 percent by our purchase of renewable energy certificates (RECs) and carbon offsets. We support renewable energy projects in almost every country or region where we have offices.	Local offices
Worldline	Through this program, in 2016 Worldline financed the installation of 200 wind turbines and thus supported the development of a wind farm in India, home to 6% of the company's employees.	India, home to 6% of the company's employees.

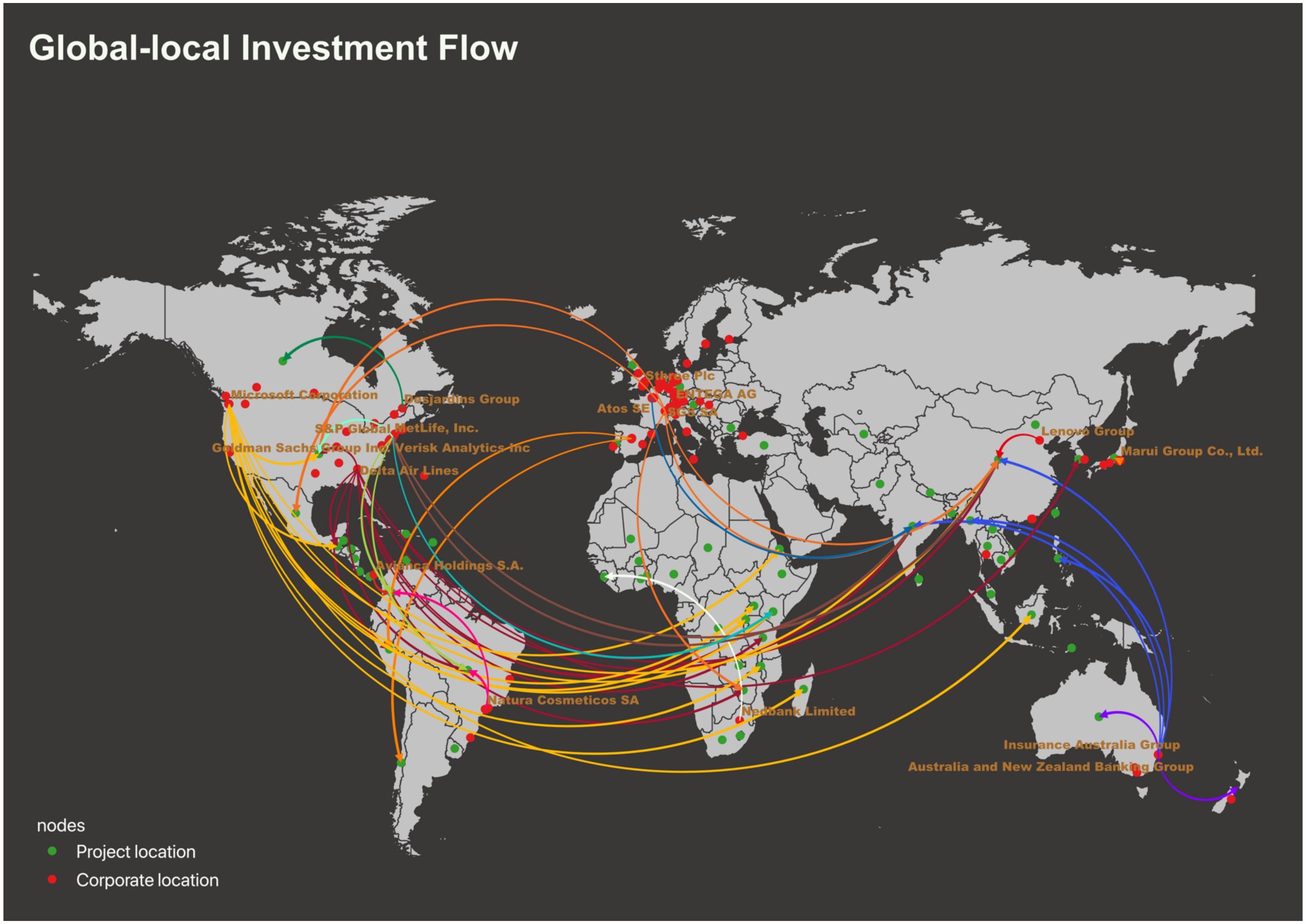


Figure B 4-8. Full map of global-to-local offset investment flow. *This map includes 20 companies with their 92 purchased offset projects.*

