Climatic Change (2021) 167: 45
https://doi.org/10.1007/s10584-021-03190-1

Mobilizing private adaptation finance: lessons learned from the Green Climate Fund

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Received: 19 February 2021 / Accepted: 28 July 2021/ Published online: 20 August 2021

Abstract
The mobilization of effective private sector engagement is considered to be critical to address the adaptation challenge, but literature demonstrates that it has proven difficult. In the context of international climate finance, the focus has been on mobilizing private finance for adaptation and in addressing barriers that prevent investments from materializing. In contrast, this article identifies options to engage the private sector in adaptation beyond finance and focuses on market imperfections instead of barriers. This moves the focus away from simply mobilizing more private adaptation finance towards identifying market forces that innovate, engage, and direct investments towards adaptation. The Green Climate Fund (GCF) and its portfolio of 74 adaptation projects serve as a case study. Two of these projects are categorized as private sector projects and an additional nine mobilize private co-finance or non-financial private contributions. Beyond these two indicators, we demonstrate that an additional 60 projects engage the private sector in other ways, thus indicating the important broader role of the private sector in adaptation. Furthermore, our ordinal regression demonstrates that by addressing the market imperfections of positive externalities, imperfect financial markets, and incomplete and/or asymmetric information, all have a significant positive effect on private sector engagement in the GCF's adaptation portfolio. Both findings indicate that there is a large potential for the GCF—and other climate finance providers—to increase private sector engagement in adaptation. It must be noted, however, that the mobilization of private sector engagement in adaptation is a means to an end, not an end in itself. The main aim should be to adapt society as a whole in an efficient manner, including the most vulnerable groups and people.

Keywords Private sector · Adaptation finance · Green Climate Fund (GCF) · Market imperfections

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1 Introduction

The adaptation challenge grows in the face of the deepening climate crisis. Adaptation costs in developing countries alone are estimated to increase to US$140–300 billion per year by 2030 (UNEP 2021). The public sector has long considered adaptation to be a public response to climate change, but in the context of the UN climate negotiations, it is increasingly stimulating the private sector to invest in adaptation. This shift in focus from public towards private finance in adaptation is rational. Adaptation literature often defines the private sector as ranging from large international and domestic corporations to micro, small, and medium-sized enterprises (MSMEs) and smallholder farmers, thus including private sector actors in the financial sector as well as in the real economy (see Druce et al. 2016; Fayolle et al. 2019). For a country to be resilient, it requires its private sector to be resilient. In Africa, for example, the private sector provides almost 67% of the continent's investment, 75% of its economic output, and 90% of its formal and informal employment (AfDB 2011). It is also in the self-interest of private actors to adapt its own operations and assets to climate change and to invest in new business opportunities to achieve business sustainability (Druce et al. 2016; Averchenkova et al. 2016).

However, literature demonstrates that mobilizing private investments in adaptation is challenging (Pauw et al. 2016; Micale et al. 2018; Bisaro and Hinkel 2018; Khan et al. 2020). After having discussed a "seemingly endless" list of barriers to adaptation in general (Biesbroek et al. 2013; 1119), the literature later started to discuss barriers that specifically prevent private investments in adaptation from materializing (see e.g., Antwi-Agyei et al. 2013; Biagini and Miller 2013; Trabacchi and Mazza 2015; Hallmeyer and Tonkonogy 2018; PCIR 2012), including financial, institutional, technological, and information barriers. As Pauw et al. (2021) explained, the focus on these barriers has major limitations: they are descriptive rather than explanatory, and sometimes mix cause and effect and tend to focus on eliminating specific obstacles, rather than adapting efficiently.

This article takes a different approach. First, successful private sector engagement in adaptation goes beyond the current focus on (co-)financing. This article therefore identifies different private sector actors' roles in the planning, implementing, financing, and supporting of adaptation efforts. Our assumption is that this could help to clarify structural conditions that either enable or constrain private investments towards urgently needed adaptation.

Second, instead of looking at barriers, this article assumes that addressing market imperfections would facilitate to attract more private sector engagement in adaptation. Market imperfections create distortions in the risk/return profiles of investments and can result in under-investment (Cohen and Winn 2007). Three particularly relevant observed market imperfections that are inhibiting adaptation-related activities are as follows: positive externalities, incomplete or asymmetric information, and imperfect financial markets (Druce et al. 2016; Pauw et al. 2021).

This article investigates whether addressing these three market imperfections results in a higher level of private sector engagement in adaptation. As a case study, it uses the 74 adaptation project proposals that have been approved by the Board of the Green Climate Fund (GCF) to date. The GCF is the largest multilateral climate fund and has a clear mandate to shift and mobilize finance managed by the private sector to increase its impact into low-emission and climate-resilient investments in developing countries.

This paper is structured as follows: the next section explains how the GCF efforts engage the private sector in its activities, and how a focus on market imperfections could increase such

engagement. Section 3 explains our method, including an ordinal regression analysis. Section 4 provides our results, and finally, Section 5 concludes and provides recommendations to the GCF and the broader climate finance community.

