Journal of Climate Finance 9 (2024) 100051

Contents lists available at ScienceDirect

Journal of Climate Finance

journal homepage: www.journals.elsevier.com/journal-of-climate-finance

The role of cost-effectiveness in multisector climate investment programs: The Swedish Climate Leap

Abenezer Zeleke Aklilu [a], Rebecca Swärd [b], Katarina Elofsson [a,c,*]

[a] Department of Social Sciences, Södertörn University, Huddinge 141 89, Sweden
[b] Department of Economics, Swedish University of Agricultural Sciences, Box 7013, Uppsala 750 07, Sweden
[c] Department of Environmental Science, Aarhus University, Frederiksborgvej 399, Roskilde 4000, Denmark

ARTICLE INFO

JEL classification:
Q52
Q54
Q58

Keywords:
Climate investments
Cost-effectiveness
Electric car charging stations
Energy efficiency
Municipalities
Transport

ABSTRACT

To increase the speed of implementation of carbon mitigation technologies, many countries set up publicly funded investment programs, where private and/or public entities can apply for support. These schemes are often criticized for not being cost-effective. The purpose of this study is to evaluate the Swedish Climate Leap Program, which differs from most other programs through the multisector approach. We examine determinants of project approval and evaluate the heterogeneity in implicit carbon pricing across sectors. Several econometric methods are used to assess equality in carbon pricing. Results show that although the cost-effectiveness ratio plays an important role in project approval, carbon pricing differs significantly across project types. Project guidelines favor charging stations and transport measures that aid in adopting new technology and reaching economies of scale. However, the preference for transport measures is not reflected in the carbon pricing while instead energy conversion measures have a higher probability of being funded given the cost-effectiveness of the investment. Funding decisions favor densely populated municipalities, which could be motivated for investments in public goods, but is questionable for transport and housing.

1. Introduction

Climate change, mainly due to combustion of fossil fuels and changes in land use, gives rise to a range of negative impacts, including rising sea levels, more frequent and severe weather events, heat waves, droughts, and wildfires. These impacts are foreseen to negatively impact the economy in the longer term and in poorer, hotter, and lower-lying countries (Tol, 2018; Nordhaus, 2019). Through the Paris Agreement at the UN Climate Change Conference (COP21) in 2015, most of the world's countries have committed to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. National commitments with varying ambition levels and different target years have followed (Iyer et al., 2017). For example, the EU Member States have agreed to turning the EU into a climate neutral continent by 2050, setting as a milestone a reduction in emissions by at least 55 % by 2030 compared to 1990 (EC European Commission, 2023), while the USA has effectively committed to a 26 % reduction in emissions from 2005 levels by 2025 (Liu & Raftery, 2021).

To meet the ambitious targets for reductions in greenhouse gas emissions, investments in low-carbon technologies, transport infrastructure, energy efficiency, and renewable energy are needed. These investments are to a certain extent encouraged through market-based policy instruments, such as carbon taxation and carbon emission trading. However, the impact of such policy instruments on climate friendly investments depends on policy stringency and stability (Baker & Shittu, 2006; Carraro et al., 2012; Bumpus, 2015). Policies that are costly for polluters, such as carbon taxes and emission trading, often meet considerable resistance implying that in practice policy stringency is lower than optimal. To increase the speed of implementation of carbon mitigation technologies, many countries therefore set up publicly funded investment programs, where private and/or public entities can apply for support. Typically, applications for support are evaluated based on multiple criteria, including, for example, the cost-benefit ratio of the project, environmental and health co-benefits generated, job opportunities created, and contributions to energy security (Forslund et al., 2008). When private entities are eligible to apply, the funding agency needs to consider the possibility that the support displaces private investments. In addition, explicit or implicit political objectives could affect the decisions, for example giving priority to applicants of a particular type or from certain regions. Despite such publicly funded

* Corresponding author at: Department of Social Sciences, Södertörn University, Huddinge 141 89, Sweden.
E-mail address: katarina.elofsson@envs.au.dk (K. Elofsson).

https://doi.org/10.1016/j.jclimf.2024.100051
Received 25 April 2024; Received in revised form 12 September 2024; Accepted 8 October 2024
Available online 15 October 2024

environmental investment programs being common in many parts of the world (Economidou et al., 2020; Fowlie et al., 2018), there are few studies evaluating whether the program aims are fulfilled in an efficient manner, and identifying the dominant drivers of the decision to approve support to investments (Owen et al., 2018). This is a problem, because such knowledge is necessary to understand whether public funds are used for their intended purpose and in a cost-effective manner, and because concerns regarding the weight given to possible implicit political objectives could undermine the publics' trust in the programs.

The purpose of this study is to identify factors that determine the Swedish Environmental Protection Agency's decision to grant funding to climate friendly investments through the Climate Leap Program. We are particularly interested in the effectiveness of the program in reaching climate goals at low costs. The program was initiated in 2015 and is funded via the government's budget.[1] The program differs from many earlier investment programs by broadly addressing multiple sectors, including transport, energy, and waste, thereby making it possible for the agency to allocate the support in a cost-effective manner within and across sectors. We hypothesize that the decision to grant funding is determined by projects' cost-effectiveness ratio, measured as the cost per unit of carbon emissions abated, expecting that cost-effectiveness will positively influence project approval. In addition, we consider the possibility that the agency might consider technology type, and that projects involving new technologies or critical infrastructure may receive preferential treatment despite lower cost-effectiveness. We also hypothesize that the funding agency could have preferences over private and public sector applicant types motivated, for example, by an aim to avoid crowding-out private investments or redistribute public funding across regions. Moreover, we consider the possibility that socio-economic factors may affect the distribution of funds, potentially favoring more densely populated or poorer or wealthier municipalities. Finally, we examine the heterogeneity in the cost-effectiveness ratio across sectors, i.e., the implied heterogeneity in carbon pricing.

The literature which is relevant to our study is that which investigates the determinants of governmental agencies' decisions to financially support private and public investments in environment related projects. Most of this literature studies decisions on investments in transport infrastructure. McFadden (McFadden, 1975, 1976) outlines methods for revelation of the preferences of government bureaucracies based on the investment decisions taken. The methods are applied to decisions taken on investments in highway infrastructure by the California Division of Highways, using a multinomial logit model. Results provide evidence that decisions are consistent with the theory of utility maximization, with a strong weight being placed on the cost-benefit ratio, and with local governments having a large influence on the route decisions. Fridstrom and Elvik (Fridstrom & Elvik, 1997) examine the preferences of road investments based on decisions taken within the regional Norwegian public roads' administration, using a rank order multinomial logit model. Their results show no evidence that projects that have an advantageous cost-benefit ratio are given a higher priority than projects that do not. Moreover, the cost of a project is twice as important as the benefits, and smaller projects are preferred to larger ones. Studying an investment plan for the Swedish transport sector, Eliasson and Lundberg (Eliasson & Lundberg, 2012) show that the cost-benefit criterion plays a large role for planners, but not for politicians.[2] Moreover, planners' implicit valuation of freight benefits was higher, and the valuation of traffic safety was lower than recommended by official guidelines. Bertoméu-Sánchez and Estache (Bertoméu-Sánchez & Estache, 2017) investigate the extent to which public investment decisions within the framework of Spain's land transport infrastructure policy are mainly driven by political or economic motives. Using data envelopment analysis, they conclude that investments decisions are mainly driven by a political objective: centralization of economic power, while economic objectives, such as increased mobility, play a small role. Bondemark et al (Bondemark et al., 2020). evaluate determinants of the decision by planners to include an investment in the draft Swedish national transport plan 2018–2029. They show that even though many attributes of the investments are appraised beforehand, only few (the cost-benefit ratio, and dummies for the presence of negative environmental externalities and other socio-economic impacts) affected the outcome, while others such as distributional effects, contribution to sector goal fulfilment, noise pollution, and safety, do not have a significant impact on the decision. A couple of studies are applied to other sectors than transport. Fernandez (Fernandez, 2004) studies the approval of environmental improvement projects along the USA-Mexico border, financed under the North American Free Trade Agreement (NAFTA), examining how it is affected by observed attributes of the proposed projects. Results show preference for projects solving transboundary wastewater pollution, while cost-effectiveness does not have a significant impact on decisions. Forslund et al (Forslund et al., 2008). examine the cost-effectiveness of the Swedish Local Investment Program (LIP) between 1998 and 2002, given two different political objectives; stepping up the transformation into an ecologically sustainable society and reducing unemployment. Results from a hurdle model show that projects aimed at remediation of contaminated sites received a disproportionate amount of the budget but did not prioritize the most hazardous sites in a cost-effective manner. Furthermore, society's cost for the employment opportunities generated exceeded the corresponding costs for traditional labor market policies.