Chapter 5 Conclusion

The pathway of low-carbon development present both challenges and opportunities for the developing world. Unlike the developed world, these developing countries are facing multiple challenges in the new course. They must prioritize promoting high-quality economic development, maintaining economic, financial and energy security, protecting environment and controlling carbon emissions, while facing limited sources. As a result, many of these priorities, yet could play an important role in long-term development strategies, are competing with each other in the short-term with resources. This limits their capacity today and create uncertainly about viability in the long run. On the other hand, the low-carbon development pathway could help the developing world to create real opportunities to achieve real sustainable growth and reduce emissions at a lower cost and in a shorter period of time.

Co-benefits of climate finance are the backbone of a green and low-carbon development of the developing world, which serves as a solution to fix those aforementioned challenges and accelerate the low-carbon transition. As a result, concerted international efforts, national policies, and individual actions are urgently needed to be on the ground. However, how the climate finance market values co-benefits remains poorly understood. By focusing on local co-benefits, this research highlights the importance of valuing co-benefits where projects are located, and how these projects deliver impacts for local communities.

In 2018, global market capitalization was about $68 trillion,[61] and the $3 trillion asset value of 186 corporates represented about 4 percent of market capitalization. Channeling available finance to offset projects that benefit local communities is a must.

However, we need new courses of action that deliver on the ground.

My research shows that in the CDM context, a project with a likelihood of delivering more co-benefits receives a higher CER price from the buyer. The price differences between projects with the highest co-benefits and lowest co-benefits is $4.9 /tCO$_2$e on average or a difference of 27.6 percent. The large variability in the price of CERs partially comes from the buyer's location. and project location, while prices of CERs do not differ based on buyers' profit status, sectors, or number of projects they hosted. In the quality branding context, I see that quality control indicators (particularly, the independently generated label of "Gold Standard") have a significant effect on CER prices with a price premium in the range of $1.13/tCO$_2$e to $4.2/tCO$_2$e. Additionally, I see a strong commitment from public finance in delivering co-benefits in the local commitment by paying a price premium to projects with a Gold Standard certification. In the voluntary carbon markets, I find that corporate motivations show a large degree of consistency and orientation, which was aligned with the findings of the purchasing behavior on offset standards. Companies with a primary motivation to reduce emissions will prioritize purchasing cost-effective offset projects. While companies with primary motivations from non-emission impacts (such as company values or company market competitiveness) value co-benefits more, they are willing to pay more to fulfill these impacts.

---

[61] World Bank Data, Market capitalization of listed domestic companies (current USD).

From the results of my three essays, I see a transition in the private sector. A transition from compliance carbon markets to voluntary carbon markets, a transition from public finance to private finance, and a transition from pure emission reductions to sustainable investments. I see that the private sector is to ready to advance on this new course. I see that co-benefits, although still are under-estimated, play a critical role in delivering a better growth and a better climate into reality.

Our contribution is that I find that buyers are willing to pay a price premium of projects with higher co-benefits in the market. Previous research focus on emphasizing the importance of integrating sustainable development elements into the infrastructure investment, but none of the previous research actually using the market itself to study whether these co-benefits are valued by market actors or not. If market actors value the co-benefits, and willing to pay the price premium for these co-benefits. It in turn can encourage project developers to integrating co-benefits at the project design stage. This dissertation contributes to the research community by bringing together empirical evidence and qualitative analysis, learning from the real-world experiences from both the public and private sectors.

By using the carbon markets as a case study, I do find that market behavior in the areas of carbon finance do value co-benefits. In the compliance carbon markets, public actors are more responsive to projects with more benefits by paying a price premium. While in the voluntary carbon markets, although at a small scale, private actors with primary motivations from company value and market competitiveness intend to value co-benefits more, and they are willing to pay more to fulfill these impacts. However, some private actors with a primary motivation to cut emission reductions still prioritize purchasing cost-effective offset projects at a lower cost.

More importantly, these three essays can contribute to the original research motivation of this dissertation, sustainable infrastructure, in the following three ways:

First, by creating the SDG-interaction score system, using this system in one specific context (carbon markets), and validating the legitimate and effectiveness of the scoring system empirically, I think we are able to apply this system into a broader climate finance world, and also in sustainable infrastructure investments.