2 The GCF, private sector engagement, and market imperfections

2.1 A push for adaptation by the private sector

The push for private sector engagement in adaptation comes from at least three different, partly overlapping directions. It can be argued that it started with the Copenhagen Accord that was negotiated at the UN climate summit of the United Nations Framework Convention on Climate Change (UNFCCC) in 2009. Here, the private sector was mentioned as a source of finance that contributes to the target to mobilize US$100 billion of climate finance annually by 2020 to support developing countries with mitigation and adaptation. Ever since, there has been a strong focus on mobilizing finance from the private sector for adaptation and mitigation (Pauw et al. 2016).

Secondly, the decision to adopt the Paris Agreement also recognizes the role of the "non-Party stakeholders," including cities, regions, the private sector, and financial institutions. It is a pledge to support the necessary climate actions needed that complement national government actions (see e.g., Roger et al. 2017). An analysis of pledges of such "non-state climate actions" made at the 2014 New York UN Climate Summit and the Lima-Paris Action Agenda indicates a strong focus on mitigation. The underrepresented adaptation actions mostly take place in agriculture, disaster management, and trade and investment (Chan and Amling 2019). However, developing countries do refer to sub- and non-state actors in their Nationally Determined Contributions much more frequently than higher-income countries, particularly in terms of adaptation (Hsu et al. 2020). This indicates the recognition from the governments of developing countries and the important role of private sector actors in adaptation.

And finally, the private sector itself is already experiencing the impacts of climate change. Actors in the real economy are starting to adapt (Pauw et al. 2016; Schaer and Kuruppu 2018), and investors are increasingly asking companies to disclose climate risks as the physical consequences of climate change become financially material (Goldstein et al. 2018).

2.2 Mobilizing private sector investments through the Green Climate Fund

In the broader debate on adaptation by the private sector, this article focuses on how climate finance under the UNFCCC can engage the private sector in adaptation and takes the GCF as a case study. The GCF, created by the UNFCCC in 2010, represents a new kind of funding institution in the emerging field of climate finance governance. With a board that has an equal representation of developed and developing countries, the goal of the fund is to channel a large part of the US$100 billion target and to aim to balance this 50:50 between mitigation and adaptation. In line with the Copenhagen Accord and later decisions taken at the UN climate negotiations, crowding-in and maximization of private sector participation is central to its strategic priorities (Zamarioli et al. 2020). The large fund size, risk appetite, and flexible suite of financial instruments give the GCF the strongest private sector focus of all bilateral and multilateral climate funds and the best ability to scale projects (Binet et al. 2021). In addition, the GCF has set up the Private Sector Facility (PSF), a dedicated division designed to directly

and indirectly finance private sector investments and encourage private investment in low-carbon, climate resilient activities (GCF Decision B.04/08). Under the GCF, such private finance is defined as all financial resources that flow into projects/programs from entities that are more than 50% owned and/or controlled by private shareholders (GCF/B.24/17). The objective of the PSF is to address barriers to private sector investment in adaptation and mitigation activities by providing instruments, such as loans, grants, and equity. Interaction with the private sector is not exclusively with the PSF. National Designated Authorities (NDAs), in the role of a GCF focal point, should explicitly engage the private sector in all forwarded projects, country programing, and support private sector mobilization by capacity building activities.

Project proposals are developed by accredited entities (AEs) that meet the GCF's standards such as fiduciary responsibilities, as well as environmental and social safeguards. AEs are categorized as private or public and direct access entity (national or regional) or international. In its Updated Strategic Plan, the GCF aims to significantly increase funding through both AEs from the private sector and regional and domestic "direct access entities" (DAEs) (GCF 2020). AEs can act as the direct implementer of funding proposals, or contract an executing entity (EE) to be responsible for project implementation on their behalf or as a beneficiary.

While the GCF successfully mobilizes private finance in its mitigation project portfolio, it has not exhibited the same success in mobilizing private finance for adaptation. For example, mitigation projects generally mobilize more co-finance than adaptation projects, and adaptation projects have attracted almost no co-financing from private sources (Gruening et al. 2020). Furthermore, only two of the 74 GCF adaptation projects were developed by "private" AEs, in comparison to the 24 out of 58 mitigation projects. In an evaluation of the GCF's adaptation portfolio, stakeholders explain the low private sector engagement in adaptation through market-related factors, including fewer investable opportunities and predictable return flows, as well as reactive business models, lack of predictability, and the upfront costs of adaptation projects (Binet et al. 2021).

2.3 Going beyond private sector financing of adaptation

In order to address the gap between ambition and reality, we argue that private sector engagement can be increased by looking beyond the binary GCF classification of private versus public sector projects (dependent on the AE that developed the project) and private-sector co-financing. Literature also points in this direction. Although the financial sector and actors in the real economy have complementary roles in adaptation (Agrawala et al. 2011; Barkó et al. 2018; Fayolle et al. 2019; International Finance Cooperation 2012), the current focus in the debate on private sector adaptation is too narrowly focused on financing and hardly differentiates the various types of private sector actors (Schaer and Kuruppu 2018). This is also important for the GCF because the private sector in developing countries might be interested in adaptation, but not in the US$100 billion climate finance target (Dzebo and Pauw 2019). In the examples of non-state climate action mentioned above, finance is only one aspect among many, including pooling of resources and knowledge, building confidence between different types of actors, engendering a sense of shared responsibility and solidarity, and stimulating collective learning (Chan and Amling 2019). In a study on private sector financing of adaptation in the agricultural sector in Zambia, Pauw (2015) identified a variety of activities and small investments with which the domestic private sector could contribute to adaptation, but few examples of how the international private sector could finance adaptation. Schaer and