Our study contributes to the literature by studying the determinants of project approval and the cost-effectiveness of an investment program covering multiple sectors, with the program being focused on carbon emission reductions. The inclusion of multiple sectors raises the question of whether the responsible agency has preferences across these sectors within the framework of a given program due to, for example, the possibility to achieve economies of scale effects, possibilities to promote technological development, and concerns for overlaps with other environmental policies. This would lead to heterogeneity in carbon pricing across sectors. Moreover, unlike the above-mentioned studies, both private and public entities are eligible to apply, and we examine whether the agency has preferences across those.

The remainder of the paper is organized as follows. In Section 2, we describe the Climate Leap program. Section 3 presents the methods, and Section 4 discusses the data. In Section 5, we present and discuss empirical results from an econometric strategy described in this section. Section 6 provides the conclusions.

2. The Climate Leap Program

The Climate Leap Program was initiated in 2015 by the Swedish government with an aim to support investment in regional and local initiatives to reduce greenhouse gas emissions. The purpose of the initiative is to help reach the parliament's environmental quality objective "A Reduced Climate Impact" in line with the Paris Agreement, and it is classified as a Nationally Determined Contribution. The Climate Leap Program support should, together with other climate policy instruments such as the EU ETS, the national carbon tax, and subsidies to renewables, help transforming markets in a more sustainable and environmentally friendly direction, without negatively impacting the efficiency and economic growth.

The Climate Leap Program aims to reach activities that are not covered by other environmental policies, and support cannot be given to

[1] The Swedish carbon tax revenues go into the general budget and is not earmarked for climate investments or used to compensate for distributional impacts. This can have advantages in terms of the revenues being used optimally, broadly considering different societal needs, but also disadvantages as it could limit the public acceptance of high tax levels as suggested in Maestre-Andrés et al (Maestre-Andrés et al., 2021).

[2] Politicians first selected their preferred investment; the plan was later extended with investments selected by planners.

projects that are already mandatory through legal regulations (Swedish Environmental Protection Agency, 2024a). The support can be given to private companies, regional administrations, county councils, municipalities, municipal corporations, and different types of associations.[3] Private persons are not eligible and the same holds for activities that require a permit within the EU ETS.[4] In contrast, activities subject to full and reduced carbon dioxide taxation are eligible for support. This could hypothetically lead to overregulation, but the joint effect of the measures is not sufficient for meeting climate targets set by the Parliament.[5] The implementation of the program falls upon the Swedish Environmental Protection Agency (Swedish Environmental Protection Agency, 2024a).

An important factor for determining whether a project gets approved or not is the reduction in carbon emissions per invested USD (Swedish Environmental Protection Agency, 2024b). The applicant must also be able to prove the capacity to pay for the parts of the project not supported by the Climate Leap Program and ensure the project's finalization. Furthermore, an applicant must provide calculations showing that the repayment period is long enough for the project not to be financially profitable for the organization applying. This is required to avoid that the investment could be made without the support, i.e., to ensure additionality. The calculations provided by the applicants are carefully examined and controlled by the Swedish Environmental Protection Agency. The agency then checks that the cost and CO_2e reduction calculations follow the guidelines. The guidelines stipulate the emission coefficients, lifetime of different investments, and discount rate (4 %) to be applied in the applications. There are also more detailed guidelines for certain types of investments to ensure that both costs and CO_2e avoided are calculated in a consistent manner. The agency corrects calculations so that guidelines are adhered to.[6] In the case of an equal reduction of carbon emission per USD by any two applications, effects on other environmental quality goals, employment effects, and benefits of introducing new technologies are considered (Swedish Environmental Protection Agency, 2024a). For charging stations and transport measures it is deemed that a higher cost per unit of carbon abatement is appropriate as the measures are considered to contribute to the dispersal of new technology. In the first rounds, charging stations were granted support based on arguments that this would facilitate dispersal of new technology. Later, a pre-determined cost effectiveness ratio was introduced. In practice this ratio has varied and has mostly fallen over time. In mid-2017 it required at least 7.4 kg of CO_2e emission mitigation per USD applied support (National Swedish Audit Office, 2019).

3. Method

We assume that the Swedish Environmental Protection Agency chooses projects that maximize social benefits considering costs, emission reductions, and adoption of new technology. In the sense of the random utility approach, the decision problem can be thought of as a utility maximization problem, the utility being social benefit. The agency derives a utility by approving to fund an optimal combination of I projects. The utility that the agency derives from a single project is $U_i, i = 1, \ldots, N$, and alternative projects are chosen such that $U_i > U_j \; \forall j \neq i$.[7] Let a binary outcome variable, $approve_{it}$, represent approval of project applications (projects chosen for funding) at time t by the agency such that:

$$approve_{it} = \begin{cases} 1 \text{ with probability } p_{it}, \\ 0 \text{ with probability } 1 - p_{it} \end{cases} \tag{1}$$

where $approve_{it}$ takes 1 if project i is approved for funding and 0 if it is declined in year t. p_{it} determines the probability of the outcome. Then,

$$p_{it} = \Pr[approve_{it} = 1|X] = F(X'_{it}\beta), \tag{2}$$

where X is a vector of regressors, β is a vector of parameters, and $F(.)$ is a standard normal cumulative distribution function. The conditional probability specified in Eq. 2 that parametrizes p_i corresponds to the probit model.[8] The marginal effect of a continuous variable regressor j on the probability that a project is approved corresponds to (Cameron & Trivedi, 2005):

$$\frac{\partial \Pr[approve_{it} = 1|X_{it}]}{\partial x_{itj}} = \frac{\partial F(X'_{it}\beta)}{\partial x_{itj}} \beta_{j.} \tag{3}$$

For a population of N projects $(approve_{it}, \quad X_{it})$, $i = 1, \quad \ldots, \quad N$, the maximum likelihood estimator (MLE) can consistently and efficiently estimate the parameters β (Cameron & Trivedi, 2005). The associated log-likelihood function is:

$$\mathscr{L}_N(\beta) = \sum_t \sum_i \{approve_{it} \ln F(X'_{it}\beta) + (1 - approve_{it}) \ln(1 - F(X'_{it}\beta))\}, \tag{4}$$

where $\mathscr{L}_N(\beta)$ is the log-likelihood function and the rest of the variables remain as defined before. The probit model has the attractive feature that predicted probabilities are always between zero and one. In other words, the conditional expectation function produced by the probit model respects the limited dependent variable boundaries (Angrist & Pischke, 2008). However, validity of the probit model is dependent on distributional assumptions. In contrast, the linear probability model (LPM) does not rely on distributional assumptions about the data, and it is less sensitive to the list of covariates (Angrist & Pischke, 2008). LPM results in heteroskedastic standard errors relating to the dependent variable being binary and the estimated probabilities being continuous from zero to one. To correct for heteroskedasticity in both LPM and the probit models, heteroskedastic robust standard errors and standard errors clustered by organization are calculated.

In contrast to the probit model, the LPM has a simple linear specification estimated using ordinary least squares:

$$approve_{it} = \alpha_i + \lambda_t + \gamma X_{it} + \epsilon_{it}, \tag{5}$$

where α_i is county fixed effects of where the applicant is located, λ_t is year fixed effects, γ is a vector of coefficients to be estimated and ϵ_i is an error term. The remaining variables are as defined above. The estimated β from the probit model and γ from the LPM are compared to ensure the robustness of the results to misspecifications. County fixed effects control for observable and unobservable time invariant factors such as geographic proximity to international shipping routes, protected natural habitat, area and land use of the county, and mineral endowments, which might correlate with organization's intentions to invest in environmental projects. The year fixed effects control for common political, social, and economic trends.

