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Not All Policies Are Created Equal: Impact of Different Climate Policy Instruments on Sustainable Venture Investments

Jingting Liu[1]

Abstract: This paper examines the efficacy of different climate policies in inducing sustainable investments and the policy efficiency measured by the business outcomes of investment-receiving firms and the environmental outcomes. Focusing on sustainable venture investments worldwide between 2000 and 2022, our estimates show heterogeneous effects across different types of policies: more binding policies have a greater impact on investments while less binding policies such as strategy and target have an insignificant impact. Regarding the policy transmission channel, different climate policies induce investments in different types of firms. While policy decisions of economic instruments providing subsidies and less binding strategy and target instruments induce a higher share of investments in newly founded start-ups, the reverse is true for more stringent policies such as cost-imposing economic instruments (e.g., carbon taxes) and regulatory instruments. Moreover, these more stringent policies foster more favorable business outcomes in start-ups founded in the years after policy decisions and significantly increase renewable energy generation. Our results thus point to more stringent policies being more effective and efficient in driving energy transition.

Keywords: climate policy, sustainable investment, venture capital, renewable energy

JEL Classification: G11, G18, Q56, Q58

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1. Introduction

The growing push for energy transition globally requires sustainable investments to increase in tandem (Gourinchas, Schwerhoff, and Spilimbergo, 2023). According to the International Renewable Energy Agency (IRENA), close to US$1.3 trillion annual investments in renewables are needed by 2030 to reach the goals set out in the Paris Agreement. How can these investments happen? As noted in Pisani-Ferry and Mahfouz (2023), energy transition will be "driven by public policy rather than by technological innovations and market forces," climate policies play a pivotal role in driving the transition and potentially drawing investments (Zheng, 2023).

However, there is also a rising consensus that climate policies must be efficient, taking both political and economic challenges into account (Gourinchas, Schwerhoff, and Spilimbergo, 2023). Such considerations are particularly relevant given the different policy approaches adopted in the EU and the US. While the EU uses carbon pricing, the US largely employs subsidies to renewable energy production exemplified by the Inflation Reduction Act (IRA), which has drawn criticisms for lack of efficiency and scalability (Stock, 2023). Meanwhile, the EU may grapple with an exodus of domestic EV firms for not providing enough incentives (*Bloomberg,* 2024). Against this backdrop, a key question is how different climate policies affect the economy, balancing the needs of achieving the efficacy of lowering emissions and efficiency (Krusell, Hassler, and Olovsson, 2024).

We address the question by empirically assessing the impact of climate policies on promoting energy transition through induced investments and their efficiency. To do so, we first establish the link between different climate policy instruments and sustainable investments, focusing on venture capital investments in sustainability-related industries. This speaks to the efficacy of the climate policies with the underlying assumption that more sustainable investments help reduce emission. Second, we examine how different climate policy instruments affect both the business outcomes of the start-ups that received investments and the environmental outcomes measured by renewable power generation. Examining the business outcomes — such as whether the start-ups have been acquired or undergone IPO — provides a gauge of the efficiency associated with different climate policies.

First, we identify the link between climate policy decisions and sustainable venture investments by leveraging the variation in the number of climate policy decisions of different instrument types across countries that had at least one sustainable venture investment deal between 2000 and 2022. We find that more binding policies have greater impacts on sustainable venture investments. An increase in the number of economic instruments providing revenue or subsidies, or regulatory instruments, significantly boosts the number of sustainable venture investments. Conversely, an increase in economic instruments that impose costs or taxes reduces the level of sustainable venture investments. Less binding policy instruments, such as policy support, strategy, and targets, do not significantly affect the volume of investments.

To understand the climate policy transmission mechanism, we examine how different types of policy instruments impact the types of start-ups that receive funding. We find that following stricter policy instrument decisions, such as cost-imposing economic instruments (taxes) and regulatory instruments, the share of more mature and higher-quality companies—those that ultimately secure an exit—increases among all companies receiving investments each year. In contrast, more lenient policies, such as policy support, strategy, and targets, are found to encourage more investments in new startups and companies with no exits.

Second, we examine the extent to which differences in average business outcomes of firms founded in the years following climate policy decisions can be explained by variations in the number of policy decisions of different types across countries and over time. Evidence from aggregate-level data (destination country-industry-year) shows that a higher number of cost-imposing economic instruments and regulatory instruments lead to more favorable business outcomes. This is indicated by an increased number of funding rounds secured by start-ups, a higher share of start-ups managing to exit, and a decreased share of companies becoming inactive. On the contrary, a higher number of less stringent policies, such as economic instruments providing revenue (subsidies) and policy support, strategies, and targets, is associated with a dip in favorable business outcomes. Evidence from firm-level data corroborates these findings: an increase in policy support, strategy, and target decisions predicts lower likelihoods of start-up exits. These results echo the inefficiency concerns of policies providing subsidies.

We then estimate the impact of different climate policy instruments on environmental outcomes, measured by total renewable power generation. We find that cost-imposing economic instruments and regulatory instruments significantly raise renewable energy generation.

The estimates also suggest heterogeneous effects of climate policies in inducing sustainable investments across industries and economies. For consumer goods and building industries, regulatory instruments significantly induce more investments but not economic instruments providing revenue (subsidies). For cleantech and renewable energy industries, both instruments are associated with higher number of investments. For the electric vehicle industry, economic instruments providing revenue induce more investments. Compared to the advanced economies, there is generally a stronger link between climate policies and sustainable venture investments in the emerging market economies, especially for the instrument of policy support, strategy and target. Meanwhile, regulatory instruments are increasingly associated with higher number of investments in the advanced economies in the years after such policy decisions.

This paper speaks to several strands of literature. First, in terms of methodology, this paper employs the Jorda (2005) local projection method in estimating the dynamic causal effect of climate policy shocks, and is therefore closely related to Metcalf and Stock (2023). However, while the authors estimate the macroeconomic impact of carbon tax in the Europe, we examine the sustainable venture investment creation effect of multiple types of climate policy instruments beyond carbon pricing.

Closely related to this paper is the literature studying the impact of climate policies on investments. A large body of literature in this field focuses on "green" foreign direct investment (FDI). Early theoretical works predict that FDI would flow from countries with more stringent environmental regulations to countries with less stringent regulations, in line with the pollution haven hypothesis (Markusen, Morey, and Olewiler 1993; Chichilnisky 1994). However, empirical studies have failed to provide conclusive evidence supporting this hypothesis (Cole, Elliott, and Zhang 2017). Looking into the effects of different types of climate policies, Johnstone, Haščič, and Popp (2010) find that more targeted subsidies are needed to induce innovation on costly energy technologies, such as solar power. More recently, Pienknagura (2024) finds that in countries with binding policies and measures that give out subsidies, the link between climate policies and "green" FDI is stronger. Different from Pienknagura (2024) and previous studies, this paper focuses on the venture investment space, and importantly extends the analysis to examining the link between different climate policies and the business outcomes of the firms received investments.

This study also extends earlier literature studying green bonds and cleantech venture capital (VC) investments. Both lines of literature extensively look into the differential returns of green investments compared to the others. In green bonds literature, while some show that green bonds are issued at premium thus lowering the financing cost, especially for US municipal bonds (Karpf and Mandel 2018; Pástor, Stambaugh, and Taylor 2021; Pástor, Stambaugh, and Taylor 2022), others find no evidence of green premium (Larcker and Watts 2020; Flammer 2021). In relation to climate actions, Cai and Zheng (2022) find that climate policy reduces the financing cost of green bonds compared to regular bonds. In cleantech venture investment literature, cleantech VC investments are found to yield more dismal returns compared to VC investments in the biotech or information and communication technology (ICT) sector (Gaddy, Sivaram, and O'Sullivan 2016), and Van Den Heuvel and Popp (2023) show that policies driving demand are needed. Similar to both lines of literature, we look into the performance of green investments by examining the business outcomes of the start-up firms that received the investments. Departing from existing literature, however, we include policy as a key parameter affecting the performance, and examine the heterogeneous impact of different climate policies on the performance of the start-ups.

The remainder of the paper is structured as follows. Section 2 presents the data used in the paper and discusses measures of business and environmental outcomes, while further details are left in the appendices. Section 3 outlines the empirical strategy for identifying the dynamic causal effects of climate policies on sustainable venture investments, the business, and the environmental outcomes. Section 4 conducts robustness checks. Finally, Section 5 concludes.

2. Data and Methodology

2.1 Data

2.1.1 Climate Policies and Instruments

We collect climate policy data from The Climate Policy Database, which includes national, supranational, and sub-national policies. We use national-level policies for the main analysis, which represents 97 percent of all policies. Each policy is classified into one of the five categories: (1) economic instrument – revenue, (2) economic instrument – cost, (3) regulatory instruments, (4) policy support, strategy, and target, (5) control group consisting of all the other policies.

"Economic instrument – revenue" include only policies with instruments that fund projects or provide subsidies. These policy instruments include funds to sub-national governments, infrastructure investments, procurement rules, RD&D funding, feed-in tariffs or premiums, grants and subsidies, loans, net metering, tax relief, tendering schemes, retirement premium, and direct investment.