Second, by identify the market value of one policy mechanism, quality branding in both the compliance and voluntary markets, I think it is possible to transfer this mechanism of quality branding to sustainable infrastructure investment. Using public finance, such as support from the development bank platforms, we can create a similar mechanism to showcase the idea of integrating sustainable development benefits into the infrastructure in the real world. If the concept of the sustainable infrastructure in real project development can be approved, we believe it can give the institutional investors the real exposure to this new asset class.

Third, by differentiating corporate motivations into different levels and linking these motivations to their decision-making process. We are able to mobilize private sector financing for sustainable infrastructure more specifically. Additionally, we should create a similar motivation mapping exercise for institutional investors and using motivations to mobilize them to invest in sustainable infrastructure strategically.

This dissertation seeks to inform policy decision-makers in the public sector and corporate decision-makers in the private sector, many of whom recognize the envisaged transition towards a sustainable low-carbon society necessitates the deployment of climate finance and realization of sustainability goals simultaneously in the effort of combating the climate change.

By placing my research proposition in the content of local co-benefits, I am emphasizing the importance of valuing co-benefits where these projects are located, and how these projects deliver impacts on local communities. Thus, residents from local communities can co-live with these sustainable infrastructure for years.

Empowering the local communities through generating co-benefits that closely related to the households, that have a direct positive impact on them, and that enable the fundamental societal and systems transformation, is key to make climate finance sustainable.

References

Alexeew, J., Bergset, L., Meyer, K., Petersen, J., Schneider, L., 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, 233–248. https://doi.org/10.1007/s10784-010-9121-y

Anderson, B., Bernauer, T., 2016. How much carbon offsetting and where? Implications of efficiency, effectiveness, and ethicality considerations for public opinion formation. Energy Policy 94, 387–395. https://doi.org/10.1016/j.enpol.2016.04.016

Anja, K., 2007. Carbon Offsets 101 20.

Araghi, Y., Kroesen, M., Molin, E., Van Wee, B., 2016. Revealing heterogeneity in air travelers' responses to passenger-oriented environmental policies: A discrete-choice latent class model. International Journal of Sustainable Transportation 10, 765–772. https://doi.org/10.1080/15568318.2016.1149645

Arezki, R., RArezki@imf.org, Bolton, P., PBolton@imf.org, Peters, S., SPeters@imf.org, Samama, F., FSamama@imf.org, Stiglitz, J., JStiglitz@imf.org, 2016. From Global Savings Glut to Financing Infrastructure: The Advent of Investment Platforms. IMF Working Papers 16, 1. https://doi.org/10.5089/9781475591835.001

Ascui, F., Moura Costa, P., 2007. CER Pricing and Risk. UNEP.

Ban Ki-moon Centre for Global Citizens, 2018. Ban Ki-moon delivers a speech on "The UN and Global Citizenship" at the 3rd Asia Leadership Forum. Ban Ki-moon Centre for Global Citizens.

Bayon, R., Hawn, A., Hamilton, K. (Eds.), 2009. Voluntary carbon markets: an international business guide to what they are and how they work, 2nd ed. ed. Earthscan, London ; Sterling, VA.

Ben-Amar, W., McIlkenny, P., 2015. Board Effectiveness and the Voluntary Disclosure of Climate Change Information: BOARD Effectiveness and Voluntary Climate Change Disclosures. Bus. Strat. Env. 24, 704–719. https://doi.org/10.1002/bse.1840

Bergqvist, M., Lindgren, C., 2014. Environmental, social or economic sustainability: what motivates companies to offset their emissions? Umeå School of Business and Economics.

Bhattacharya, A., Meltzer, J.P., Oppenheim, J., Qureshi, Z., Stearns, N., 2016. Delivering on Sustainble Infrastructure for Better Development and Better Climate.

Bielenberg, A., Kerlin, M., Oppenheim, J., Roberts, M., 2016. Financing change: How to mobilize private- sector financing for sustainable infrastructure. McKinsey Center for Business and Environment.

Bishop, V., 2007. Strategies for Maximizing Carbon Value. UNEP.

Blasch, J., 2013. Consumers' Valuation of Voluntary Carbon Offsets - A Choice Experiment in Switzerland.