Properties of the probit model give rise to the incidental parameter

[3] Swedish administration is divided into 21 counties and 290 municipalities.

[4] With an exemption for waste heat, which has been criticized by National Swedish Audit Office (National Swedish Audit Office, 2019).

[5] One can note that there can be gains from combining subsidies for the adoption of technologies with carbon pricing, as the former create scale and learning effects, but could also cause a rebound effect which is counteracted by carbon pricing, see Van den Bergh et al (Van den Bergh et al., 2021).

[6] The corrections are usually slight adjustments and the adjusted estimates can be higher or lower than the estimates submitted by the applicant. The number of corrected estimates is balanced between granted and non-granted applications and the results discussed in the subsequent sections are not sensitive to the corrections made.

[7] This formulation follows the textbook approach of random utility models. For a generalized and an in-depth discussion see (Cameron & Trivedi, 2005) and (Train, 2009).

[8] For alternative model specifications and advantages and shortcomings of the probit model, see (Train, 2009).

problem when the number of cross-sectional units increases while the time dimension of the data is fixed. In such instances, estimation of the probit model parameters using the maximum likelihood estimator results in inconsistent estimates (Cameron & Trivedi, 2005). These prevent including fixed effects in the probit specification because the time span in the data is three years which is not sufficiently long to avoid the incidental parameter problem.

3.1. Data

The data used in this study are unique administrative data which contains all project applications submitted to the Swedish Environmental Protection Agency from 2016 to 2018. The data records characteristics of the application and the applicant organization including project approval status, date of application, project cost, carbon dioxide reduction, type of applying organization, and availability of external funding.

Organizations can submit multiple applications for projects conducted in the same county or different counties in the same year and can submit applications in several consecutive years. This creates a data that has structures of both repeated cross section and panel data. However, there is only one record per project in the data because the same project cannot be funded multiple times. In addition, it can be seen from the data if a company has submitted multiple applications either in the same year or in consecutive years, but it cannot be identified if the same projects is submitted multiple times, i.e. if a particular project is rejected this year and approved next year, the data does not state.

There is a total of 5434 applications, 2931 approved and 2503 denied, with an approval rate of 54 %. One of the main factors that determine project approval is the greenhouse gas (GHG) emission reduction per total invested USD. The Swedish Environmental Protection Agency examines the applicants own financing (own invested USD), applied support (financing by the agency) and total invested USD. The National Swedish Audit Office (National Swedish Audit Office, 2019) argues that GHG reduction per USD provided as support is a good measure of cost-effectiveness because private agents would only offer co-funding to the extent that it generates the corresponding private benefits. On the other hand, municipalities and county administrations'

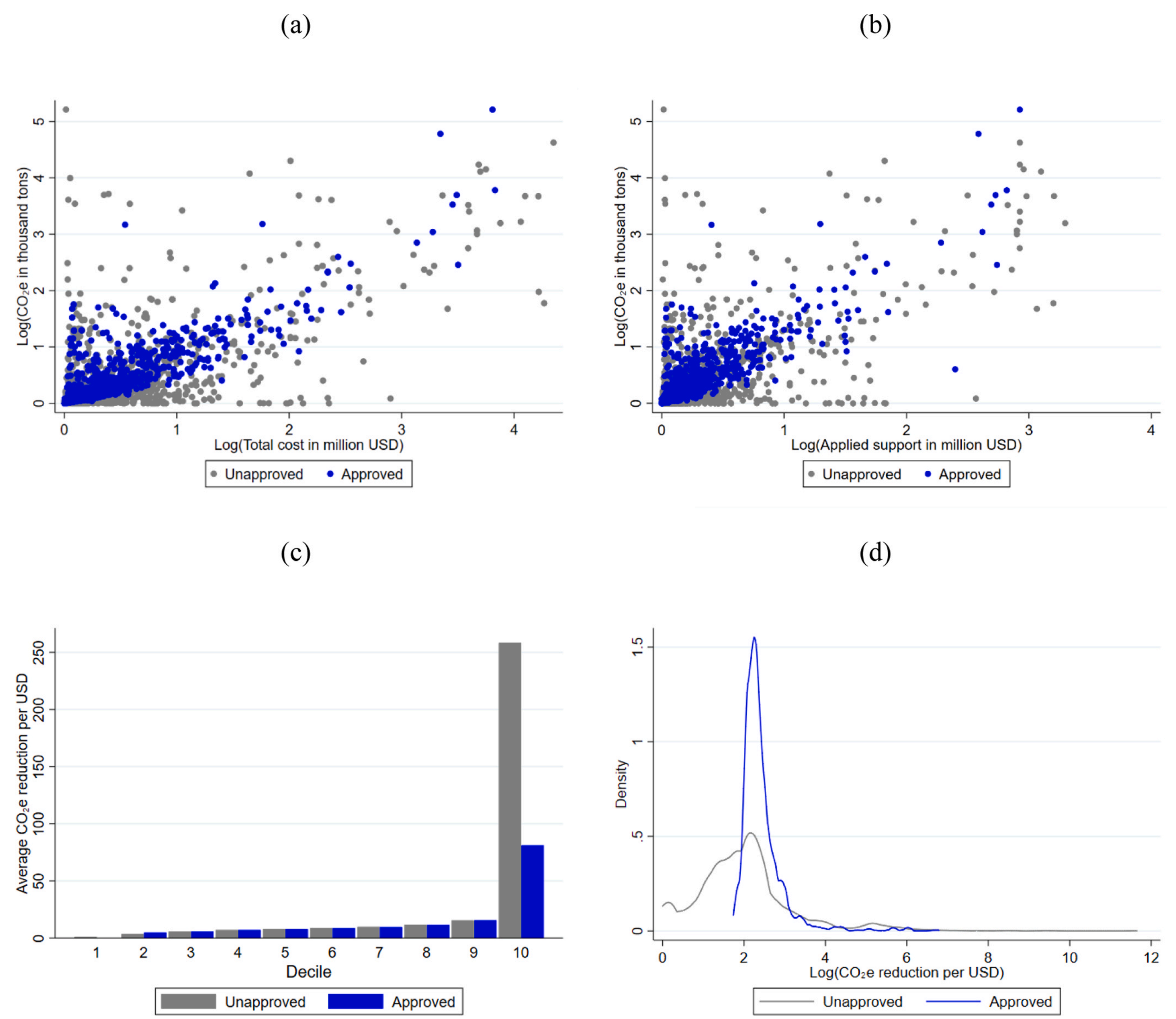

Fig. 1. Panel (a): GHG emissions per total invested USD. Panel (b): GHG emissions per applied USD. Panel (c): Cost effectiveness ratio across different deciles. Panel (d): Cumulative distribution of cost effectiveness ratio. Note: to make comparison easily observable, outlier project applications submitted and unapproved that are discussed above are omitted from the data used to plot the bar graph in panel (c).

social costs for an investment could equal the total investment cost, because their co-funding must be paid by the respective government budget (i.e., it is ultimately paid for by the taxpayers). To account for the possibilities that own financing and total cost may play varying roles, we examine the relationship between project approval and the two cost types.

4. Results

4.1. Descriptive results

4.1.1. Approval and the cost effectiveness ratio

We first examine the relationship between project approval and the cost effectiveness ratio in Fig. 1. Fig. 1 panel (a) depicts the GHG emission reduction per project on the vertical axis and total project cost in million USD on the horizontal axis. Likewise, Fig. 1 panel (b) shows GHG emission reduction on the vertical axis and applied financing in million USD on the horizontal axis. For both approved and unapproved projects the total project cost increases when the total amount of GHG mitigation increases. There are a few exceptions for outlier projects that claim to reduce more than 100 thousand tons of CO_2e per project at minimal cost. These outlier projects are unapproved, and they are proposals to invest in energy conversion systems, transport systems, and vehicle fleets, of the applying organization. The similarity between Fig. 1 panel (a) and panel (b) is notable, suggesting that applied financing has a similar distribution as total cost. In addition, the average percent of the total cost that the applicant proposed to cover using the grant is similar between granted and non-granted projects across different project types (see Figure A.1 in the Appendix).