"Economic instrument – cost" are policy instruments that incur costs to firms, such as CO_2 taxes, energy and other taxes, user charges, greenhouse gas (GHG) emissions allowances, GHG emission reduction crediting and offsetting mechanism, green certificates, white certificates, and market-based instruments.

Regulatory instruments include policy instruments labelled as building codes and standards, industrial air pollution standards, product standards, sectoral standards, vehicle air pollution standards, vehicle fuel-economy and emissions standards, auditing, monitoring, obligation schemes, other mandatory requirements, codes and standards, and regulatory instruments.

Policy support, strategy, and target include overarching strategies and targets. These are the instruments with the following labels: institutional creation, strategic planning, formal and legally binding climate strategy, political and non-binding climate strategy, coordinating body for climate strategy, energy efficiency target, GHG reduction target, renewable energy target, policy support, climate strategy, and target.

Finally, the last group is a collection of all the remaining policies. These include instruments associated with information provision and education, research program, voluntary approaches, barrier removal, and economic instruments with no specification of whether they provide subsidies or would raise costs to firms, as well as policies that do not uniquely fall under one of the previous four categories. This last group enters the regressions as a control for identifying the impact of the earlier four categories of policies.

2.1.2 Sustainable Investments

We collect all sustainable venture investments available from Crunchbase. Crunchbase categorizes the following 23 industries under the sustainability industry group: biofuel, biomass energy, carbon capture, clean energy, cleantech, energy efficiency, environmental engineering, geothermal energy, green building, green consumer goods, greentech, hydroelectric, natural resources, organic, pollution control, recycling, renewable energy, solar, sustainability, waste management, water purification, wildlife conservation, and wind energy. We further add electric vehicle and organic food to the sustainability industry group. Each sustainability investment is then classified into one of the five industry groups, including (1) electric vehicle, (2) energy, (3) environment, (4) consumer and building, and (5) cleantech. As each portfolio company can be tagged with multiple industry labels, we classify each deal in the order of categories listed above, meaning that a company with both "electric vehicle" and "renewable energy" label would be classified as "electric vehicle". We document investment classification procedure in Appendix B. Figure 2 below displays the top 10 keywords[2] from all the portfolio company descriptions associated with the deals within each of the five categories.

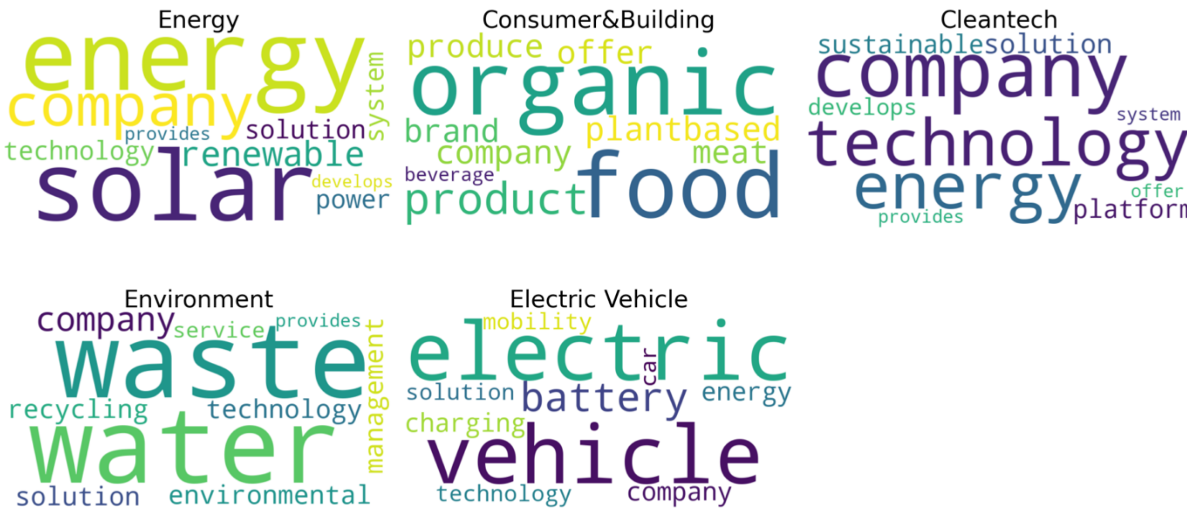

Figure 1. Word clouds for sustainable investments by category.

[2] Keywords are selected based on Term Frequency-Inverse Document Frequency method, which weighs the importance of each word based on the frequency it appears within a category and the uniqueness of the word to each of the category.

We further measure the business outcomes of startups that have received investments by the average number of funding rounds secured, the share of startups that exited—either through acquisition or IPO—and the share of companies that became inactive among startups founded each year. To examine the characteristics of ventures through which climate policies have impacted investment attraction, we also evaluate the share of newly founded start-ups and the share of companies that have exited among all companies that secured funding each year following policy decisions. Finally, we measure the energy transition outcomes of climate policies using the amount of renewable energy generation by country. We detail the calculations for both business and environmental outcomes below. Appendix C additionally provides a summary of the business outcomes of the firms by industry.

Number of Funding rounds

We calculate the average number of funding rounds secured by companies in each country-industry group by each year the companies were founded, $nrounds_{c,i,t(founding)}$. Although it's not necessary for successful start-ups to go through many rounds of funding, but being able to secure higher number of funding rounds provides a proxy for how promising and attractive the company is to the investors.

Exits

Successful venture capital or private equity investments usually end with exits through acquisitions or IPOs. We assign the exit status of each portfolio company to be one if they have exited and zero if they have not. We first calculate the share of companies that have exited out of all the companies received funding in each year, $\pi^{exits}_{c,i,t(current)}$, for examining the type of companies that received funding following climate policy decisions. We then calculate the share of companies that have exited out of all the companies founded in the same year,

$\pi^{exits}_{c,i,t(founding)}$, for examining how different climate policies impact the exit rate among companies of the same batch.

Inactive Firms

While exiting is often the goal of successful venture and private equity investments, companies that have not yet exited are not necessarily failing investments. We therefore additionally calculate the share of all companies founded in the same year that have become inactive, $\pi^{inactive}_{c,i,t(founding)}$ – meaning they have not secured any funding for at least three years – to further gauge the business outcomes.

New start-ups

New start-ups are portfolio companies that are founded in the same year they received a deal. We calculate the share of new start-ups out of all portfolio companies that received funding in each country-industry each year, $\pi^{startup}_{c,i,t}$.

Renewable power generation

We obtain renewable power generation in terawatt-hours from the 2023 version of Statistical Review of World Energy Data for each country each year, $rn_{c,i,t}$. The Energy Institute provides renewable power generation data as early as 1965, covering 92 countries and regions.

2.2 Descriptive Data

2.2.1 Climate Policy and Sustainable Investment

There is much variation in both the number of climate policy decisions and sustainability investments over time as shown in Figure 2 and Figure 3. Policy support, strategy and target have seen an increasing trend, growing in tandem with the number of sustainable investments.

Meanwhile, regulatory policies form the second largest policy category (Figure 2, left). For investments, renewable energy related venture deals dominate all investments in all years from 2000 to 2022 (Figure 3, left). We next group the countries into four groups: the EU, US, other OECD countries, and non-OECD countries. Non-OECD countries, which mostly are developing and emerging market economies, announced an outsized number of policy support, strategy, and target decisions compared to other economies (Figure 2, right). Meanwhile, advanced economies have announced a larger share of more binding policies such as economic instruments – revenue, which involve funding projects or providing subsidies, and regulatory instruments. Figure 3 right panel plots the share of policies and investments between 2000 and 2022 accounted for by each of the four regions – generally higher share of policies is seen together with higher share of investments, except for the US, which accounts for an outsized share of investments but much smaller share of policies.

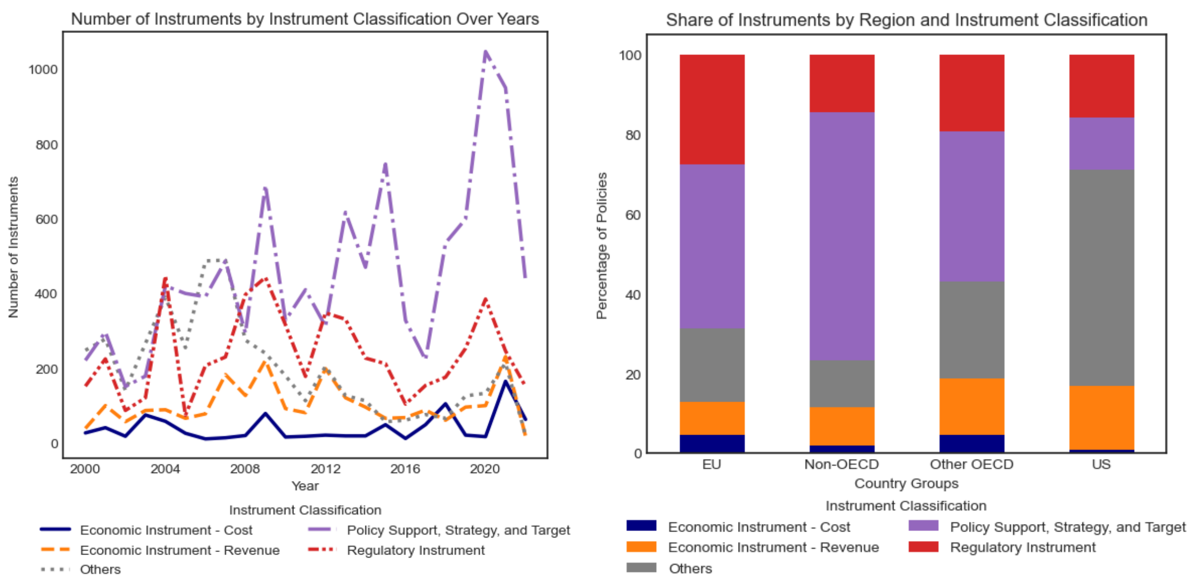

Figure 2. Evolution and heterogeneity of climate policy instruments by type and across country groups.