Kuruppu (2018) argue that micro, small, and medium-sized enterprises (MSMEs) should play a major role in adaptation. MSMEs are the backbone for developing countries' economies, face high risks due to climate change, and have the inherent agency to take action and change their practices. However, private sector actors such as MSMEs typically do not apply for accreditation with the GCF and do not provide significant co-finance for projects. Literature on development finance, a topic often closely related to adaptation finance (see Denton 2010; Romani and Stern 2011), has also looked at how private sector engagement can go beyond co-financing. While direct co-finance arguably brings the highest and most measurable level of private sector engagement, other modalities such as knowledge sharing, technical cooperation, capacity development, and grants or donations, engage the private sector and can likewise achieve development benefits (Di Bella et al. 2013; Pauw 2015).

In the context of the sections above, we have developed and further defined criteria to classify levels of private sector engagement in GCF projects. Complementary to the binary GCF classification (level I with no private sector engagement and level V as fully private project), we see private sector actors as implementing partners (level II), as actors being "mobilized" during a project (level III), and as possible co-financiers or co-contributors (level IV, see Table 1 and concrete examples in the Section 4). This derivation of engagement levels was based on two underlying motivations. On the one hand, our more detailed spectrum of the roles can help the GCF and other climate finance providers to have a better understanding of how to engage the private sector in adaptation and mobilize more private sector finance over time. For example, a private sector actor that now "only" serves as an executing entity might learn to adapt effectively and provide co-finance or apply for accreditation in the future. On the other hand, for a society to adapt it requires an "adapted" private sector. This goes beyond the GCF and beyond finance, and more clarity is needed on levels and roles of any private sector contributions to adaptation.

2.4 Addressing market imperfections to stimulate private sector engagement in adaptation

Druce et al. (2016) and Pauw et al. (2021, see below) hypothesize that private sector engagement in adaptation can be increased by addressing three market imperfections: positive

Table 1 Criteria used to assess the level of private sector engagement in GCF adaptation projects

I	**No private sector engagement**	Purely public project
II	**Private sector as implementing partner**	Private sector involvement only as a paid planning or implementing entity. No contribution/investment by private sector or long-term engagement
III	**Mobilization of private sector engagement**	Development of programs/projects specifically for private sector engagement. Efforts primarily go from the creation of new programs/-committees/units, over to staffing, and capacity building (for example through workshops, feasibility studies) with the clear goal to incentivize private sector engagement.
IV	**Private sector as co-financier/contributor**	Active private sector participation with own resources (financial and/or non-financial): business case/ bankability and contribution. Includes public-private partnerships (PPPs)
V	**GCF private sector project**	Strict private sector definition of the GCF: all financial resources that are provided for the implementation of a funded activity from entities that are more than 50% owned and/or controlled by private shareholders (GCF, 2019)

externalities of adaptation projects, incomplete/asymmetric information, and imperfect financial markets.

Positive externalities occur when private investments generate public goods. These are benefits to society that do not necessarily generate additional cash flows and hence are not captured by the financial return of an investment. As the societal benefits and other externalities are not part of the routine financial metrics, they are rarely documented, recorded, or even quantified, which means financial returns on the investment do not reflect the full value of undertaking the activity (Druce et al. 2016). Addressing positive externalities from a private sector perspective means quantitatively leveraging them in such a way that it effectively improves the risk-return characteristics of an adaptation investment, hence making it more attractive from an economic point of view through either innovative ways of generating additional revenues or effectively de-risking the endeavor. Some experience addressing positive externalities in adaptation by leveraging them as an additional source of financing already exists: modest water tariffs by local beneficiaries of water supply projects can finance operation and maintenance requirements, while tax incentives, grants, and vouchers support mechanisms that can be made available to recompense and incentivize the private sector (Ahenkan et al. 2018). A concrete example is a stormwater management project in Kuala Lumpur. In this urban setting, flood risk was mitigated through a public-private partnership (PPP) for the construction of a mixed-use tunnel. The tunnel allows the diversion and storage of floodwater in times of heavy rain while otherwise functioning as a tunnel for traffic. The positive externalities of mitigated flooding risk (and reduced congestion) were leveraged through a toll fee for cars and light vans, making the project bankable for the private sector partner (Gardiner et al. 2015).

Incomplete/asymmetric information occurs when critical information is unavailable, inaccessible, or distributed unevenly among different actors (see Akerlof 1970). In adaptation, this market imperfection occurs when actors, be it investors, farmers, or businesses, are unaware of the risks and impacts that climate change exacerbates, as well as the measures available to mitigate these risks (Fayolle et al. 2019). Unavailability, inaccessibility, or uneven distribution of information among relevant actors disempowers them from making adaptation decisions and investing accordingly, in particular in developing economies (Antwi-Agyei et al. 2013; Stenek et al. 2013). The market imperfection can be addressed. For example, our assessment of GCF projects shows that AEs address the market imperfection through workshops held with affected stakeholders; broadcasting relevant information via television, radio, or cell phone; networking events; and pilot projects serving as showcases for possible replications and the continuous collection and access of climate relevant data and models. A non-GCF example of how asymmetric information can be addressed is provided by the Public-Private Infrastructure Advisory Facility (PPIAF). To adapt the transport sector to climate risks, the PPIAF developed a tool which performs scenario analyses and provides a range of implications and actions for stakeholders to identify, price, and act on the risks that climate change exacerbates. The tool enables PPP parties to integrate climate considerations into contracts as well as into maintenance and operating performance standards and has already found application in several countries, including Georgia, Vietnam, and Cambodia (Weekes and Diaz-Fanas 2021).