To further examine project approval and the cost effectiveness ratio, Fig. 1 panel (c) and panel (d) plot average GHG reduction per total invested USD across decile and the cumulative distribution of GHG reduction per total invested USD, respectively. Despite cost effectiveness being one of the main criteria for project approval, in all deciles except the 10th, there is no observable difference in the average cost effectiveness between approved and unapproved projects. In the tenth decile, the average cost effectiveness is higher for unapproved projects. However, approved projects GHG reduction per total invested USD (cost effectiveness) is highly concentrated around the mean.

There could be at least two explanations for the seemingly weak relationship between the cost-effectiveness ratio and project approval. First, several projects that claim to reduce emissions at low cost might be deemed unfeasible or unrealistic by the Swedish Environmental Protection Agency. There is no information in the dataset that informs whether this is the case. Second, projects that are classified as priority, e.g., because they contribute to the introduction of a new technology, can obtain funding even if they are not cost effective (Swedish Environmental Protection Agency, 2024a; National Swedish Audit Office, 2019). The latter can be motivated by the agency correcting yet another market failure, related economies of scale, where a technology becomes cost effective only if it is applied at a certain scale. The argument could be that markets do not sufficiently incentivize private actors to take the initial leap of investing in environmental projects, because for the first movers the investment costs exceed future private profits. Also, for novel technologies private agents are faced with a highly uncertain payoff, due to the uncertain performance of the technology, which can deter investments (Hourcade et al., 2021). In such instances, agencies such as the Swedish Environmental Protection Agency can play an important role by providing project funding. Such strategic considerations might explain the patterns in Fig. 1. Thus, to confirm the role of the cost-effectiveness ratio for project approval, we need to take project (i.e. technology) type into account, which is done in Section 5 below.

4.1.2. Heterogeneity in cost per unit of carbon reduction across sectors

If the Swedish Environmental Protection Agency considers also market failures relating to economies of scale for different technologies, this implies that the agency implicitly assigns differing emission reduction value to different project types, i.e. different technologies. For example, think of two hypothetical projects. First, an electric car charging station is estimated to reduce 1 ton of CO_2e emissions per 1000 USD invested. Charging stations could be argued to have a pivotal role in electric car adoption because their availability is essential for electric cars to be demanded. A second project on improving waste removal from restaurants is estimated to reduce 1 ton of CO_2e emissions per 500 USD invested. Restaurants' waste removal improvements could be approved because of its direct effect on emissions, which might be large, even though the technology is well established. Assume further that these two projects are the most expensive ones (in terms of the cost per CO_2e emission reduction) that the Swedish Environmental Protection Agency deem relevant and decides to fund for the two technology types. Also, suppose that there are multiple bids with both higher and lower cost-effectiveness ratios, such as indicated by Fig. 1. By funding the two projects, the agency assigns an implicit carbon price of 1000 USD and 500 USD per ton of CO_2 reduced through the investments in charging stations and restaurant waste removal, respectively.

To see how such carbon pricing is implemented, we first check the marginally funded project for each project type. This exercise reveals that the highest cost per CO_2e emission reduction in approved projects is found for electric charging stations, followed by (in order) vehicles, infrastructure, and transport, see Table S.1 in the Supplementary Material. This is consistent with program aims to the degree that charging stations and transport measures are prioritized. However, the same table shows that there are numerous unapproved projects for which the cost per CO_2e emissions reduction is lower than for the marginally approved project. This raises the question whether cost-effectiveness has been systematically considered across the whole range of project bids.

Next, we plot projects' average CO_2e emissions reduction per total spending for different project types in Fig. 2 panel (a). The associated total USD per kg of CO_2e emissions reduced are presented in Fig. 2 panel (b). Two facts are observable in Fig. 2. First, the figure confirms the suspicion from above that funded projects are not always the most cost-efficient ones. Second, for approved projects the average amount of invested USD required to reduce one kg of GHG differs by project type. This could potentially be due to differences in the distribution of bids across project types.

We return to a closer examination of factors that influence the probability of project approval and heterogeneity in the cost-effectiveness ratio across project types in Section 5.

4.1.3. Summary statistics

Table 1 presents summary statistics of project approval and the projects' and the applicants' characteristics. The variable that captures the cost effectiveness ratio, GHG emission reduction per invested USD, informs on the aggregate effect across the estimated life span of the project. The average project proposes to reduce 48.29 kg of CO_2e emission per total invested USD (i.e. total investment including investment support and own co-funding). Cost effectiveness in terms of applied investment cost corresponds to 70.78 kg of CO_2e per USD. The projects are conducted combining own funds, funding from the Swedish Environmental Protection Agency and external funds.[9] However, the share of external funding other than the EPA's is low, for example only 3.56 % of submitted projects obtain EU support. The average project applies for a 54.26 % funding from the agency.

The projects submitted to the Climate Leap program are classified into 10 broad categories. However, most of the projects (53.57 %) propose to build electric car charging stations. The remaining nine categories account for 46.43 % of the applications of which 20.61 % inquire funding to invest in energy systems, 7.37 % propose to upgrade

[9] The total cost itself varies from USD 600 to USD 76 million which depends on the size of the project.

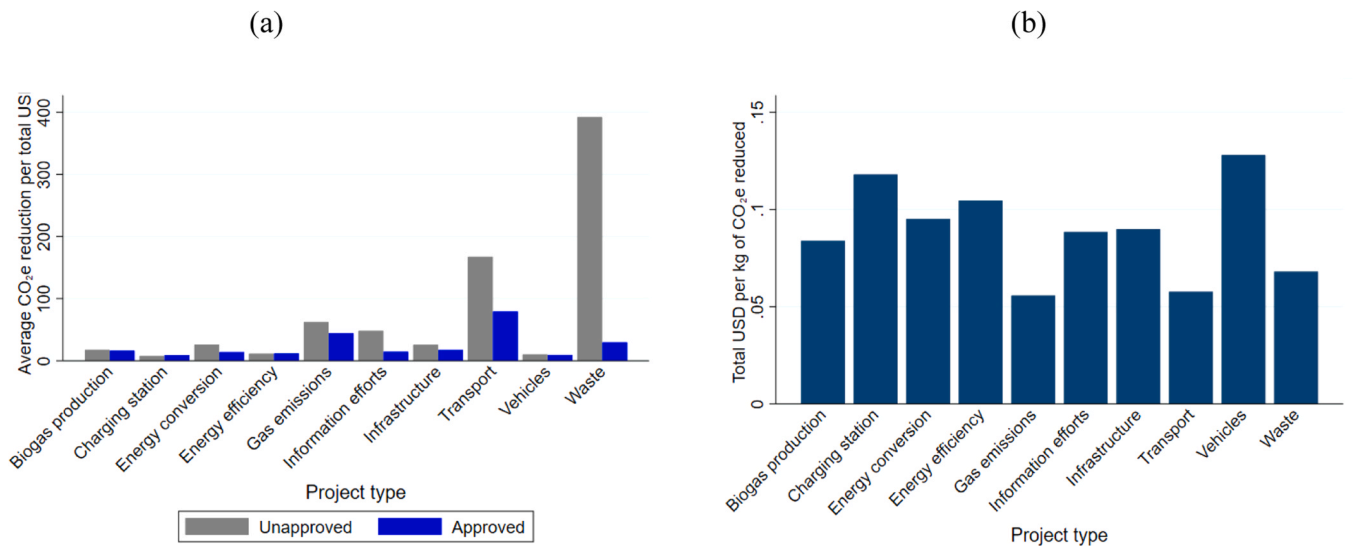

Fig. 2. Panel (a): Cost effectiveness in terms of GHG reduction divided by total cost. Panel (b): Implied average carbon price per project type by total cost for approved projects.

Table 1
Summary statistics.