Borges da Cunha, K., Walter, A., Rei, F., 2007. CDM implementation in Brazil's rural and isolated regions: the Amazonian case. Climatic Change 84, 111–129. https://doi.org/10.1007/s10584-007-9272-1

Boyd, E., Hultman, N., Timmons Roberts, J., Corbera, E., Cole, J., Bozmoski, A., Ebeling, J., Tippman, R., Mann, P., Brown, K., Liverman, D.M., 2009. Reforming the CDM for sustainable development: lessons learned and policy futures. Environmental Science & Policy 12, 820–831. https://doi.org/10.1016/j.envsci.2009.06.007

Brundtland Commission, 1987. Report of the World Commission on Environment and Development: Our Common Future. Accessed Feb 10.

Caliendo, M., Kopeinig, S., 2008. SOME PRACTICAL GUIDANCE FOR THE IMPLEMENTATION OF PROPENSITY SCORE MATCHING. Journal of Economic Surveys 22, 31–72. https://doi.org/10.1111/j.1467-6419.2007.00527.x

Castro, P., Michaelowa, A., 2008. Empirical analysis of performance of CDM projects. Climate Strategies, London.

Choi, A.S., Ritchie, B.W., 2014. Willingness to pay for flying carbon neutral in Australia: an exploratory study of offsetter profiles. Journal of Sustainable Tourism 22, 1236–1256. https://doi.org/10.1080/09669582.2014.894518

Cogeco Inc., 2018. Cogeco Inc._CSR_REPORT_2017.pdf.

Cole, J.C., Roberts, J.T., 2011. Lost opportunities? A comparative assessment of social development elements of six hydroelectricity CDM projects in Brazil and Peru. Climate and Development 3, 361–379. https://doi.org/10.1080/17565529.2011.623831

Conte, M.N., Kotchen, M.J., 2010. Explaining the Price of Voluntary Carbon Offsets. Climate Change Economics 01, 93–111. https://doi.org/10.1142/S2010007810000091

Corbera, E., Estrada, M., Brown, K., 2009. How do regulated and voluntary carbon-offset schemes compare? Journal of Integrative Environmental Sciences 6, 25–50.

Creswell, J.W., Clark, V.L.P., 2017. Designing and Conducting Mixed Methods Research. SAGE Publications.

Crowe, T.L., 2013. The potential of the CDM to deliver pro-poor benefits. Climate Policy 13, 58–79. https://doi.org/10.1080/14693062.2012.709080

Dechezleprêtre, A., Glachant, M., Ménière, Y., 2008. The Clean Development Mechanism and the international diffusion of technologies: An empirical study. Energy Policy 36, 1273–1283. https://doi.org/10.1016/j.enpol.2007.12.009

Dhanda, K.K., Hartman, L.P., 2011. The Ethics of Carbon Neutrality: A Critical Examination of Voluntary Carbon Offset Providers. J Bus Ethics 100, 119–149. https://doi.org/10.1007/s10551-011-0766-4

Dirix, J., Peeters, W., Sterckx, S., 2016. Is the Clean Development Mechanism delivering benefits to the poorest communities in the developing world? A critical evaluation and proposals for reform. Environment, Development and Sustainability 18, 839–855. https://doi.org/10.1007/s10668-015-9680-8

Disch, D., 2010. A comparative analysis of the ‘development dividend’ of Clean Development Mechanism projects in six host countries. Climate and Development 2, 50–64. https://doi.org/10.3763/cdev.2010.0034

Drupp, M.A., 2011. Does the Gold Standard label hold its promise in delivering higher Sustainable Development benefits? A multi-criteria comparison of CDM projects. Energy Policy 39, 1213–1227. https://doi.org/10.1016/j.enpol.2010.11.049

Dufrasne, G., 2018. COP24 overshadowed by market failure as countries fail to agree on basic accounting principles and the future of the CDM. Carbon Market Watch. URL https://carbonmarketwatch.org/2018/12/15/cop24-overshadowed-by-market-failure-as-countries-fail-to-agree-on-basic-accounting-principles-and-the-future-of-the-cdm/ (accessed 12.20.18).

EcoRodovias Infraestrutura e Logística SA, 2019. EcoRodovias Infraestrutura e Logística SA_Sustainability Report Ecorodovias 2018.pdf.