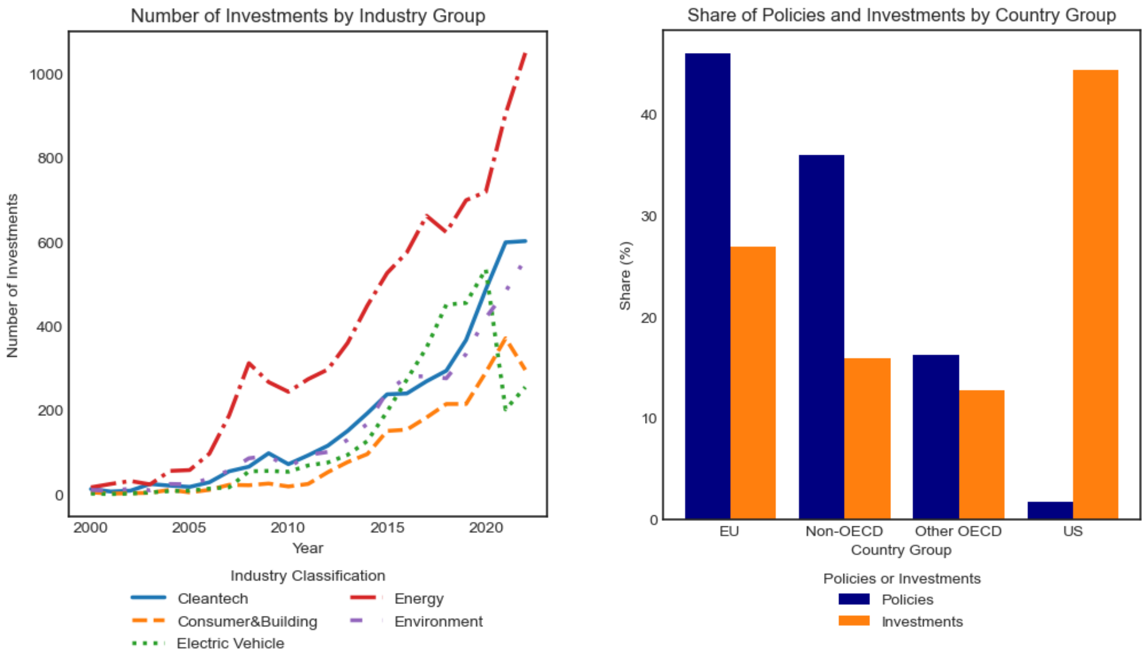

Figure 3. Investment growth and climate policies.

3. Empirical Strategy and Results

3.1 Dynamic Causal Effects of Climate Policy

3.1.1 Average Effects Across Policies

In this section, we first examine the average effects of climate policies in attracting sustainable investments across different policy types and industries, before delving into the heterogeneous impact of the four policy instruments on sustainable investments. To this end, we first estimate Equation (1), which resembles local projection models.

$$y_{c,i,t+h} = \exp\left(\beta_h Instrument_{c,t} + \boldsymbol{\theta_{c,h} X_{c,t}} + \psi_{c,h} + \psi_{i,h} + \psi_{c,i,h} + \psi_{t,h} + \psi_{i,t,h}\right) + \epsilon_{c,i,t+h} \qquad (1)$$

where $y_{c,i,t+h}$ is the number of sustainable investments in destination country c, industry i, h periods after year t. $Instrument_{c,t}$ is the total number of new climate policy decisions in country c and year t, which is standardized across country-industry groups and years. So, $Instrument_{c,t}$ taking a value of one means that the number of climate policy decisions is at one standard deviation above the average across countries and years. We take $Instrument_{c,t}$ as the climate policy shock and β_h therefore captures the effect of climate policy shock in year t on the level of the number of sustainable investments in year $t + h$. $\boldsymbol{X_{c,t}}$ is a set of country-specific control variables, including contemporaneous and up to two lags of annual real GDP per capita, inflation rate, real interest rate, and up to two lags of climate policy shocks and the number of sustainable investments in each country-industry group. Macroeconomic data are sourced from World Development Indicators (WDI), and when unavailable, from CEIC database. $\psi_{c,h}$, $\psi_{i,h}$, and $\psi_{c,i,h}$ are country, industry, and country-industry fixed effects, capturing time-invariant heterogeneities in the number of investments across countries, industries, and country-industry groups. Finally, $\psi_{t,h}$ is the time fixed effects that capture common shocks to all countries and industries, such as the COVID-19 and US-China trade war, whereas $\psi_{i,t,h}$ are industry-specific time fixed effects.

Identification rests upon time series variation in the innovations to total number of climate policy decisions in each country each year. Changes to the number of climate policies net of the component predictable by historical investment changes and current and past international economic shocks are exogenous (Metcalf and Stock (2023)). This assumption enables the identification of the dynamic effects of the unexpected component of climate policy changes on sustainable investment changes.

We estimate Equation (1) using Poisson pseudo-likelihood regression with multiple levels of fixed effects. Figure 5 shows that the overall effect of climate policies in attracting sustainable investments is rather muted in the initial periods. Six years after a one standard deviation increase in climate policy decisions, the number of sustainable investments increases by nearly five percent, which is statistically significant at both 90 and 95 percent confidence levels.

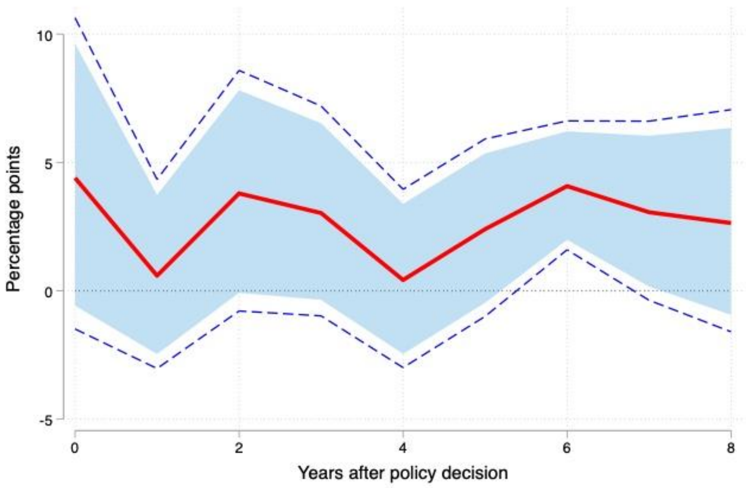

Figure 5. Overal dynamic effects of climate policy shocks on sustainable investments. Blue shaded area is the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

3.1.2 Heterogeneous Effects of Different Policy Instruments

Different climate policy instruments have been documented to have different impact on carbon emission reductions (Gugler, Haxhimusa, and Liebensteiner (2021)). Likewise, we conjecture that different climate policy instruments may impact sustainable investments differently, which we explore by estimating the modified local projection model below:

$$y_{c,i,t+h} = \exp\left(\sum_{j=1}^{5} \beta_{j,h} Instrument_{c,j,t} + \boldsymbol{\theta_{c,h} X_{c,t}} + \psi_{c,h} + \psi_{i,h} + \psi_{c,i,h} + \psi_{t,h} + \psi_{i,t,h}\right) + \tilde{\epsilon}_{c,i,t+h} \quad (2)$$

where $Instrument_{c,j,t}$ represents the number of climate policies of instrument type j ($j = 1,2,3,4,5$) decided in country c and year t, and $\beta_{j,h}$ captures the effect h periods after the climate policies of instrument type j were decided. We consider four climate policy instrument types: (1) economic instrument – cost, (2) economic instrument – revenue, (3) regulatory instrument, (4) policy support, strategy and target, and (5) the remaining policies. The fifth group of policies enters the regression as a control. We think of policies belonging to type (1), (2), and (3) as more binding instruments, whereas (4) policy support, strategy and target as the less binding instruments.

Ex-ante, it is unclear whether more or less binding instruments are more conducive to attracting sustainable investments. While providing incentives and implementing regulations may induce higher demand for low-emission energy and products therefore draw more sustainable investments (Van Den Heuvel and Popp (2023)), it is unclear how sustainable such incentive schemes are. Further, new regulations aimed at mitigation may raise production and operating costs for business ventures (van der Ploeg (2016)), therefore hampering investments. Less binding policy instruments, on the other hand, may increase mitigation efforts and momentum, especially in the early stage, by setting out over-arching strategies.