	Categories	Obs.	Percent	Mean (Std. Dev.)
Dependent variable:				
Approved	Yes	2283	45.11	
	No	2778	54.89	
Explanatory variables:				
GHG reduction per total USD (CO_2e kg)		5060		48.29 (1639.17)
GHG reduction per applied USD (CO_2e kg)		5056		70.78 (1677)
Percent of applied investment support out of total cost		5059		54.26 (14.03)
Project type	Biogas production	69	1.36	
	Charging station	2711	53.57	
	Energy conversion	1043	20.61	
	Energy efficiency	281	5.55	
	Gas emissions	45	0.89	
	Information efforts	206	4.07	
	Infrastructure	91	1.8	
	Transport	373	7.37	
	Vehicles	188	3.71	
	Waste	54	1.07	
Organization type	Housing cooperative	756	14.94	
	Private company	3242	64.06	
	Non-profit organization	172	3.4	
	Municipalities and counties	446	8.81	
	Municipal companies	445	8.79	
EU support	Yes	180	3.56	
	No	4881	96.44	
Taxpayer	Yes	4046	79.94	
	No	1015	20.06	
Gini Coefficient		5055		0.5 (.03)
Population density per km^2		5055		762.72 (1543.99)
Disposable income in thousand USD, constant prices		5055		29.76 (3.25)
At-risk-of-poverty, percent		5055		14.61 (3.82)

or change transport mode, 5.55 % ask for investment to improve energy efficiency, 4.07 % propose to conduct information campaigns intended to increase awareness, and 3.71 % propose to upgrade their vehicle fleet. The remaining projects propose to build infrastructure, invest in mechanisms of reducing gas emissions, and install or upgrade waste management systems.[10]

The applying organizations are classified into five broad categories among which 64 % are private firms and 15 % are housing cooperatives. Municipality administrations, county administrations, and companies that are either owned by or are subsidiaries of municipalities account for about 18 % of the applying organizations. Non-profit organizations are also among the applicants seeking funding from the Climate Leap program, but they account for only about 3 %.

Additional data on inequality, population density, income and poverty are obtained from Statistics Sweden. To explore the role of distributional concerns for the decisions on investment support, we consider the Gini Coefficient, the population density per square kilometer, the median disposable income in thousand USD in 2020 constant prices, and the percentage of population at-risk-of-poverty. The data on these variables is municipal level data spanning the study period. The average Gini coefficient across the Swedish municipalities is 0.5 and the average percentage of the population classified as at-risk-of-poverty is 14.61 %. The average municipality population density, across all applications in the dataset, is 763 persons per square kilometer. This reveals that applications from densely populated municipalities are overrepresented, as the country average is 25 persons per square kilometer. Calculated similarly, the average pre-tax income is 29,760 USD in 2020 prices, including earnings from both employment and capital gains.

4.2. Results from regression analysis

4.2.1. Determinants of project approval

We begin our analysis by investigating the determinants of project

[10] Energy conversion (i.e., change of energy source) and energy efficiency projects can both be implemented in different sectors (industry, agriculture, and buildings). Infrastructure projects include investments in biking and pedestrian facilities, equipment for ship charging or refueling, district heating/cooling, and hydrogen production. The vehicle category includes heavy vehicles, bikes, ships, railways, while the transport category includes refueling stations including their pipelines and ‘other transport projects’. Electric car charging stations, biogas, waste, gas emissions, and information, projects are not disaggregated into subcategories in the EPA’s guidelines and data.

approval. Table 2 presents estimation results of the probit and LPM specifications. Odd columns account for the effect of emissions reduction per total cost and even columns account for the effect of emissions reduction per applied cost. Appendix Table A1 presents estimation results of the probit specification from which marginal effects are calculated and presented in Table 2 columns (1) and (2). Columns (3) – (6) report results from the LPM specification which are the equivalent of the marginal effects. In columns (5) and (6), county and year fixed effects are included. Comparing the results in columns (2) – (4) shows that the estimated effects are consistent across different specifications despite varying model assumptions, functional specifications, and control variables.

The Swedish Environmental Protection Agency states in its Climate Leap Program description that cost effectiveness is one of the main criteria used to evaluate project proposals. Estimation results show that a one percent increase in GHG emission reduction per total invested USD increases the probability of obtaining funding by 0.11 points. In addition, applying for a larger sum of money undermines the probability of obtaining funding, confirming results in Fridstrom and Elvik (Fridstrom & Elvik, 1997). A one percentage point increase in the applied cost reduces the probability of securing funding by 0.001 percentage points. A comparison of odd numbered and even numbered columns shows that the effect of total cost and applied sum on Swedish Environmental Protection Agency's project approval rate are very similar, despite the average applied sum being just slightly more than half of total cost, see Table 1. This implies that the share of contribution to the project from applicants own funding plays a limited role. This result confirms the patterns observed in Figs. 1 and 2 above.

In the result reported in Table 2, the comparison benchmark for project type is transport, which includes transport mode and transport infrastructure projects, such as biogas stations, hydrogen stations, bicycle parking and car parking. Compared to the transport category, charging stations and energy conversion have a higher probability of being funded, while projects aiming to improve energy efficiency and waste treatment have a lower probability of being funded. The high probability for charging stations is in line with the Swedish Environmental Protection Agency's statement that those are particularly encouraged (Swedish Environmental Protection Agency, 2024a). However, transport measures, i.e. the reference category, are also a priority project type, and it is therefore not evident why energy conversion projects have a higher probability of approval, given that the cost-effectiveness ratio is controlled for. Among the organization types, municipalities and counties constitute the benchmark. Compared to those, housing cooperatives and municipal companies have a better chance of being funded, while non-profit organizations have a lower probability of obtaining funding. A potential explanation is that funding towards housing cooperatives and municipal companies could both be directed towards the housing sector, directly encouraging climate related investments in apartment buildings, for which there are comparatively few other positive economic incentives.

4.2.2. Heterogeneity in cost per unit of carbon reduction

In a market for environmental goods where demand and supply sides function well, market mechanisms ensure that prices of identical goods are equated across market space. Likewise, implicit carbon prices, i.e. the cost per unit of CO_2e emission reduction, associated with the Swedish Environmental Protection Agency's Climate Leap Program, could be expected to be similar across different project types for a cost-effective investment program. However, as shown in Fig. 2 panel (b) and in Table S.1 in the Supplementary Material, the agency does not associate similar values to a unit of GHG emission reduced from different project types.

In this subsection, we empirically test the equality of the marginal cost-effectiveness, i.e. the cost per unit of GHG reduction at the margin, across different project types. More specifically, we test whether the cost of reducing one more kg of GHG across projects is equal. The null hypothesis is that the dollar value of an additional unit GHG emission reduction across project types is the same. We also test equality of average cost-effectiveness across projects. To this end, we implement the following two strategies.

First, we test equality of marginal rate of substitution between GHG emission reduction and total cost for approved projects. To this end, we estimate the following equation:

$$\log(total\_cost_{it}) = \delta_1 \log(CO2_{it}) + \sum_j \mu_j (\log(CO2_{it}) \times project_j) + \sum_j \nu_j project_j + \alpha_i + \lambda_t + \gamma X + \epsilon_{it} \quad (6)$$

where $total\_cost_{it}$ is total cost of a project, $CO2_{it}$ is total CO_2e reduction of a project, and $project_j$ are indicators of the project types. X is a vector of regressors, α_i is county fixed effects of where the applicant is located, λ_t is year fixed effects, γ is a vector of coefficients to be estimated and ϵ_i is an error term. The coefficient of interest is thus μ_j which measures the project specific marginal rate of substitution between total cost and CO_2e reduction.

The specification in Eq. (6) allows identifying the project specific marginal rate of substitution separately from the Swedish Environmental Protection Agency's preferences for projects that incentivizes adoption of new technologies such as charging stations and capacity and ambition differences of the applying firm by controlling for type of project and total GHG reduction. Then, we test joint equality of $\mu_j, j = 1, \ldots, J$ using Wald test. The tested hypothesis is that, after accounting for the Swedish Environmental Protection Agency's preferences for projects and capacity and ambition differences of the applying firms, the marginal rate of substitution between total cost and GHG reduction should be constant across projects.

Second, we test the equality of average cost effectiveness across all project types jointly, excluding one type of project at a time using multivariate tests on mean log of invested USD per kg of CO_2e emission reduction. Testing equality of the means by excluding one project type at the time addresses the concern that differences in the average cost of reducing a unit of GHG emission could be driven by a single project type favored by the Swedish Environmental Protection Agency such as charging stations.