Ellis, J., Winkler, H., Corfee-Morlot, J., Gagnon-Lebrun, F., 2007. CDM: Taking stock and looking forward. Energy Policy 35, 15–28. https://doi.org/10.1016/j.enpol.2005.09.018

Eloff, I., 2019. Handbook of Quality of Life in African Societies. Springer.

Evans, S., Timperley, J., 2018. COP24: Key outcomes agreed at the UN climate talks in Katowice [WWW Document]. Carbon Brief. URL https://www.carbonbrief.org/cop24-key-outcomes-agreed-at-the-un-climate-talks-in-katowice (accessed 12.20.18).

Forest Trends' Ecosystem Marketplace, 2019. Financing Emissions Reductions for the Future: State of the Voluntary Carbon Markets 2019. Forest Trends, Washington D.C.

Freeman, A., Herriges, J., Kling, C., 2014. The Measurement of Environmental and Resource Values: Theory and Methods, 3rd Edition. ed. RFF Press, Washington, D.C.

Freeman, O.E., Zerriffi, H., 2012. Carbon credits for cookstoves: Trade-offs in climate and health benefits. The Forestry Chronicle 88, 600–608.

Gao, G., Li Liyan, 2007. Initial Thoughts on Equitable CER Prices: The View from China. UNEP.

Garrido, M.M., Kelley, A.S., Paris, J., Roza, K., Meier, D.E., Morrison, R.S., Aldridge, M.D., 2014. Methods for Constructing and Assessing Propensity Scores. Health Services Research 49, 1701–1720. https://doi.org/10.1111/1475-6773.12182

GCEC, 2016. The Sustainable Infrastructure Imperative. The Global Commission on the Economy and Climate, The New Climate Economy, Washington, D.C.

Gibson, R.B., 1999. Voluntary Initiatives and the New Politics of Corporate Greening. University of Toronto Press.

Glazerman, S., Levy, D.M., Myers, D., 2003. Nonexperimental Versus Experimental Estimates of Earnings Impacts. The ANNALS of the American Academy of Political and Social Science 589, 63–93. https://doi.org/10.1177/0002716203254879

Global CCS Institute, 2011. Developing CCS projects under the Clean Development Mechanism. Global CCS Institute.

Gold Standard, 2019. Gold Standard Market Report 2018.

Gold Standard, 2014. The Real Value of Robust Climate Action: Impact Investment Far Greater than Previously Understood. The Gold Standard Foundation, Geneva-Cointrin Switzerland.

Goldstein, A., 2016. Buying in: Taking Stock of the Role of Carbon Offsets in Corporate Carbon Strategies. Forest Trends' Ecosystem Marketplace.

Goldstein, A., 2015. Bottom Line: Taking Stock of the Role of Offsets in Corporate Carbon Strategies,. Forest Trends' Ecosystem Marketplace.

Goldstein, A., Hamrick, K., 2015. Sharing the Stage: State of the Voluntary Carbon Markets 2014. Forest Trends' Ecosystem Marketplace.

Goldstein, A., Turner, W.R., Gladstone, J., Hole, D.G., 2019. The private sector's climate change risk and adaptation blind spots. Nature Climate Change 9, 18–25. https://doi.org/10.1038/s41558-018-0340-5

Hamrick, K., 2017. Unlocking Potential: State of the Voluntary Carbon Markets 2017. Forest Trends' Ecosystem Marketplace.

Hamrick, K., 2016. Raising Ambition: State of the voluntary carbon markets 2016. Forest Trends' Ecosystem Marketplace.

Hamrick, K., Gallant, M., 2018. Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends. Forest Trends' Ecosystem Marketplace.

Haya, B., 2007. Failed mechanism: How the CDM is subsidizing hydro developers and harming the Kyoto Protocol. International Rivers, Berkeley, California.

Haya, B., Parekh, P., 2011. Hydropower in the CDM: Examining additionality and criteria for sustainability (Energy and Resources Group Working Paper ERG-11-001.). University of California, Berkeley.