Indeed, Figure 6 suggests mixed results. Economic instruments that provide revenue (such as subsidies) to firms increase the number of sustainable investments by almost five percent initially, although on average the number of investments dips four years after the initial policy decision. On the contrary, a one standard-deviation increase in the number of economic instruments that impose costs (such as carbon taxes) on firms reduce the number of investments by almost eight percent at its trough four years after the policy decision. A one standard-deviation increase in the number of regulatory instruments on average raises the number of investments by nearly 10 percent at its peak, despite the initial dip. Finally, the less binding policy support, strategy and target policies do not seem to significantly impact the number of investments on average.

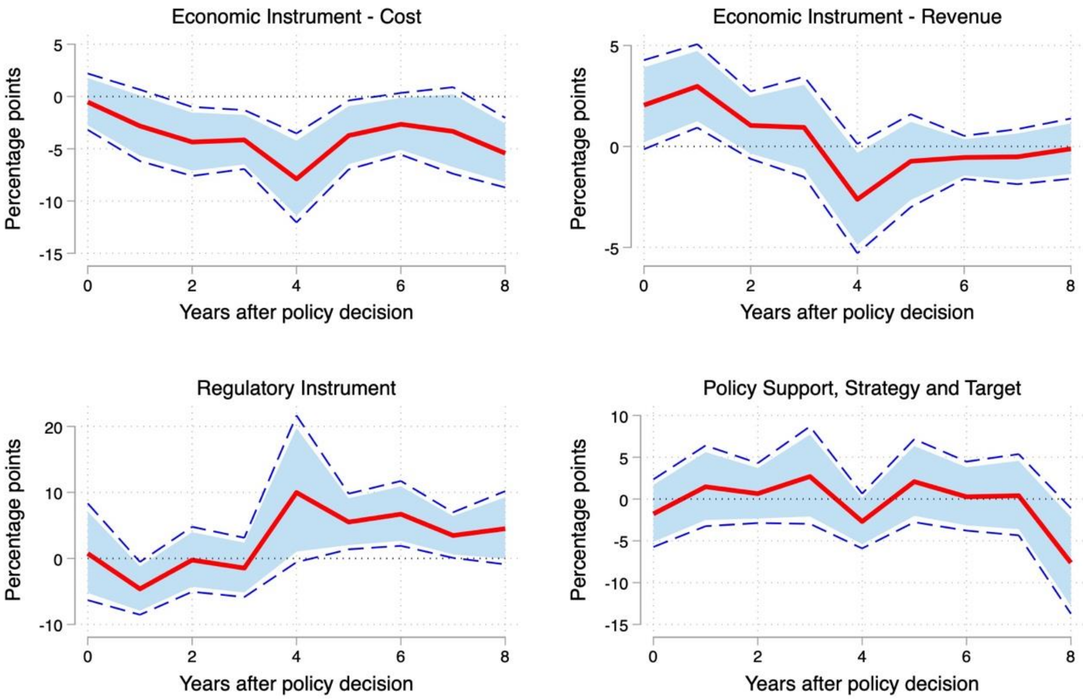

Figure 6. Dynamic effects of different policy instruments on sustainable investments. Blue shaded areas are the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

3.2 Heterogeneity Analysis

3.2.1 Heterogeneous Effects Across Industries

We next examine the heterogeneous effects of economic instruments that provide revenue and regulatory instruments, the two types of policies that are found to significantly induce sustainable investments across different industry groups. Figure 7 plots the effects of different climate policies on number of investments across five industries. Economic instruments that provide revenue induce more investments in cleantech, electric vehicle, and renewable energy industries (Figure 7 panel (a)). Meanwhile, regulatory instruments predict significantly higher number of investments in cleantech and renewable energy industries (Figure 7 panel (b)).

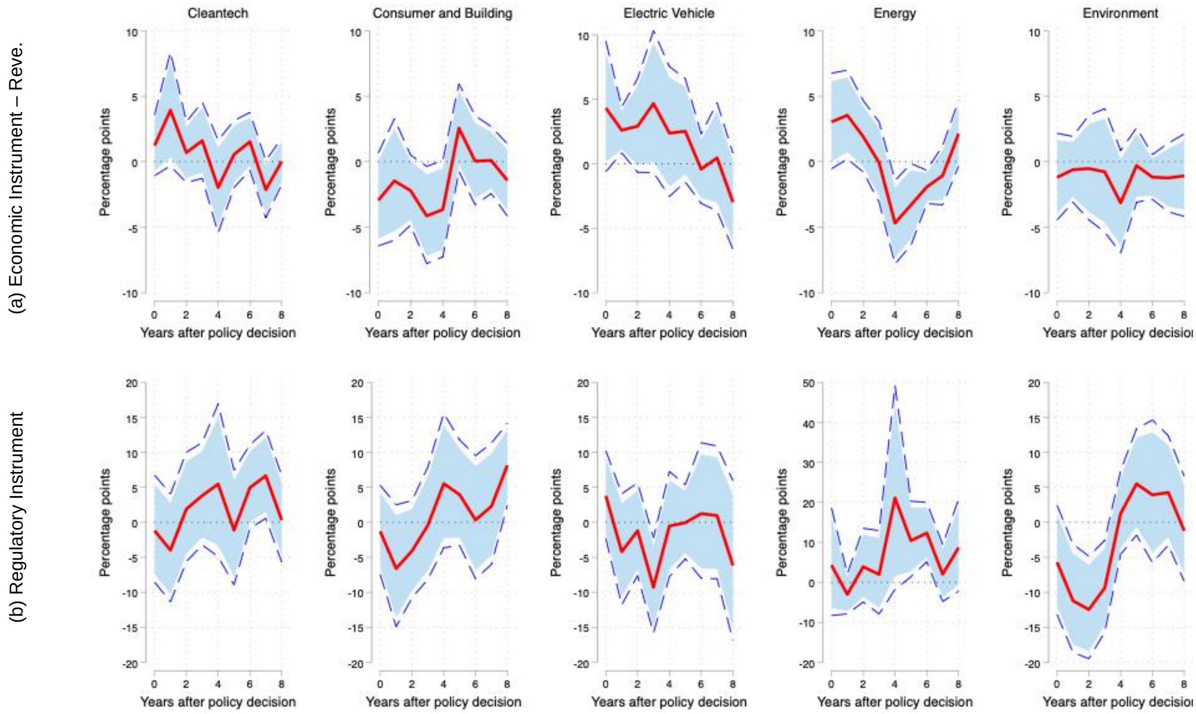

Figure 7. Dynamic effects of different policy instruments on sustainable investments for each of the five industries (red solid lines) and the remaining industries (blue dashed lines). Shaded areas are the 90 percent confidence intervals.

3.2.2 Heterogeneous Effects Across Economies

In this section, we examine to what extent the effects of different climate policy instruments differ between advanced (AEs) and emerging market economies (EMEs). To this end, we re-estimate Equation (2) separately for AEs and EMEs. Figure 8 shows that for AEs (Figure 8, top panel), regulatory instruments are found to induce higher number of investments over time. For EMEs (Figure 8, lower panel), economic instruments that provide revenue to firms, regulatory instruments, and policy support, strategy and target induce more sustainable investments. These results seem to suggest that the link between climate policies and sustainable investments is stronger for EMEs, consistent with Pienknagura (2024).

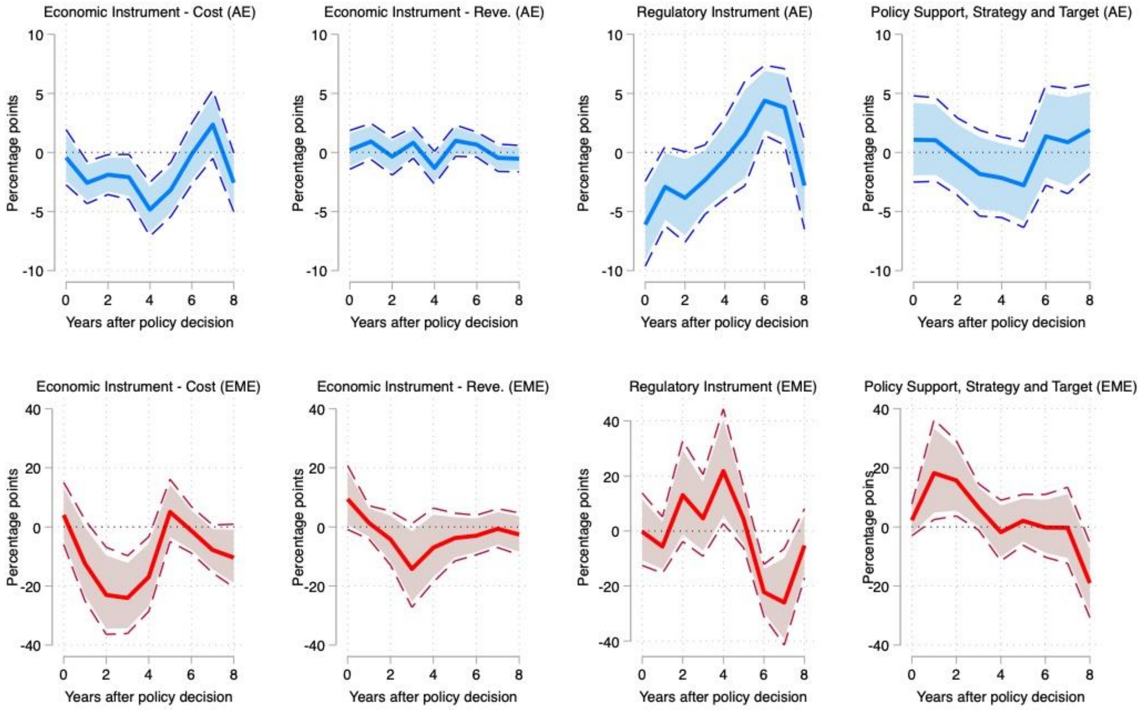

Figure 8. Dynamic effects of different policy instruments on sustainable investments for developing and emerging market economies (DEMEs, red solid lines) and advanced economies (AEs, blue dashed lines). Shaded areas are the 90 percent confidence intervals.