Table 3 presents results of test of equality of marginal rate of substitution between total cost and CO_2e emission reduction across approved projects. The full regression table is shown in Table A2. The results show that the null hypothesis of equality of the marginal rate of substitution between total cost and CO_2e emission reduction across approved projects is rejected.

The results of the comparison of the average cost effectiveness of projects are presented in Table 4. Columns (1) to (4) of Table 4 present different statistics of the same test obtained using Wilks' lambda, Pillai's trace, Lawley-Hotelling trace, and Roy's largest root. These multivariate tests behave differently based on the test's degrees of freedom and distribution of the data.[11] The results show that the calculated statistics reject the null hypothesis indicating that average cost effectiveness differs across projects.

These results indicate that the Swedish Environmental Protection Agency implicitly assigns different values to a unit of CO_2e emission reduction and project based social cost of carbon both at the margin and on average. There are several explanations why this might be the case. First, applicants of the climate project submit varying estimates of the cost of reducing GHG emissions and the agency is forced to select from available options. Second, the agency uses the cost of reducing a unit of CO_2e emission but does not pay attention to equality of the average and marginal costs. Third, a well-functioning market for carbon in Sweden does not exist and implicit prices of carbon are set on ad hoc basis. A fourth explanation could be the agency accepts a unit cost of CO_2e emission reduction less than or equal to a certain threshold.

[11] For details, see (Timm, 2002).

Table 2
Regression results. Dependent variable: Approved.

		Probit			OLS		
	Categories	(1)	(2)	(3)	(4)	(5)	(6)
Log GHG reduction per total USD (CO_2e kg)		0.112***		0.116***		0.121***	
		(0.015)		(0.016)		(0.014)	
Log GHG reduction per applied USD (CO_2e kg)			0.105***		0.106***		0.111***
			(0.013)		(0.014)		(0.013)
Applied percentage		−0.001**	0.000	−0.001**	0	−0.001*	0
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Project type	Biogas production	0.057	0.05	0.053	0.043	0.055	0.045
		(0.077)	(0.077)	(0.086)	(0.086)	(0.083)	(0.083)
	Charging station	0.240***	0.235***	0.258***	0.249***	0.247***	0.238***
		(0.066)	(0.066)	(0.075)	(0.074)	(0.074)	(0.074)
	Energy conversion	0.211***	0.207***	0.227***	0.220***	0.210***	0.203***
		(0.053)	(0.053)	(0.057)	(0.057)	(0.050)	(0.050)
	Energy efficiency	−0.133**	−0.140**	−0.110*	−0.119**	−0.100*	−0.110**
		(0.060)	(0.059)	(0.058)	(0.057)	(0.055)	(0.054)
	Gas emissions	0.014	0.013	0.014	0.011	0.025	0.022
		(0.085)	(0.084)	-(0.091)	(0.090)	(0.091)	(0.090)
	Information efforts	−0.119	−0.119	−0.079	−0.082	−0.105	−0.108
		(0.091)	(0.091)	(0.082)	(0.082)	(0.077)	(0.077)
	Infrastructure	0.016	0.005	0.017	0.004	0.01	−0.003
		(0.081)	(0.083)	(0.085)	(0.086)	(0.081)	(0.081)
	Vehicles	0.014	0.005	0.014	0.003	−0.008	−0.019
		(0.061)	(0.061)	(0.061)	(0.061)	(0.056)	(0.056)
	Waste	−0.281***	−0.284***	−0.232***	−0.232***	−0.267***	−0.263***
		(0.103)	(0.102)	(0.082)	(0.080)	(0.077)	(0.076)
Organization type	Housing cooperative	0.279***	0.279***	0.254***	0.255***	0.175***	0.176***
		(0.036)	(0.036)	(0.035)	(0.035)	(0.037)	(0.037)
	Private company	−0.043	−0.041	−0.04	−0.038	−0.084**	−0.082**
		(0.036)	(0.036)	(0.039)	(0.039)	(0.037)	(0.038)
	Non-profit organization	−0.210***	−0.212***	−0.162***	−0.166***	−0.183***	−0.186***
		(0.050)	(0.050)	(0.043)	(0.043)	(0.045)	(0.045)
	Municipal companies	0.059*	0.059*	0.069*	0.069*	0.045	0.045
		(0.034)	(0.034)	(0.037)	(0.037)	(0.036)	(0.036)
EU support	Yes	0.012	0.012	0.012	0.009	0.021	0.017
		-(0.043)	(0.043)	(0.042)	(0.042)	(0.042)	(0.042)
Taxpayer	Yes	−0.019	−0.02	−0.016	−0.016	−0.019	−0.019
		(0.026)	(0.026)	(0.024)	(0.024)	(0.024)	(0.024)
Constant				0.189**	0.08	0.216***	0.102
				(0.080)	(0.084)	(0.079)	(0.085)
Fixed effects						Yes	Yes
Observations		5055	5054	5055	5054	5055	5054

Note: Column numbers (1)-(6) indicate models. In models (1) and (3) the dependent variable is total project cost, in models (2) and (4) the dependent variable is applied cost. Models (3) and (6) are estimated with a constant, using total costs as dependent variable. * p<0.1, ** p<0.05, *** p<0.01. Standard errors in parenthesis are clustered by organization. Column (4) includes county and year fixed effects.

Table 3
Test of equality of marginal rate of substitution between total cost and GHG emission reduction across approved projects.

	Coefficients equality test
F-statistic	7.40***
Controls	Yes
Degrees of freedom	2094

Note: This table reports results of equality test of project specific marginal rate of substitution between total cost and CO_2e reduction estimated from Eq. (6). In the regression, standard errors are clustered by organization. The regression sample contains only approved projects. * p<0.1, ** p<0.05.
*** p<0.01.

The results have important implications for how public agencies choose to fund climate projects and for their abatement costs. To guarantee cost effectiveness of public spending, guidelines for selecting funded projects should clearly state and take into consideration the optimal level of unit cost of emission reduction and the implied carbon price when other objectives, such as technology adoption, are not priorities.

4.2.3. Distributional effects

Studies have shown that environmental policies affect income inequality through changes in prices, welfare, and firms' compliance

Table 4
Test of equality of average cost effectiveness across project types.

	Multivariate tests on means			
	Wilks' lambda (1)	Pillai's trace (2)	Lawley-Hotelling trace (3)	Roy's largest root (4)
All projects	0.788***	0.212***	0.269***	0.269***
Dropping one project at a time. Dropped project type:				
Biogas production	0.789***	0.211***	0.267***	0.267***
Charging station	0.83***	0.17***	0.205***	0.205***
Energy conversion	0.766***	0.234***	0.305***	0.305***
Energy efficiency	0.785***	0.215***	0.273***	0.273***
Gas emissions	0.797***	0.203***	0.254***	0.254***
Information efforts	0.788***	0.212***	0.269***	0.269***
Infrastructure	0.786***	0.214***	0.273***	0.273***
Transport	0.878***	0.121***	0.138***	0.138***
Vehicles	0.786***	0.214***	0.272***	0.272***
Waste	0.79***	0.21***	0.266***	0.266***

Note: * p<0.1, ** p<0.05.
*** p<0.01.

(Jha et al., 2019). Hence, policies like the Climate Leap Program could potentially be used by the Swedish Environmental Protection Agency for the purpose of redistributing income and welfare, and the approval of investment support could be modified to reduce negative distributional impacts associated with the cost-efficient distribution. In this section, we examine if the agency directs project funding (intentionally or unintentionally) towards applicants in response to the income and demographic characteristics of the municipalities where they are located. We consider four variables that indicate the distributional characteristics of a municipality: (i) the municipality specific Gini coefficients, which measure income inequality, (ii) the population density per square kilometer, which indicates the potential for a given investment to benefit a larger number of people, (iii) the disposable income in thousand USD in 2020 constant prices, and (iv) the percentage of population at-risk-of-poverty. All of those are available over the years considered.