Hinnen, G., Hille, S.L., Wittmer, A., 2017. Willingness to Pay for Green Products in Air Travel: Ready for Take-Off?: Willingness to Pay for Green Products in Air Travel. Business Strategy and the Environment 26, 197–208. https://doi.org/10.1002/bse.1909

Hultman, N.E., Lou, J., Hutton, S., 2019. A review of community co-benefits of the Clean Development Mechanism (CDM). Environ. Res. Lett. https://doi.org/10.1088/1748-9326/ab6396

ICROA, Imperial College, 2016. Business Leadership on Climate Action: Drivers and Benefits of Offsetting. International Carbon Reduction & Offset Alliance.

ICROA, Imperial College, 2014. Unlocking the Hidden Value of Carbon Offsetting. International Carbon Reduction & Offset Alliance.

ICROA, University of Bristol, 2015. Insetting: Developing Carbon Offset Projects with a Company's Own Supply Chain and Supply Chain Communities. International Carbon Reduction & Offset Alliance.

IETA, 2018. COP24 fails to deliver on mandate for carbon market cooperation [WWW Document]. URL https://www.ieta.org/page-18192/6961313 (accessed 12.20.18).

IPCC, 2018. Global Warming of 1.5 °C_ chapter5.pdf.

Ivankova, N.V., Creswell, J.W., Stick, S.L., 2006. Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. Field Methods 18, 3–20. https://doi.org/10.1177/1525822X05282260

Jou, R.-C., Chen, T.-Y., 2015. Willingness to Pay of Air Passengers for Carbon-Offset. Sustainability 7, 3071–3085. https://doi.org/10.3390/su7033071

Kamel, S., Hodes, G., UNEP Risoe Centre on Energy, C., and Sustainable Development, Capacity Development for the Clean Development Mechanism (projekt), 2007. Equal exchange: determining a fair price for carbon. UNEP Risoe Centre, Roskilde.

Kim, J.E., Popp, D., Prag, A., 2013. The Clean Development Mechanism and neglected environmental technologies. Energy Policy 55, 165–179. https://doi.org/10.1016/j.enpol.2012.11.049

Koch, N., Fuss, S., Grosjean, G., Edenhofer, O., 2014. Causes of the EU ETS price drop: Recession, CDM, renewable policies or a bit of everything?—New evidence. Energy Policy 73, 676–685. https://doi.org/10.1016/j.enpol.2014.06.024

Kolbe, R.H., Burnett, M.S., 1991. Content-Analysis Research: An Examination of Applications with Directives for Improving Research Reliability and Objectivity. Journal of Consumer Research 18, 243–250.

Koninklijke Philips NV, 2019. Koninklijke Philips NV_2018 Annual Report.

Lewis, E., Pinchot, A., Christianson, G., 2016. Navigating the Sustainable Investment Landscape. World Resources Institute.

Lovell, H., Bulkeley, H., Liverman, D., 2009. Carbon Offsetting: Sustaining Consumption? Environ Plan A 41, 2357–2379. https://doi.org/10.1068/a40345

Lozano, R., 2012. Towards better embedding sustainability into companies' systems: an analysis of voluntary corporate initiatives. Journal of Cleaner Production 25, 14–26. https://doi.org/10.1016/j.jclepro.2011.11.060

Lunt, M., 2014. Propensity Analysis in Stata Revision: 1.1 30.

MacKerron, G.J., Egerton, C., Gaskell, C., Parpia, A., Mourato, S., 2009. Willingness to pay for carbon offset certification and co-benefits among (high-)flying young adults in the UK. Energy Policy 37, 1372–1381. https://doi.org/10.1016/j.enpol.2008.11.023

Maraseni, T., Reardon-Smith, K., 2019. Meeting National Emissions Reduction Obligations: A Case Study of Australia. Energies 12, 438. https://doi.org/10.3390/en12030438

Marui Group Co., Ltd., 2017. Marui Group Co., Ltd._Co-Creation Sustainability Report 2017.

Mayrhofer, J.P., Gupta, J., 2016. The science and politics of co-benefits in climate policy. Environmental Science & Policy 57, 22–30. https://doi.org/10.1016/j.envsci.2015.11.005

McCollum, D.L., Echeverri, L.G., Busch, S., Pachauri, S., Parkinson, S., Rogelj, J., Krey, V., Minx, J.C., Nilsson, M., Stevance, A.-S., Riahi, K., 2018. Connecting the sustainable development goals by their energy inter-linkages. Environmental Research Letters 13, 033006. https://doi.org/10.1088/1748-9326/aaafe3

Meyrick, M., 2007. What is a Fair Price for CDM Credits? UNEP.