Imperfect financial markets can limit adaptation in many ways. For example, because climate risks often materialize on longer time-horizon investments in adaptation may require long-term debt. However, the market has short-term maturity preferences (Biagini and Miller 2013), and developing countries in particular often lack a liquid, long-term financial market (Kempa and Moslener 2017). Inefficient allocation and availability of

capital as well as inadequate risk transfers lead to the development of unfavorable business climates. This limits opportunities and availability of resources for financing adaptation projects, especially in the context of their already challenging risk-return characteristics (Trabacchi and Stadelmann 2013; Fayolle et al. 2019). Alleviating this market imperfection could, for example, be done by strengthening and supporting financial institutions in the development of adequate products to finance adaptation projects based on their specific needs. In terms of debt, for example, this includes adapting framework conditions of loans but also comprises offerings such as guarantee mechanisms, policy insurance, and local currency solutions (Brown 2011). A case study from Maharashtra, India, provides a concrete example. Here, Action on Climate Today (ACT) partnered with the World Bank-funded Project on Climate Resilient Agriculture (PoCRA) to develop a rating tool that enables local financial institutions to better understand and assess potential agricultural clients. In return, the institutions can provide local farmers with better access to financing at more transparent conditions to meet their respective needs (ACT 2019).

This article will test the expectations of Druce et al. (2016) and Pauw et al. (2021) that addressing these market imperfections can increase private sector engagement in adaptation. In this research, "increasing" means that projects that address market imperfections score higher on the five-level ordinal scale of private sector engagement (see Table 1). A focus on market imperfections should not be confused with arguing in favor of an "adaptation market" or with laissez-faire economics. It is possible to do cost-benefit analyses (UNFCCC 2011) and value-for-money assessments (Savage 2015) of adaptation measures. However, it is unfeasible to commodify and trade adaptation on a larger scale, partly also because it is multifaceted and locally contextualized (Persson 2011). In addition, there are many adaptation-related areas where market principles could have negative effects. Governments also have purely distributional goals, such as immediate disaster response, as well as legal obligations for protection (e.g., against coastal flooding, see Bisaro and Hinkel 2018). The development of markets should aim to contribute to the overall welfare of society, including the most vulnerable—it is not an end in itself. In that sense, the focus on market imperfections is a call for a larger role of public actors (Pauw et al. 2021)

3 Method

The study is based on a critical content analysis of all 74 adaptation projects approved by the GCF Board (including the one approved at its 29th meeting in June 2021) with a value of close to US$4 billion (GCF Dashboard 2021). The portfolio includes projects from over 40 countries across all GCF regions of Africa, Asia and Pacific, Eastern Europe, Latin America, and the Caribbean. Thematically, the majority of projects concern agriculture and land use, followed by water management projects, disaster risk management, information systems and sharing, and biodiversity protection. On average, the GCF's adaptation projects exceed US$55 million in value but range from US$2.3 million (Project SAP003, Bahrain) to US$405 million (Project FP008, Fiji). The projects have a co-finance ratio of about 1:1 (109%) and a duration of just above 7 years on average.

Based on the typologies described above, we analyze the private sector engagement level and examine whether those projects address market imperfections. Cross-cutting GCF projects

have been excluded from the analysis, as it would not always be possible to identify whether a private sector actor has been mobilized for the mitigation or adaptation share of the project.

We first identified the level of private sector engagement of each project proposal using the criteria introduced in Table 1. This analytical criteria-based approach draws on existing methodology in climate finance literature and (multi-)criteria scoring systems that allow for comparisons and ranking (Grafakos et al. 2019; Lee et al. 2014). To source the right information, all proposals were read in their entirety with a particular focus on the main project activities (specifically chapter C.3: "Project/Programme Description") and stakeholders. In addition, a keyword search was conducted to make sure all parts of the funding proposal were considered that might relate to private sector engagement. Searched words included "private," "businesses," "compan[y/ies]," "bank[able]," "value chain," and "entrepreneur,"

Secondly, we assessed if a given project addresses any of the three market imperfections (see Section 2.2) through a set of criteria (see Table 2) which yielded a "1" or "0" for each market imperfection and project using manual content analysis.

Intercoder subjectivity was mitigated by using two coders that evaluated all 74 funding proposals independently. Intercoder reliability was substantial, with 83% agreement on the private sector engagement levels and an average Cohen's kappa of 0.63 for the three market imperfections. Discrepancies have been discussed between and settled by the two coders.