3.3 Transmission Channels

We next ask through which kind of firms does each of the climate policy type affect sustainable investments. To do so, we aim to capture the characteristics of firms that attracted funding in years following policy decisions. We consider two measures: The first is the share of new start-ups among all companies that attracted investments in the same year, $\pi_{c,i,t}^{startup}$. New start-ups are defined as companies that were founded in the same year they attracted investments. The second is the share of companies with exits, $\pi_{c,i,t(current)}^{exits}$. The first measure is a proxy for the maturity of firms while the second measure is a proxy for the quality of firms.

We re-estimate Equation (2) using standard panel regression methods, but with the dependent variable replaced with $\pi_{c,i,t}^{startup}$ and $\pi_{c,i,t(current)}^{exits}$, respectively.

$$\pi_{c,i,t+h}^{\{startup,exits)} = \sum_{j=1}^{5} \beta_{j,h} Instrument_{c,j,t} \quad + \boldsymbol{\theta_{c,h} X_{c,t}} + \psi_{c,h} + \psi_{i,h} + \psi_{c,i,h} + \psi_{t,h} + \psi_{i,t,h} + \varepsilon_{c,i,t+h} \tag{3}$$

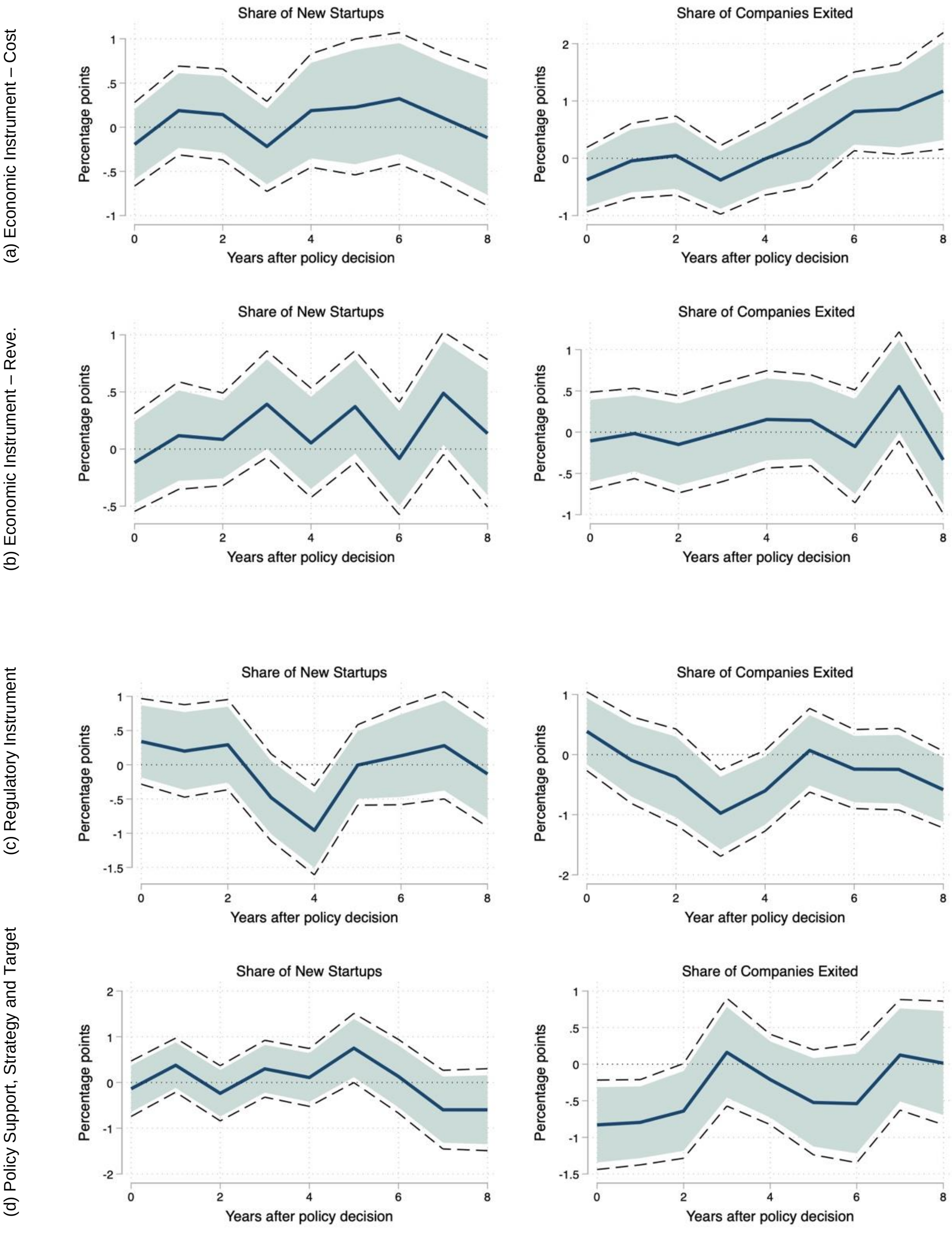

Figure 9. Share of new startups and share of companies with exits among the companies received funding each year after policy decision by policy instrument.

We plot the average share of new start-up firms that received funding in years after the four types of policy instruments in the first column of Figure 9, and the share of companies received funding with exits in the second column. We make three main observations. First, share of companies with successful exits increases significantly among all those received funding after decisions of economic instrument – cost (panel (a)). Jointly with results found in Section 3.1.2, it suggests that while such stringent policies imposing costs on firms may stifle investments, companies that receive investments are potentially the higher quality ones that have attracted acquisitions or undergone IPOs.

Second, following regulatory policy decisions, share of newly founded start-ups among those received investments declined significantly. This means that it's largely more mature firms that received investments following regulatory policy decisions (panel (b), left), although they need not have successful exits (panel (b), right).

Third, following policy support, strategy and target policy decisions, share of new start-ups receiving funding increased while share of companies having exits dropped. These suggest that while policy support, strategy and target encourage investments in new start-ups in sustainability industries, they may not ultimately become successful investments.

The results in this section thus show that different climate policies induce investments in different profiles of start-ups, with less stringent policies induce more investments in new start-ups.

3.4. Business Outcomes

In this section, we study the impact of climate policies on the business outcomes of start-ups. We look at the changes in the average number of funding rounds secured, average share of companies with exits, and average share of companies that have become inactive in the same batch in the years after policy decisions. Companies founded in the same year are of the same batch.

Figure 10 shows that cost-imposing economic instruments induce more desirable business outcomes among the batches of start-ups founded in the years after policy decisions. A one standard-deviation increase in the number of policies employing cost-imposing economic instruments translates to a 0.7 percentage point increase in the share of companies with exits six years after policy decision and depresses the share of inactive companies by 0.8 percentage points two years after policy decision.

Meanwhile, a one standard-deviation increase in economic instruments that provide revenue predicts fewer number of funding rounds secured by companies founded in years after policy decisions, and an increase in the share of inactive firms albeit statistically insignificant.

The results for regulatory instruments are somewhat mixed. While the share of companies with exits increases initially following regulatory policy decisions, it also dips briefly in year 2 and 3 after policy decision. The share of inactive companies is estimated to drop by one percentage point two years after a one standard-deviation increase in the number of regulatory policy decisions. The estimate is statistically significant at 90 percent confidence level.

Finally, a one standard-deviation increase in the number policy support, strategy and target decisions translates to a dip in the number of funding rounds secured by batches of companies founded after the policy decision. Average share of companies with exits also drops by 0.6 percentage points on impact.