Michaelowa, A., Friedmann, V., Hoch, S., Honegger, M., Hans, F., 2016. The Impact of INDCS, NAMAs and LEDS on Ci-Dev Operations and Programs. The World Bank Group.

Michaelowa, A., Michaelowa, K., 2011. Climate business for poverty reduction? The role of the World Bank. The Review of International Organizations 6, 259–286. https://doi.org/10.1007/s11558-011-9103-z

Mori-Clement, Y., 2019. Impacts of CDM projects on sustainable development: Improving living standards across Brazilian municipalities? World Development 113, 222–236. https://doi.org/10.1016/j.worlddev.2018.06.014

Murata, A., Liang, J., Eto, R., Tokimatsu, K., Okajima, K., Uchiyama, Y., 2016. Environmental co-benefits of the promotion of renewable power generation in China and India through clean development mechanisms. Renewable Energy 87, 120–129. https://doi.org/10.1016/j.renene.2015.09.046

New Climate Economy, 2018. Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times.

Nordseth, M., Buen, J., Lokshall, E., 2007. CER Market Dynamics. UNEP.

Nussbaumer, P., 2009. On the contribution of labelled Certified Emission Reductions to sustainable development: A multi-criteria evaluation of CDM projects. Energy Policy 37, 91–101. https://doi.org/10.1016/j.enpol.2008.07.033

Olsen, K.H., 2007. The clean development mechanism's contribution to sustainable development: a review of the literature. Climatic Change 84, 59–73. https://doi.org/10.1007/s10584-007-9267-y

Olsen, K.H., Fenhann, J., 2008. Sustainable development benefits of clean development mechanism projects. Energy Policy 36, 2819–2830. https://doi.org/10.1016/j.enpol.2008.02.039

Palmisano, J., 2007. Risk, Uncertainty, and Individual Decision Making in Emission Markets. UNEP.

Parnphumeesup, P., Kerr, S.A., 2015. Willingness to Pay for Gold Standard Carbon Credits. Energy Sources, Part B: Economics, Planning, and Policy 10, 412–417. https://doi.org/10.1080/15567249.2010.551251

Parnphumeesup, P., Kerr, S.A., 2011. Classifying carbon credit buyers according to their attitudes towards and involvement in CDM sustainability labels. Energy Policy 39, 6271–6279. https://doi.org/10.1016/j.enpol.2011.07.026

Petticrew, M., Roberts, H., 2008. Systematic Reviews in the Social Sciences: A Practical Guide. John Wiley & Sons.

Pohl, M., Tolhurst, N., 2012. Responsible Business: How to Manage a CSR Strategy Successfully. John Wiley & Sons.

Roberts, J., Popli, G., Harris, R.J., 2018. Do environmental concerns affect commuting choices?: hybrid choice modelling with household survey data. Journal of the Royal Statistical Society: Series A (Statistics in Society) 181, 299–320. https://doi.org/10.1111/rssa.12274

Rousseau, J.-F., 2017. Does carbon finance make a sustainable difference? Hydropower expansion and livelihood trade-offs in the Red River valley, Yunnan Province, China. Singapore Journal of Tropical Geography 38, 90–107. https://doi.org/10.1111/sjtg.12176

Savitz, A., Weber, K., 2014. The triple bottom line, Second Ediction. ed. Weber, Ebook.

Schneider, L., 2007. Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement. WWF, Berlin.

Shorten, A., Smith, J., 2017. Mixed methods research: expanding the evidence base. Evid Based Nurs 20, 74–75. https://doi.org/10.1136/eb-2017-102699

Sirohi, S., 2007. CDM: Is it a 'win–win' strategy for rural poverty alleviation in India? Climatic Change 84, 91–110. https://doi.org/10.1007/s10584-007-9271-2

S&P Global, 2018. U.S. Green Finance Sees A Clearer (And Brighter) Year Ahead.

Spalding-Fecher, R., Achanta, A.N., Erickson, P., Haites, E., Lazarus, M., Pahuja, N., Pandey, N., Seres, S., Tewari, R., 2012. Assessing the impact of the clean development mechanism. CDM Policy Dialogue, Luxembourg.