In addition to private sector engagement and addressed market imperfections, we collected project and country-specific parameters for each project. Project-specific parameters are

Table 2 Framework used to assess market imperfection are addressed in GCF adaptation projects

Positive externalities (Pos_Ext)	Project-specific instruments/mechanisms are derived to address the positive externalities created by the project to improve the risk-return profile for the private sector actor. Identifying or developing an additional source of funding or risk mitigation creates an incentive for a private sector actor to engage in positive externality creating activities.	Examples: grants (FP113, Kenya; FP059, Grenada), tariffs (FP043, Morocco), and tolls, fees (FP075, Tajikistan) to raise funds from the externalities that would otherwise not exist. Tax incentives, supply-demand match making mechanisms, and vouchers also count.
Incomplete/asymmetric information (As_Info)	The project integrates actions that contribute to private sector actors' knowledge and understanding of climate change impacts and adaptation measures and strategies. In order to meet the requirements, these activities must be (i) targeted at the private sector and (ii) be continuous or otherwise intensive.	Examples: climate forecast service (FP002, Malawi), value chain and business advisory (FP011, the Gambia; SAP003, Senegal), comprehensive training leading to income diversification (FP072, Zambia). Actions like one-time workshops or the dissemination of flyers would not be sufficient to count towards addressing incomplete/asymmetric information.
Incomplete financial markets (Inc_fin_M)	The project offers services that improve or facilitate the access to finance for private sector actors. This can be achieved by financial institutions through innovative products addressing specific private sector needs, funding schemes, or other activities that provide a source of capital that were not available or feasible before.	Examples: cooperation with (micro-) finance institutions for special loans, revolving financing facilities, community trust schemes (FP069, Bangladesh; FP108, Pakistan; SAP011, the Gambia)

Table 3 Description of the independent variables used for the analysis of GCF adaptation projects (N =70)

Parameter	Type	Description	Source	Min	Max	Mean
Private sector engagement	*Ordinal*	Level of private sector engagement, dependent variable	Own assessment based on Table 1	1	5	2.70
Pos_Ext	*Dummy*	"1" if been addressed in GCF project, "0" otherwise (see Table 2)	Own assessment based on data from funding proposal	0	1	0.464
As_Info	*Dummy*	"1" if been addressed in GCF project, "0" otherwise (see Table 2)	Own assessment based on data from funding proposal	0	1	0.676
Inc_fin_M	*Dummy*	"1" if been addressed in GCF project, "0" otherwise (see Table 2)	Own assessment based on data from funding proposal	0	1	0.211
*p*_size	*Continuous*	Sum of GCF financing and any co-financing (in US$ millions)	Calculation based on data from funding proposal	2.32	405.1	54.70
f_type	*Dummy*	"0" if the given project contains only grant financing, "1" otherwise	Own assessment based on data from funding proposal	0	1	0.070
AE_type	*Dummy*	"1" if the accrediting entity is national, i.e., a DAE, "0" otherwise	Data from funding proposal	0	1	0.21
*t*_elapsed	*Continuous*	Time elapsed since board approval of the first GCF adaption project (t=0)	Calculation based on data from funding proposal	0	5.72	2.89
T	*Continuous*	Length of the project in years	Data from funding proposal	4	26	7.20
HDI	*Continuous*	Index of life expectancy, gross nat. income, and years of education	United Nations Development Programme	0.422	0.852	0.629
DB	*Continuous*	Index of the business friendliness of a country's regulatory environment	World Bank Group	40.41	82.80	56.37
CR	*Continuous*	Index analyzing to what extent countries have been affected by weather-related loss events	Developed by NGO Germanwatch e.V.	−13.4	11.75	−2.16

whether an accredited entity is domestic or regional/international (AE_type), project size (*p*_size), funding type (*f*_type) (grant vs. non-grant, loans, and guarantees), time elapsed since the first GCF board approval (*t*_elapsed), and project duration (*t*). Country-specific parameters were used to record macroeconomic and climate aspects. For each project country of implementation[2], the World Bank's Ease of Doing Business (DB), the Human Development Index (HDI), and the Climate Risk Index (CR) scores of the respective approval year were taken into consideration. Table 3 summarizes the variables for country and project context and provides descriptive statistics of the GCF adaptation portfolio. Lacking country-specific data for three countries led to the exclusion of three projects from the regression analysis, reducing the sample size down to 71.

An ordinal project-level regression model was used to evaluate the hypothesis. This is appropriate because the private sector engagement level is an ordinal, i.e., non-continuous variable with an arbitrary scale where only the relative ordering between values is relevant (Betancourt 2019; Shi et al. 2015; Mase et al. 2017). We used private sector engagement as a dependent variable and the project and country-specific parameters mentioned above as independent variables. Technically, the data are nested, i.e., there are projects that come from the same country. Therefore, a multilevel regression would be more appropriate. Against the background of the limited sample size however, we implemented a project-level model only using Stata 16.1.

To also assess the relationship between variables and optimize our method, we performed a correlation analysis and found no critical correlations between our independent variables. In addition, we calculated variance inflation factors (VIFs) for all variables. The low VIFs (mean of 1.00) are all significantly below the threshold of 10, which further supports our method and selection of variables. We also examined if our findings were robust against varying model specifications. As the sample only included two level V projects and they both addressed all market imperfections, a sanity check was conducted to identify whether these level V projects distorted the analysis. We omitted these two projects from the sample and re-ran the regression. This regression had a slightly lower pseudo R^2 of 0.42, still indicating a very good fit, as well as strong statistical significance of the coefficients that we will elaborate on later in Section 4.