We assess the distributional effects using eight regressions. First, we run four separate regressions using the entire data where the dependent variable is project approval status and using one of the four independent variables together with control variables and fixed effects. The intention is to measure if project approval is correlated with measures of income inequality, population density, and income status. The results are reported in Table 5 column (1). Second, we regress the log of applied USD on the four variables using data containing only approved projects. The objective is to identify if the amount of money allocated per approved project correlates with income distribution and population pressure. The results are reported in Table 5 columns (2). Control variables listed in Table 1 and fixed effects are included in all regressions. The results do not show conclusive evidence that the Swedish Environmental Protection Agency approves projects or allocates funds with an intention of redistributing income. Alternatively, if the agency decides on project approval with the intention of income redistribution, it is not significantly observable in the data. However, we find positive and strong evidence indicating municipalities with higher population density receive higher funding even if project approval rate is not significantly correlated with population density. The results show that a project located in a municipality with one percent higher population density receives 0.06 percent more funding if the project is approved.

5. Discussion and conclusions

This paper examines an investment program, the Swedish Climate Leap Program, that aims to reduce greenhouse gas emissions in a cost-effective manner. To that end, the investment program broadly targets multiple sectors and private as well as public applicants. To achieve cost effectiveness, the dollar cost of per unit of CO_2e emission mitigation should be similar across sectors. However, the program guidelines suggest that some preference should be given to projects that help to increase the dispersal of new technologies, such as electric car charging stations and transport related measures. This could be motivated from an economic viewpoint by the potential existence of scale economies in the use of technologies. We examine this investment program with respect to factors affecting grant approval, considering the projects' cost effectiveness ratio, technology type, applicant characteristics, and socioeconomic characteristics of the municipality where the applicant is located.

Table 5
Income distribution effect.

Explanatory variable	Dependent variable Approved (1)	 Log of granted USD (2)
Gini coefficient	0.176 (0.194)	−0.879 (0.686)
Log of population density	−0.001 (0.010)	0.060*** (0.023)
Log of disposable income	0.026 (0.166)	0.24 (0.331)
At-risk-of-poverty rate, percent	0.002 (0.003)	−0.005 (0.007)
Control variables	Yes	Yes
Fixed effects	Yes	Yes
Observations	5050	2775

Note: * p<0.1, ** p<0.05, *** p<0.01. Each cell reports a coefficient from independent regressions. Standard errors reported in parenthesis are clustered robust standard errors. The clustering is by organization.

In line with several earlier studies applied to transport sector infrastructure investment (McFadden, 1975, 1976; Fridstrom & Elvik, 1997; Eliasson & Lundberg, 2012), but in contrast with studies applied to investment in water pollution mitigation (Fernandez, 2004) and remediation of contaminated sites Forslund et al (2008), our results show that the cost-effectiveness ratio plays an important role in the Climate Leap Program. However, results also suggest full cost effectiveness is not achieved, as the cost effectiveness ratio varies significantly across project (technology) type. Program guidelines allow for higher unit costs for charging stations and transport measures because these measures are considered important for technology dispersal. An economic argument for this is that the Swedish Environmental Protection Agency might strive to solve another market failure simultaneously, that related to the economies of scale, where a certain volume of investment is necessary for a technology to be cost effective. The unit cost for emission reduction through charging stations are indeed higher than for most other technologies, but the unit cost for transport measures is comparatively low, while investments in vehicle fleets, and in energy conversion and energy efficiency receive high support in relation to carbon mitigation achieved. We do not find any obvious reasons for this result, but fear that the outcome could be due to inefficient administrative procedures.

Results show that larger grants are approved for applicants located in densely populated municipalities. This could potentially be explained by the Swedish Environmental Protection Agency also considering the public good nature of some of the technologies supported through the program. For example, the benefits of charging stations and transport measures could be higher when applied in densely populated areas because more people would make use of them. On the other hand, a widely distributed network of charging stations could be important for people's choice to purchase electric cars, given that they might want to be able to use the car also for driving to more remote areas, even when living in a densely populated one. Previous studies have considered the possibility that the regional distribution of investment support could be explained by political motives, with mixed evidence (Forslund et al., 2008; Bertoméu-Sánchez & Estache, 2017). Our results indicate that concerns for the public good characteristics of the investment supported, with associated implications for the benefits generated, could add to these explanations.

A limitation of our study is the lack of information on the Swedish Environmental Protection Agency's evaluation of the different projects when it comes to projects' feasibility, and resources for completing the project. The results show somewhat surprisingly that the applicants' share of own funding does not play any significant role in project approval, but the feasibility of projects could also be related to other factors, including the applicants experience with similar projects, and the ability to manage project risks. Also. the Climate Leap Program is designed to allow all interested organizations to apply but the data collected for the program shows only those organizations that have applied. While the program design encourages climate investment, it is not designed to induce a random variation which could enable identifying causal mechanisms. For this reason, the effects measured in the empirical exercise of this study are unlikely to be free from endogeneity and self-selection bias.[12] The results should be interpreted with this in mind and feature projects that collaborate with an environmental

[12] For example, a recent study by Ferguson and Nolgren (Ferguson & Nolgren, 2024) suggests that larger and more experienced firms are disproportionately represented among the Climate Leap applicants and grantees, albeit the consequences for the effectiveness of the program in meeting its aims are not studied.

agency to introduce a random variation to the decision-making process would be able to solve this issue.

The research has important policy implications. From an economic viewpoint, a support scheme targeting multiple sectors is superior to schemes targeting only a single sector because of the opportunity to equalize marginal abatement costs. However, the multisector approach has been criticized by the National Swedish Audit Office (National Swedish Audit Office, 2019), that argues that the multisector approach is difficult to handle due to the presence of other policy instruments for incentivizing GHG mitigation that affect only some of the sectors eligible to apply for investment support. Also, they argue that because of the large variety of companies eligible, those could obtain an informational advantage in relation to the Swedish Environmental Protection Agency, because it can become difficult for the agency's administrators to compare applications that are highly heterogeneous. Our study contributes by informing us on the actual resulting heterogeneity of cost effectiveness ratios across project technology types. This information can be used by the agency for evaluating whether the magnitude of the variation across project type is motivated given the economies of scale effects and the presence of other policy instruments that are to be considered. It can also be used by the agency for comparing the cost effectiveness of the Climate Leap program to earlier programs targeting a narrower range of project types, thereby allowing the agency to evaluate whether the multisector approach is more cost effective or not.

Our study also has interesting implications for research. First, it would be of interest to evaluate the cost-effectiveness of the program in its multisector form compared to alternative configurations with single sector approaches. Second, it would be valuable to carry out *ex post* evaluation of the cost-effectiveness of investment program, taking into account the actual implementation of the different projects. Finally, it would also be of interest to compare the cost-effectiveness of the program for incentivizing investments, to that of more general policy instruments such as the EU ETS and the national carbon tax applied to the non-ETS sectors.

CRediT authorship contribution statement

Abenezer Zeleke Aklilu: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Rebecca Swärd:** Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Katarina Elofsson:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to the Swedish Environmental Protection Agency for providing us with access to the data used for this study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

APPENDIX A

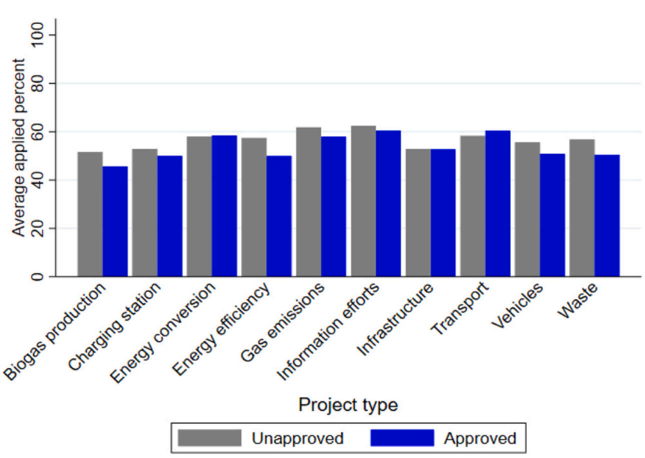

Fig. A.1. Percent of total cost applicants proposed to cover using project funding from the EPA.

Table A.1
Probit results.