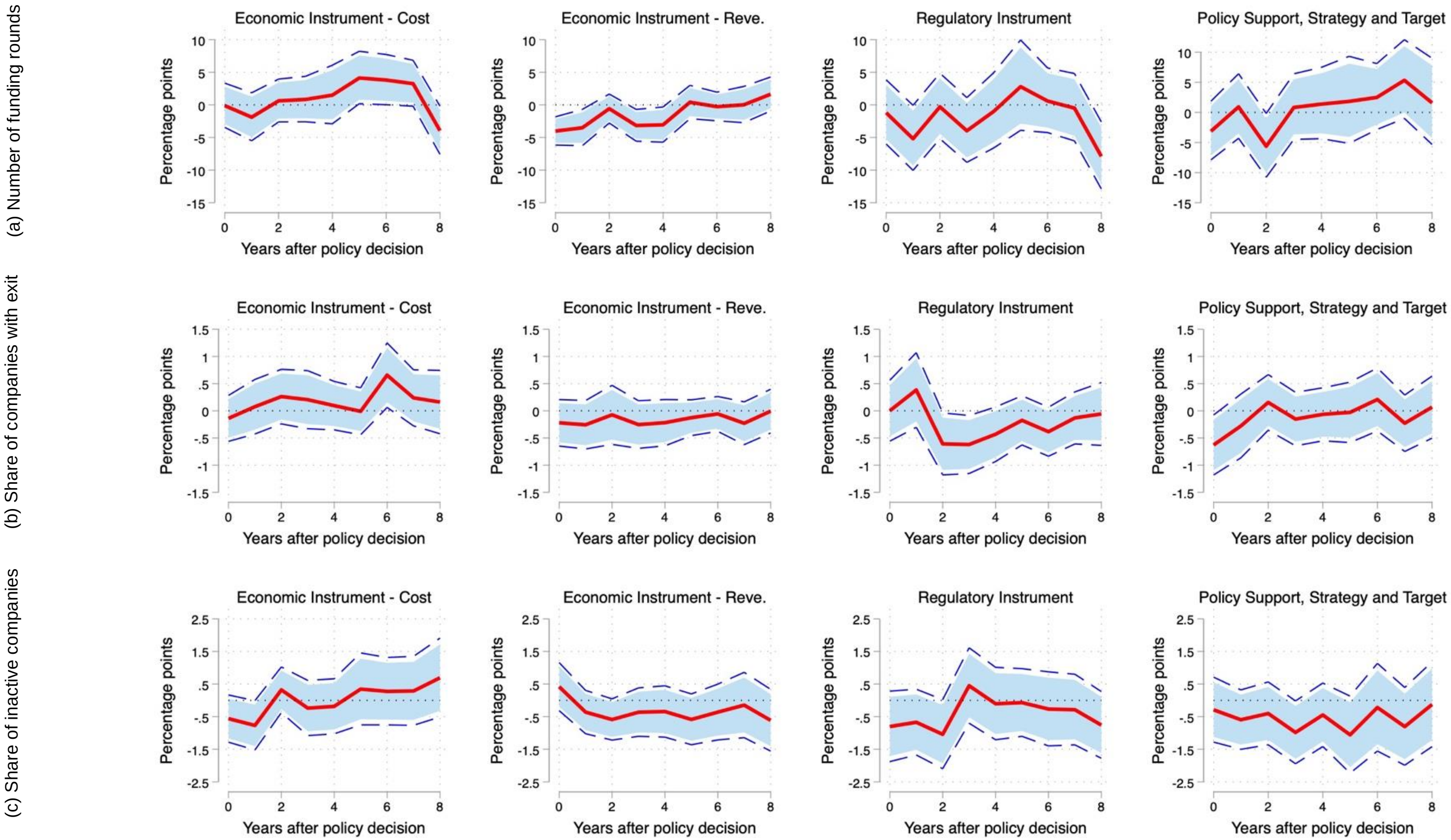

Figure 10. Dynamic effects of different policy instruments on average number of funding rounds (top), average share of companies with exits (middle), and average share of inactive companies (bottom) among the companies founded each year after policy decision.

Overall, the results in this section suggest that more binding policy instruments such as type (1) economic instrument – cost and type (3) regulatory instrument promote more desirable business outcomes while the less stringent ones such as type (2) economic instrument – revenue and type (4) policy support, strategy and target reduce the share of firms with desirable business outcomes such as having exits or remaining active in attracting investments.

3.5 Firm-Level Evidence

We next supplement the analyses of business outcomes in the previous section with firm-level evidence. Specifically, we compile a cross-section of 11,362 portfolio firms that received investments in sustainability industries matched with country-level data, including the stock of policies of different instrument types, and macroeconomic variables such as average real GDP per capita, average inflation rate, and average real interest rate over the period between 2000 and 2022. We then resort to the logit model below and estimate the effect of both firm characteristics, such as industry category and country-level characteristics on the log odds of the firm having an exit:

$$\log \frac{p_{exit}}{1-p_{exit}} = \sum_{j=1}^{5} \beta_j Instrument\_stock_{c,j} + \boldsymbol{\theta_f X_f} + \boldsymbol{\theta_c X_c} + \epsilon_f \quad (4)$$

where $Instrument\_stock_{c,j}$ is the stock of policy instruments in country c of type j. $\boldsymbol{X_f}$ is the collection of firm level characteristics, including indicators of whether the firm has received investment from government agencies, the industry category of the firm, and whether the industry labels of the firm is related to IT or software, since earlier studies suggest that venture investments in software industry have better risk-return profiles (Gaddy, Sivaram, and O'Sullivan 2016). $\boldsymbol{X_c}$ contains the set of recipient country macroeconomic variables, as well as the indicator of whether the country is an AE or EME.

Figure 11 left panel plots the estimated percentage change in odds of firms having an exit due to the four policy instruments and the confidence bands. Consistent with results in the previous section, higher stock of policy support, strategy and target policies predict lower odds of having an exit, while the other types of policies, especially economic instrument that impose costs predicts higher odds of having an exit.

Turning to firm-level characteristics, we find that using the cleantech industry as the baseline, the odds of exit are not significantly different for firms in consumer and building and electric vehicle industries, but energy industry and environment industry predict significantly lower odds of exit, shown on the right panel of Figure 11.

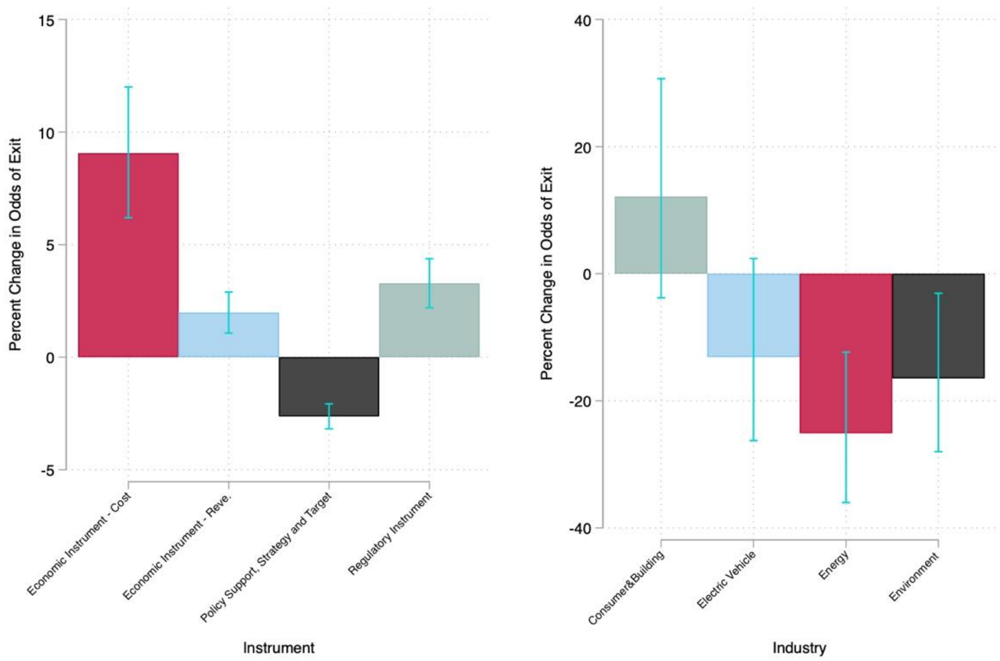

Figure 11. Percent change in odds of exit for every one unit increase in the number of policies by instrument type (left) and difference in odds of exit in the industries of consumer and building, electric vehicle, energy and environment compared to cleantech (right). The capped spikes represent 90 percent confidence intervals.

Finally, Figure 12 displays the effect of country-level macroeconomic variables on the odds of firms securing an exit. While higher income level proxied by GDP per capita predicts higher odds of exit, higher inflation and higher real interest rate predict lower odds of exits.

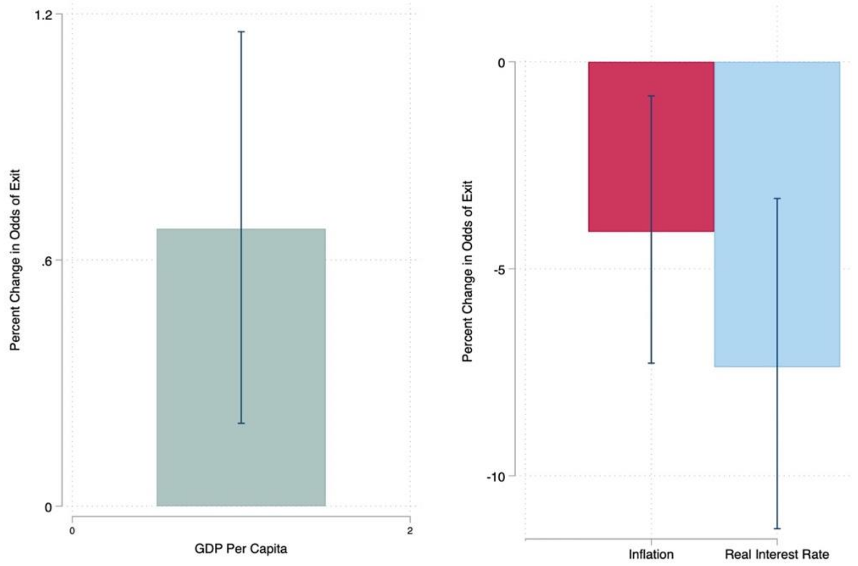

Figure 12. Percent change in odds of exits for every $1,000 increase in GDP per capita (left); percent change in odds of exit for every one percentage point increase in inflation rate and real interest rate (right). The capped spikes represent 90 percent confidence intervals.