4 Results

The results show a mixed distribution of GCF adaptation projects across all five levels of our private sector engagement spectrum (see Table 4). Descriptive evidence suggests that our assumption on private sector engagement was correct. Engagement is both larger, in

Table 4 Number of projects for each private sector engagement level ($N = 74$) (source: authors)

Private sector engagement level	Number of projects
I	3
II	28
III	29
IV	9
V	2
Total	74

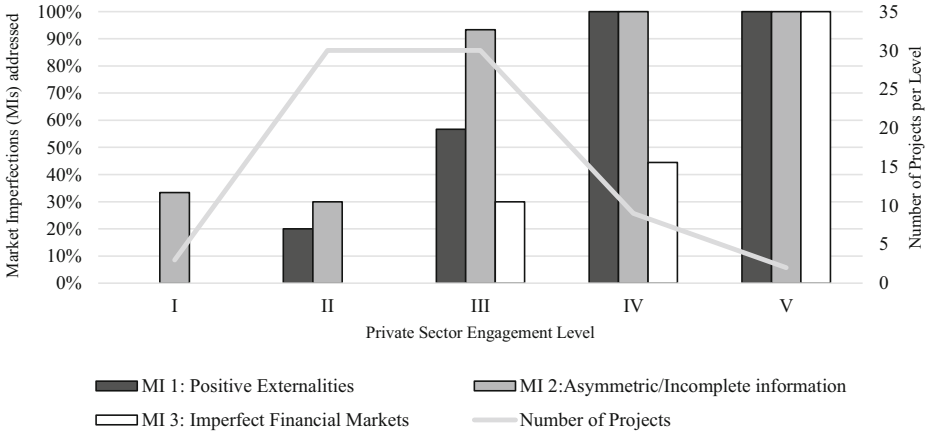

Figure 1 Summary of results by number of projects, share of market imperfections addressed, and private sector engagement level

terms of number of projects, and more diverse, in terms of levels, than we expected based on the GCF definition (see Gruening et al. 2020). Fifteen percent of the GCF adaptation projects engage the private sector in such a way that is reflected by the GCF's current indicators (as co-finance from the private sector and private sector-led projects). Only 4% of projects were found to be purely public (level I), while an additional 81% of the projects showcase private sector engagement (level II and level III) (see Tables 1 and 4).

As private sector engagement increases, so does the share of projects per engagement level that addresses market imperfections (see Figure 1).

Table 5 The table reports coefficients, standard errors, and significances for an ordinal regression analysis on private sector engagement. Significant coefficients at the *** 99%, ** 95%, and * 90% confidence levels (source: authors).

		Number of Observations = 71			
		LR Chi^2 (11) = 74.57			
		Prob > Chi^2 = 0.0000			
		Pseudo R^2 = 0.427			
Parameter	**Coefficient**	**Std. Err.**	**z**	**[95% conf. interval]**	
Pos_Ext	2.282***	0.786	2.90	0.741	3.822
As_Info	3.641***	0.932	3.91	1.815	5.467
Inc_fin_M	2.772***	0.805	3.44	1.194	4.351
p_size	0.009**	0.005	1.83	0.000	0.018
f_type	3.271***	1.122	2.91	1.071	5.470
AE_type	−0.884	0.696	−1.27	−2.247	0.480
t_elapsed	−0.073	0.178	−0.41	−0.422	0.277
T	−0.007	0.069	−0.10	−0.141	0.127
DB	−0.085*	0.050	−1.72	−0.183	0.012
HDI	−1.420	3.668	−0.39	−8.608	5.768
CR	0.103	0.075	1.37	−0.044	0.251

Table 6 Average marginal effects for significant variables. The values indicate, assuming all other variables are held equal, the impact a variable has on the likeliness of a project belonging to a respective private sector engagement level

Engagement level	I	II	III	IV	V
Pos_Ext	−0.075	−0.160	0.086	0.100	0.049
As_Info	−0.119	−0.256	0.137	0.160	0.078
Inc_fin_M	−0.090	−0.194	0.104	0.121	0.059
*p*_size	−0.000	−0.001	0.000	0.000	0.000
*f*_type	−0.107	−0.230	0.123	0.144	0.070
DB	0.002	0.005	−0.003	−0.003	−0.001

Table 5 reports the results of the ordinal regression analysis. With a McFadden pseudo R^2 of 0.43, the overall model fit is very good: a value between 0.2 and 0.4 is already considered to represent an excellent fit (Domencich and McFadden 1975).

4.1 Addressing market imperfections increases private sector engagement in GCF projects

Addressing market imperfections has a positive and statistically significant effect on private sector engagement in the GCF's adaptation portfolio. Marginal effects calculated as part of the analysis support this. They indicate that each market imperfection addressed increases the likelihood of a project scoring in the top three levels and decreases the likelihood of scoring in the bottom levels of the private sector engagement (see Table 6). The latter can be explained by the fact that there is no private sector engagement in level I and that private sector engagement is limited to implementation of project activities under level II.