Stemler, S., 2001. An Overview of Content Analysis. Practical Assessment, Research & Evaluation 137–146.

Strasser, K.A., 2008. Do Voluntary Corporate Efforts Improve Environmental Performance?: The Empirical Literature. Environmental Affairs 35, 25.

Stuart, E.A., Rubin, D.B., 2008. Best Practices in Quasi-Experimental Designs: Matching Methods for Causal Inference. SAGE Publications, Inc., Thousand Oaks, CA. https://doi.org/10.4135/9781412995627

Subbarao, S., Lloyd, B., 2011a. Can the Clean Development Mechanism (CDM) deliver? Energy Policy 39, 1600–1611. https://doi.org/10.1016/j.enpol.2010.12.036

Subbarao, S., Lloyd, B., 2011b. Can the Clean Development Mechanism (CDM) deliver? Energy Policy 39, 1600–1611. https://doi.org/10.1016/j.enpol.2010.12.036

Sun Life Financial Inc., 2018. Sun Life Financial Inc._2018 Sustainability Report: Building sustainable, healthier communities for life.

Sun, Q., Xu, B., Wennersten, R., Brandt, N., 2010. Co-benefits of CDM projects and policy implications. Environmental Economics 1.

Sutter, C., 2003. Sustainability check up for CDM projects: How to assess the sustainability of international projects under the Kyoto Protocol. ETH Zurich. https://doi.org/10.3929/ethz-a-004674122

Sutter, C., Parreño, J.C., 2007. Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. Climatic Change 84, 75–90. https://doi.org/10.1007/s10584-007-9269-9

Tiffany & Co., 2017. Tiffany & Co._2017 Sustainability Full Report.pdf.

Tolhurst, N., Embaye, A., 2010. Carbon Offsetting as a CSR Strategy.

Torvanger, A., Shrivastava, M.K., Pandey, N., Tørnblad, S.H., 2013. A two-track CDM: improved incentives for sustainable development and offset production. Climate Policy 13, 471–489. https://doi.org/10.1080/14693062.2013.781446

UNFCCC, 2017. CDM Methodology Booklet, Ninth edition. United Nations Climate Change Secretiariat, Bonn, Germany.

UNFCCC, 2012. Benefits of the Clean Development Mechanism 2012. UNFCCC.

Watson, C., Fankhauser, S., 2009. The Clean Development Mechanism: too flexible to produce sustainable development benefits?

Watts, D., Albornoz, C., Watson, A., 2015. Clean Development Mechanism (CDM) after the first commitment period: Assessment of the world's portfolio and the role of Latin America. Renewable & Sustainable Energy Reviews 41, 1176–1189.

Weizsäcker, E.U. von, Rosenau, J.N., Petschow, U., 2005. Governance and Sustainability : New Challenges for States, Companies and Civil Society. Routledge, Sheffield, UK.

Wilder, M., Willis, M., 2007. CER Pricing: Legal Influences. Baker & McKenzie.

Wood, R.G., International Institute for Environment and Development, Sustainable Markets Group, 2011. Carbon finance and pro-poor co-benefits: the gold standard and climate, community and biodiversity standards. Sustainable Markets Group, International Institute for Environment and Development, London.

World Bank, 2017. Community Development Carbon Fund Retrospective- Insights and lessons from 15 years of carbon finance benefiting communities. World Bank, Washington, DC.

World Bank, 2015. Carbon Initiative for Development (Ci-Dev), Methodology Work Program. World Bank, Washington, DC.

World Bank, 2013. CDCF Making an Impact: Carbon Finance Delivers Benefits for the Poor. World Bank.

World Bank, 2012. Carbon Finance for Sustainable Development 2012 Annual Report. World Bank, Washington, DC.

World Bank, 2011. BioCarbon Fund Experience: Insights from Afforestation and Reforestation Clean Development Mechanism Projects. World Bank, Washington, DC.

WWF, 2013. Australia’s Emissions Trading Scheme: Implications of An Early Move to A Flexible Price. World Wide Fund for Nature.

Zhang, J., Wang, C., 2011. Co-benefits and additionality of the clean development mechanism: An empirical analysis. Journal of Environmental Economics and Management 62, 140–154. https://doi.org/10.1016/j.jeem.2011.03.003