Dependent variable: Approved		**Probit**	
	Categories	**(1)**	**(2)**
Log CO_2e reduction per total USD (kg)		0.346*** (0.048)	
Log CO_2e reduction per applied USD (kg)			0.325*** (0.044)
Applied percentage		−0.004** (0.002)	0 (0.002)
Project Type	Biogas production	0.177 (0.238)	0.154 (0.237)
	Charging station	0.742*** (0.209)	0.726*** (0.208)

(*continued on next page*)

Table A.1 (*continued*)

Dependent variable: Approved	Categories	Probit (1)	Probit (2)
	Energy conversion	0.652*** (0.164)	0.639*** (0.163)
	Energy efficiency	−0.409** (0.184)	−0.431** (0.183)
	Gas emissions	0.043 (0.262)	0.04 (0.259)
	Information efforts	−0.367 (0.282)	−0.368 (0.282)
	Infrastructure	0.049 (0.251)	0.016 (0.255)
	Vehicles	0.042 (0.190)	0.016 (0.188)
	Waste	−0.868*** (0.317)	−0.876*** (0.315)
Organization type	Housing cooperative	0.860*** (0.108)	0.862*** (0.108)
	Private company	−0.132 (0.111)	−0.126 (0.111)
	Non-profit organization	−0.648*** (0.152)	−0.656*** (0.151)
	Municipal companies	0.183* (0.105)	0.183* (0.106)
EU support		0.037 (0.133)	0.036 (0.132)
Taxpayer		−0.059 (0.081)	−0.06 (0.081)
Constant		−0.891*** (0.248)	−1.261*** (0.264)
Observations		5055	5054

Table A2

Regression result of Eq. (6) using only the sample of approved projects. Dependent variable: log(total cost).

		(1)
GHG reduction		0.071 (0.070)
Log USD per GHG reduction × Project Type	Biogas production	0.155 (0.129)
	Charging station	0.186** (0.074)
	Energy conversion	0.227*** (0.081)
	Energy efficiency	0.324** (0.151)
	Gas emissions	−0.028 (0.078)
	Information efforts	0.071 (0.078)
	Infrastructure	0.119 (0.148)
	Vehicles	0.532*** (0.111)
	Waste	0.692*** (0.244)
Project Type	Biogas production	−0.758 (1.822)
	Charging station	−4.738*** (0.934)
	Energy conversion	−3.384*** (1.037)
	Energy efficiency	−3.959** (1.967)
	Gas emissions	−0.203 (1.022)
	Information efforts	−2.152** (1.044)
	Infrastructure	−1.854 (1.888)
	Vehicles	−7.613*** (1.419)
	Waste	−9.807*** (3.507)
Applied percentage		−0.014*** (0.003)
Organization type	Housing cooperative	−0.069 (0.095)
	Private company	−0.198** (0.084)
	Non-profit organization	−0.313* (0.183)
	Municipal companies	0.105 (0.111)
EU support	Yes	0.246** (0.125)
Taxpayer	Yes	0.043 (0.064)
Constant		15.328*** (0.886)
Controls		Yes
Fixed effects		No
Observations		2776

Notes: * p<0.1, ** p<0.05, *** p<0.01

Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jclimf.2024.100051.

References

Angrist, J. D., & Pischke, J.-S. (2008). *Mostly Harmless Econometrics*. New Jersey: Princeton University Press.

Baker, E., & Shittu, E. (2006). Profit-maximizing R&D in response to a random carbon tax. *Resource and Energy Economics, 28*(2), 160–180.

Van den Bergh, J. C., Castro, J., Drews, S., Exadaktylos, F., Foramitti, J., Klein, F., Konc, T., & Savin, I. (2021). Designing an effective climate-policy mix: accounting for instrument synergy. *Climate Policy, 21*(6), 745–764.

Bertoméu-Sánchez, S., & Estache, A. (2017). Unbundling political and economic rationality: A non-parametric approach tested on transport infrastructure in Spain. *Transport Policy, 59*, 181–195.

Bondemark, A., Sundbergh, P., Tornberg, P., & Brundell-Freij, K. (2020). Do impact assessments influence transport plans? The case of Sweden. *Transportation Research Part A: Policy Practice, 134*, 52–64.

Bumpus, A. G. (2015). Firm responses to a carbon price: corporate decision making under British Columbia's carbon tax. *Climate Policy, 15*(4), 475–493.

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and Applications*. New York: Cambridge University Press.

Carraro, C., Favero, A., & Massetti, E. (2012). Investments and public finance in a green, low carbon, economy. *Energy Econ, 34*, 15–28.

EC (European Commission). 2030 Climate Target Plan. ⟨https://climate.ec.europa.eu/eu-action/european-green-deal/2030-climate-target-plan_en⟩. (accessed 9 March, 2023).

Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. *Energy Build, 225*, Article 110322.
Eliasson, J., & Lundberg, M. (2012). Do cost–benefit analyses influence transport investment decisions? Experiences from the Swedish Transport Investment Plan 2010–21. *Transport Reviews, 32*(1), 29–48.
Ferguson, S., & Nolgren, J. (2024). *Who applies for abatement subsidies? Evidence from Swedish firms. Working Paper 2024:1*. Department of Economics, Swedish University of Agricultural Sciences.
Fernandez, L. (2004). Revealed preferences of an international trade and environment institution. *Land Economy, 80*(2), 224–238.
Forslund, J., Samakovlis, E., & Johansson, M. V. (2008). Is it wise to combine environmental and labour market policies? An analysis of a Swedish subsidy programme. *Ecological Economics, 65*(3), 547–558.
Fowlie, M., Greenstone, M., & Wolfram, C. (2018). Do energy efficiency investments deliver? Evidence from the weatherization assistance program. *Quarterly Journal of Economics, 133*(3), 1597–1644.
Fridstrom, L., & Elvik, R. (1997). The barely revealed preference behind road investment priorities. *Public Choice, 92*(1), 145–168.
Hourcade, J. C., Dasgupta, D., & Ghersi, F. (2021). Accelerating the speed and scale of climate finance in the post-pandemic context. *Climate Policy, 21*(10), 1383–1397.
Iyer, G., Ledna, C., Clarke, L., Edmonds, J., McJeon, H., Kyle, P., & Williams, J. H. (2017). Measuring progress from nationally determined contributions to mid-century strategies. *Nature Climate Change, 7*(12), 871–874.
Jha, A., Matthews, P. H., & Muller, N. Z. (2019). Does environmental policy affect income inequality? Evidence from the Clean Air Act. In *AEA Papers and Proceedings, 109* pp. 271–276). American Economic Association.
Liu, P. R., & Raftery, A. E. (2021). Country-based rate of emissions reductions should increase by 80% beyond nationally determined contributions to meet the 2C target. *Communications Earth & Environment, 2*(1), 29.
Maestre-Andrés, S., Drews, S., Savin, I., & Van den Bergh, J. (2021). Carbon tax acceptability with information provision and mixed revenue uses. *Nature Communications, 12*, 7017.
McFadden, D. (1975). The revealed preferences of a government bureaucracy: Theory. *Bell Journal of Economics*, 401–416.
McFadden, D. (1976). The revealed preferences of a government bureaucracy: Empirical evidence. *Bell Journal of Economics*, 55–72.
National Swedish Audit Office, 2019. Klimatklivet – stöd till lokala klimatinvesteringar. [The Climate Leap – support to local climate investments]. (In Swedish), Report 2019:1.
Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review, 109*(6), 1991–2014.
Owen, R., Brennan, G., & Lyon, F. (2018). Enabling investment for the transition to a low carbon economy: Government policy to finance early stage green innovation. *Current Opinion in Environmental Sustainability, 31*, 137–145.
Swedish Environmental Protection Agency. Om klimatklivet. [About the Climate Leap]. (In Swedish) ⟨https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/⟩ (accessed 11 September 2024a).
Swedish Environmental Protection Agency. Villkor for stod från Klimatklivet. [Conditions for support from Klimatklivet]. (In Swedish). ⟨https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/klimatklivet/forutsattningar-for-stod-fran-klimatklivet/⟩ (accessed 11 September 2024b).
Applied Multivariate Analysis. (2002). In Timm. N. H. (Ed.), (2002). New York, NY: Springer.
Tol, R. S. (2018). The economic impacts of climate change. *Review of Environmental Economics and Policy, 12*(1), 4–25.
Train, K. E. (2009). *Discrete Choice Methods with Simulation* (2nd ed.). New York: Cambridge University Press.