With more than 99% confidence, the findings indicate that addressing the barrier of *positive externalities* increases private sector engagement in the GCF's adaptation projects. Finding ways of creating stable revenue streams to offset costs and achieve bankability appears key to engaging in the private sector. Concretely, project-specific mechanisms identified to address this market imperfection include the use grants (e.g., FP113, Kenya and FP059, Grenada), tariffs (FP043, Morocco), and tolls/fees (FP075, Tajikistan). Empirically, the marginal effects indicate that addressing positive externalities increases the likeliness of a GCF project being in level IV by 10% and decreases the likeliness of being in the lowest two levels by 7.5 and 16.0%, respectively (see Table 6).

Asymmetric and incomplete information has the strongest impact on private sector engagement in adaptation with a 99% statistical significance and an even more pronounced positive coefficient. It is also the most widely addressed market imperfection (see Figure 1). More than two-thirds of the project proposals include activities such as business model and value chain advisory offerings (e.g., FP011, Gambia and SAP003, Senegal), trainings on business model improvements and income diversification (FP072, Zambia), and information services developed specifically for private sector actors (FP002, Malawi). Addressing the incomplete/asymmetric information can reduce the uncertainty of an investment decision by providing understanding of risk mitigants and create awareness of opportunities in the first place. In the GCF sample, this has an effect of dramatically decreasing the likeliness of a project being in level I (by 11.9%) or level II (by 25.6%) and increases the likeliness of being reaching level IV by 16.0%.

At a confidence level of 99%, addressing *imperfect financial markets*, i.e., improving access to finance, indicates a high potential impact in mobilizing the private sector. Addressing the issue of imperfect financial markets empirically heightens likelihood of engaging at level IV by 12.1%. However, only one-fifth of the GCF adaptation projects exhibited mechanisms to address this market imperfection. AEs and financing partners of GCF projects generally do not face financing constraints and are, to a large extent, able to provide different financing solutions. The access to finance by an actor of the local private sector is thus not an issue on the GCF level but rather on a beneficiary or project level (e.g., MSMEs or farmers). Channeling capital down to the beneficiary level poses its own challenges (regulatory, financial, and even social) making it a more complex action to perform by an AE, possibly compromising bankability in the process. Some identified mechanisms to address imperfect financial markets are cooperation with (micro-) finance institutions to provide special loans, revolving financing facilities or community trust schemes (e.g., FP069, Bangladesh; FP108, Pakistan; and SAP011, the Gambia).

4.2 Project-specific parameters

Among the project-specific parameters, only project size and GCF loan components showed statistical significance. At a 90% significance level, the *p*_size coefficient (0.009) indicates a minimal but positive relationship to private sector engagement. The marginal effects, however, show that while there is statistical significance, the impact is negligible.

A strong (99% confidence) positive relation was found between the level of private sector engagement and the existence of a GCF loan component in projects (*f*_type). In five projects, the AE used loans to finance (a part of) a project, hinting that a project component offers revenue generation and a retrievability of funds. The marginal effect also supports this, indicating that loan components positively lever private engagement sector in level IV (14.4%increase) and reduce the likelihood of a project scoring only a level I or II (10.7 and 23.7% decrease, respectively). While half of the entities that have submitted adaptation proposals have an accreditation of using non-grant instruments and providing more impactful products, 93% of adaptation-only funding remains in the form of grants (WRI, 2018). Using non-grant instruments is thus not a question of availability but relates to financial feasibility. From an AE perspective, the bankability (related to positive externalities) seems to be a larger hurdle than the available access to finance (related to imperfect financial markets).

The coefficients concerning temporal aspects have no statistical significance, indicating that the level of private sector engagement has not significantly increased over time despite GCF efforts (such as the PSF) (*t*_elapsed). Similarly, the duration (*t*) parameter also lacks statistical significance, providing no evidence for private sector engagement to vary depending on the length of a project. Similarly, the type of AE had no statistically significant effect in our GCF sample.

4.3 Country-specific parameters

Only the *Ease of Doing Business* coefficient (DB) was statistically significant (at a 90% confidence level) and exhibited a negative relation to the level of private sector engagement. The marginal effects show that the impact of the DB score, while negative, is inconsequentially small. Projects in countries with a better business climate thus scored slightly lower on our private sector engagement scale. The nature of the GCF and its priorities to focus on the

most vulnerable developing countries might offer an explanation for these outcomes. The GCF prioritizes funding towards Least Developed Countries (LDCs), Small Island Developing States (SIDS), and African States, nations that predominately perform below average on the Ease of Doing Business ranking (GCF 2016). The selectivity and mission of the GCF to focus on more fragile nations potentially demotivate some private sector actors to engage in the GCFs activities. In addition, some of these countries also hold the position that adaptation should be financed through grants by developed countries, rather than through mobilized private sector investments (Pauw 2015) or loans that need to be repaid (see e.g., the GCF Board's discussion on project FP114 (GCF 2019a, b)). The findings indicate that the GCF is not a representative tool for analyzing private adaptation efforts globally, but rather a niche with a specific focus on regions that have particular challenges in attracting private finance. Likewise, the results indicate that when indiscriminatory of the type of private sector actor (smallholder farmers to multinationals), private sector engagement in adaptation is possible regardless of the business environment.