3.6. Environmental Outcomes

3.6.1. Renewable Energy Generation

The goal of climate policies is to facilitate energy transition and foster renewable energy generation. In this section, we look beyond sustainable investments and finally turn to examining the dynamic effects of different climate policies on renewable energy generation. To do so, we estimate the following equation:

$$rn_{c,,t+h} = exp\left(\sum_{j=1}^{4}\beta_{j,h}Instrument_{c,j,t} + \boldsymbol{\theta_{c,h}X_{c,t}} + \psi_{c,h} + \psi_{i,h} + \psi_{c,i,h} + \psi_{t,h} + \psi_{i,t,h}\right) + \tilde{\varepsilon}_{c,i,t+h} \quad (3)$$

where $rn_{c,i,t+h}$ is the is the amount (terawatt-hours) of renewable energy generation in destination country c, h periods after year t. $Instrument_{c,j,t}$ again, captures the standardized number of each type of the climate policy instrument decisions in country c in period t, and $\beta_{j,h}$ measures the effect of climate policy shock of instrument type j in year t on the level of renewable energy generation in year $t + h$. We use the same set of country-specific control variables, $\boldsymbol{X_{c,t}}$, which now includes up to two lags of renewable energy generation.

We estimate Equation (3) again using Poisson pseudo-likelihood regression with multiple levels of fixed effects. Figure 13 shows although economic instrument that impose costs on firms do not stimulate more investments, it does instigate more renewable energy generation. A one standard-deviation increase in policy decisions involving "economic instrument – cost" predicts nearly 3 percent increase in renewable energy generation. Regulatory instrument similarly increases renewable energy supply. A one standard-deviation increase in regulatory policy decisions translates to an average of more than 6 percent increase in renewable energy generation.

Meanwhile, policy decisions involving "economic instrument – revenue" and policy support, strategy and target do not necessarily predict higher levels of renewable energy generation.

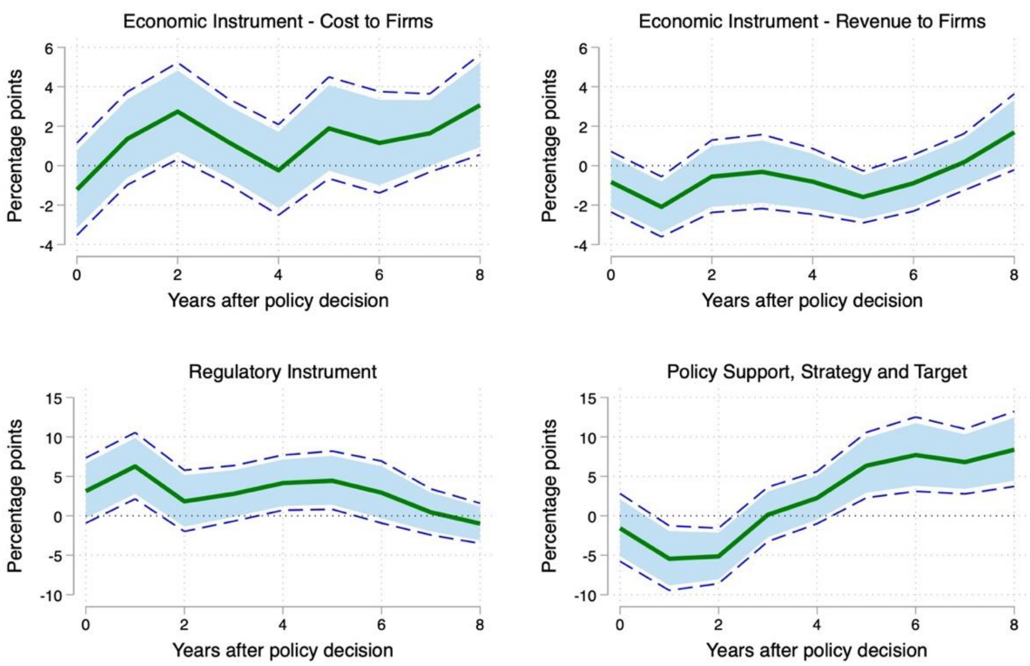

Figure 13. Dynamic effects of different policy instruments on renewable energy generation. Blue shaded areas are the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

4. Robustness Analysis

4.1 Inclusion of Country-Specific Trends

In this section, we conduct various robustness checks. In section 4.1, we include country-specific linear trend to Equation (2) to account for country-specific events or trends in sustainable investment development. Results in Figure 14 still suggest that more binding policies entail bigger impact on changes in sustainable investments, while policy support, strategy and target have no significant impact. In particular, a one standard-deviation increase in regulatory instrument decisions still predicts higher future sustainable investments despite the initial dip. Cost-imposing economic instruments still reduce the level of investments while revenue-providing economic instrument increases the level of investments, albeit less significant than the baseline case.

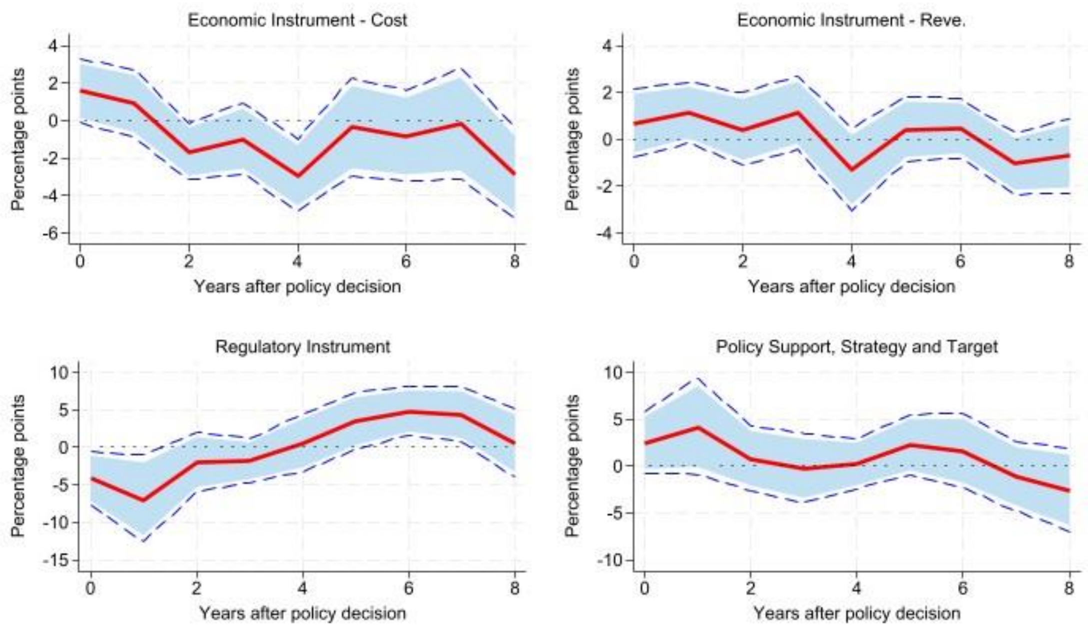

Figure 14. Dynamic effects of different policy instruments on sustainable investments. Blue shaded areas are the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

Similar to the baseline results, Figure 15 still shows that economic instruments providing revenue raises investments in cleantech, electric vehicle, and renewable energy industries, while regulatory instruments are still found to be associated with a significant increase in investments in the renewable energy industry.