4.4 Limitations

Three limitations to this research should be mentioned. First, as a relatively new fund, the GCF has not completed any adaptation projects yet. Results are therefore based on project proposals rather than implemented, monitored, and evaluated action. Although plans could be adjusted when being implemented, we nevertheless expect the results to be robust, as the projects are proposed by entities that went through careful accreditation processes.

Second, this article analyzed ways in which GCF projects address market imperfections. The options to do so are limited for this multilateral fund. For example, the GCF cannot directly apply instruments such as regulatory reform or impose policies. In that sense, the potential of the public sector to engage the private sector in adaptation is probably larger than our analysis demonstrates and falls under a larger structural environment that includes governance and policy design. In addition, the geographic focus of the GCF—developing countries, with a prioritization towards LDCs, SIDS, and African states—also means that the results of this article might not equally apply in other geographic contexts.

Finally, the GCF is a "continuously learning institution" that is still developing and updating policies to improve its work (see Independent Evaluation Unit (IEU) 2019). It is also still expanding its project portfolio. In that sense, if this analysis was to be repeated over time, we cannot rule out that it could yield different results.

At the same time, we do believe our analysis is solid, despite the limited sample size. For example, the statistical significance of the results did not change when we ran the regression for the hypothetical case in which the market imperfections for the two level V projects were not addressed. Our findings are thus not induced by the only two projects that the GCF considers "private sector."

5 Conclusion and discussion

There is a broad and increasing push for private sector engagement in adaptation. However, mobilization of private sector investments in adaptation through adaptation finance projects is limited so far because there are large structural constraints of governance and policy design that need to be overcome. Based on our study on the GCF's adaptation project portfolio, we

show that overall private sector engagement in adaptation projects can be increased by addressing market imperfections.

We demonstrate that focusing on private sector led projects and private sector finance for adaptation alone does not adequately explain the extent to which the private sector already engages in adaptation. Together, these explain private sector engagement in only 15% of all the GCF's adaptation projects. In an additional 81% of the projects, the private sector has a role as an implementing partner or as an actor that is actively incentivized to support the project implementation through subsequent activities or opportunities.

Looking at private sector engagement in a more granular way is important for two reasons. First, it can help the GCF to better understand how to engage the private sector in adaptation. Literature demonstrates that the private sector can engage in adaptation in various ways (Goldstein et al. 2018; Schaer and Kuruppu 2018; Chan and Amling 2019; Pauw, 2014). Growing experience with private sector engagement is important as it will lead to a better mutual understanding of public-private value creation. For example, NDAs' current understanding of private sector engagement appears low (Zamarioli et al. 2020), and lack of knowledge and experience with adaptation or a narrow focus on self-interest may lead the private sector to adapt ineffectively or even in counterproductive ways that increase vulnerability (Dzebo and Pauw 2019). Over time, an increased understanding is likely to stimulate the mobilization of private sector finance. For example, a private sector actor that serves as an executing entity now might learn more about risks and returns in the field of adaptation, develop its own business model, and potentially provide co-finance or apply for accreditation in the future. Tracking of such engagement by the GCF can also help to ensure that private sector engagement in adaptation is effective. Second, in a broader perspective, for a society to adapt to climate change, it is also required that the private sector adapts because it is an important part of that society. Any private sector engagement in adaptation can contribute to that, not just finance and not just engagement in the context of the GCF. If a private sector actor learns about effective adaptation in the context of a GCF project and replicates or scales up elsewhere, this can still be called a success for global adaptation efforts and for the GCF.

In order to mobilize more private sector engagement and to have more impact, the GCF and other climate finance providers should thus move beyond the binary classification of private versus public projects and aim to mobilize co-finance. Instead, they should work with their relevant public and private partners in developing countries to mobilize private sector engagement in a tailor-made way.

The second important conclusion of this article is that it is key to address market imperfections in order to mobilize private sector engagement in adaptation. The GCF has limited options to address market imperfections directly by modifying the market environment, for example, through policy and regulatory reform. The GCF is better suited to address the consequences of market imperfections, for example, through compensation, risk-sharing, and concessional approaches (see Pauw et al. 2021; Druce et al. 2016). While it was out of the scope of this paper to identify what the most effective ways are to address market imperfections, the GFC data do provide a clear connection between the engagement of the private sector and the three market imperfections that can directly be related to specific instruments used by the GCF and other entities engaged in adaptation (such as matching grant funds, technical assistance programs, risk sharing facilities, and other approaches introduced in Section 2.4). The GCF could further map the use of these instruments and further promote them among partners including accredited entities and National Designated Authorities.

In addressing market imperfections, the GCF and other climate finance providers should take into account that they also have distributional responsibilities, including reducing the vulnerability of the most marginalized. While private sector engagement might be stimulated by addressing market imperfections, policy objectives such as equity (just allocation of resources) or affordability of essential goods such as water (see Osberghaus et al. 2010) should not be undermined. The mobilization of private sector engagement in adaptation can be a means to an end; it is not an end in itself. The main aim should be to efficiently adapt society as a whole, including the most vulnerable people.

Funding This work was supported by Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (Grant Number GZ: 414 K8187-0372/001).

Availability of data and material The data that support the findings of this study are available from the corresponding author, WPP, upon request.

Code availability The Stata code that supports the findings of this study is available from the corresponding author, WPP, upon request.

Declarations

Conflict of interest The authors declare no competing interests.

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