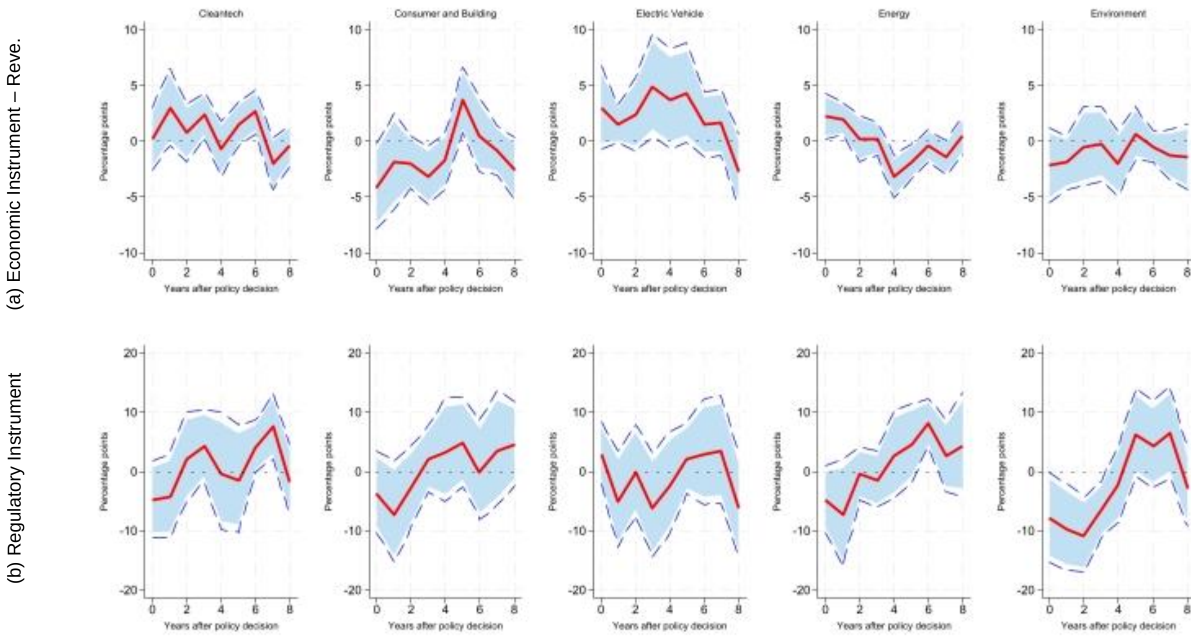

Figure 15. Dynamic effects of different policy instruments on sustainable investments for each of the six industries (red solid lines) and the remaining industries (blue dashed lines). Shaded areas are the 90 percent confidence intervals.

4.2 Inclusion of Further Lags

We included up to two lags in the previous analyses given that our sample only spans 20 years. In this section, we include up to four lags for all the macroeconomic control variables, the shock variable, and the dependent variable, and Figure 16 and Figure 17 show that our results are robust to the inclusion of additional lags.

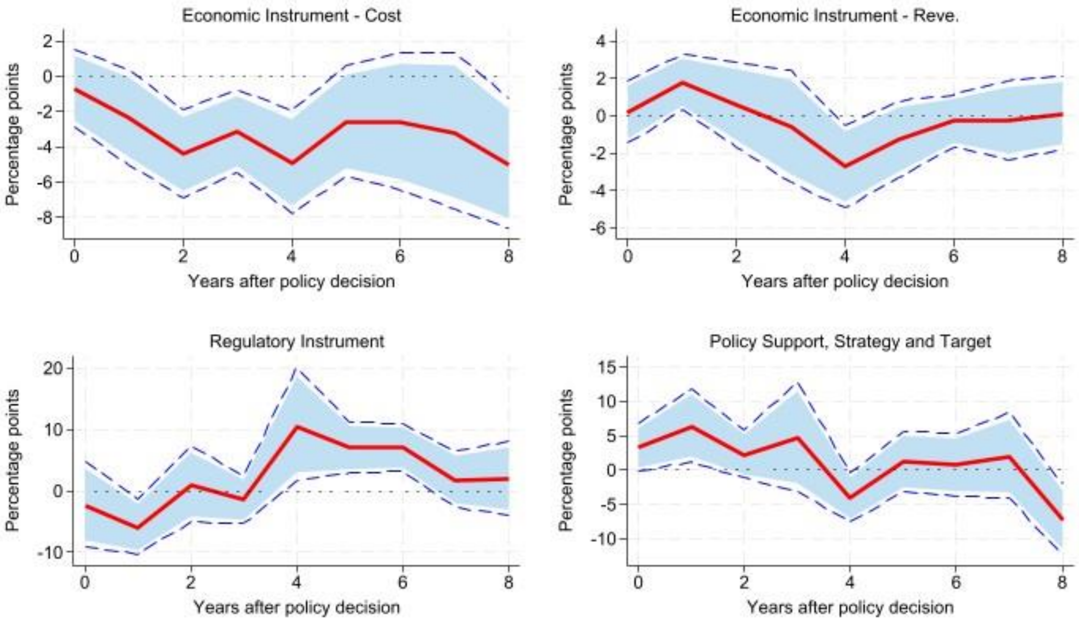

Figure 16. Dynamic effects of different policy instruments on sustainable investments. Blue shaded areas are the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

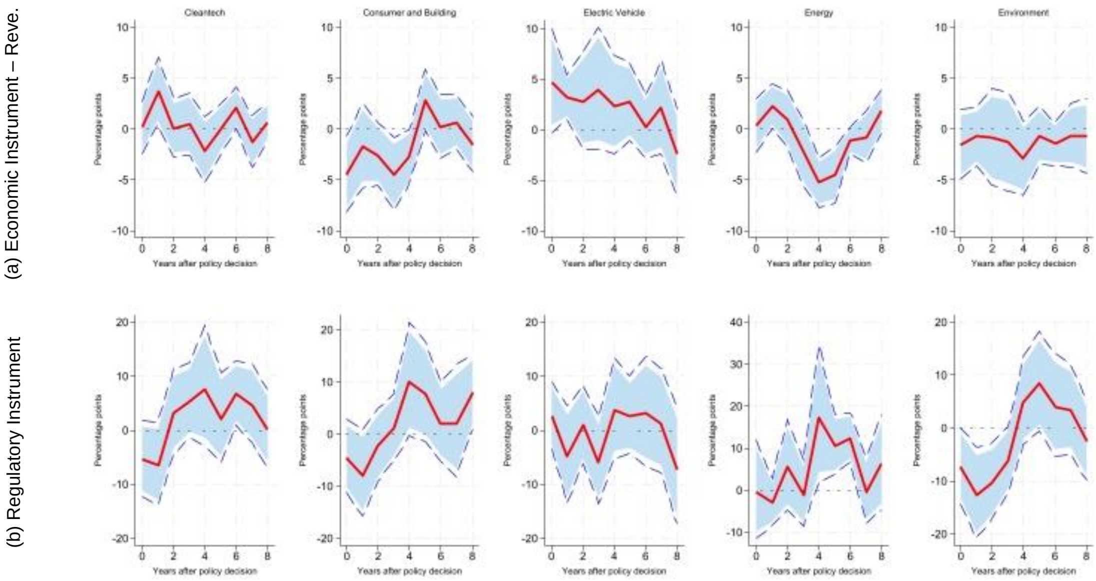

Figure 17. Dynamic effects of different policy instruments on sustainable investments for each of the six industries (red solid lines) and the remaining industries (blue dashed lines). Shaded areas are the 90 percent confidence intervals.

4.3 Using Value of Deals

Finally, in the earlier analyses we used number of projects to preserve as many observations as possible, as deal value is not available for all venture capital deals. In this section, we show that our results are largely robust to using value of deals instead of number of deals. In particular, Figure 18 shows that regulatory instrument still significantly raises value of investments, while revenue-providing economic instrument now predicts a dip in the value of investments. Likewise, Figure 19 shows that regulatory instrument still significant raises value of investments in cleantech, consumer and building, and renewable energy industries. Additionally, it also raises value of investments in electric vehicle industry. Meanwhile, economic instrument providing revenue or subsidies still predicts higher value of investments in electric vehicle and renewable energy industries.

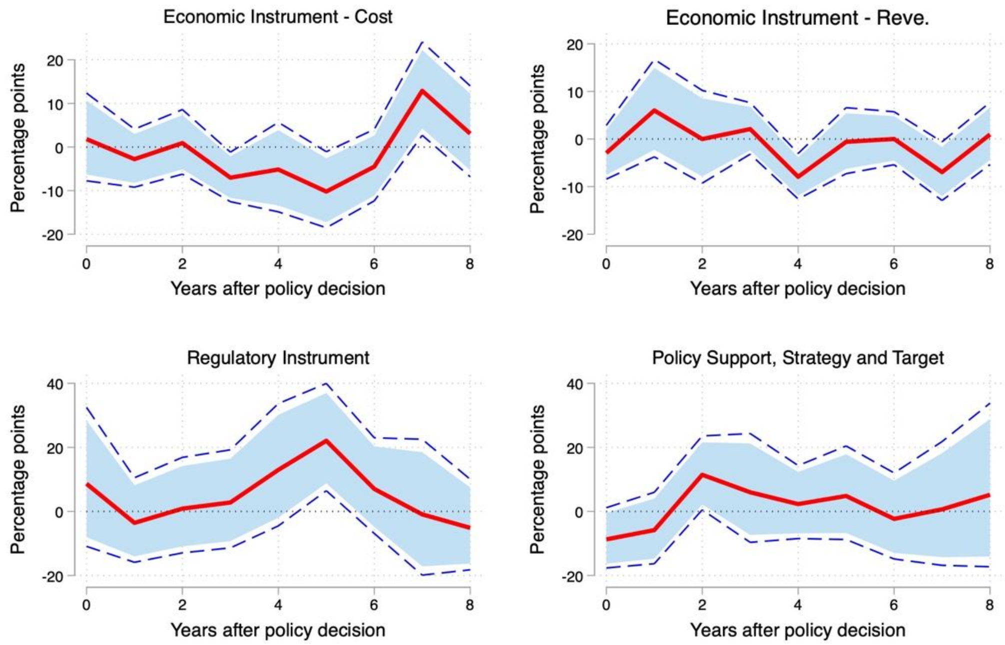

Figure 18. Dynamic effects of different policy instruments on value of sustainable investments. Blue shaded areas are the 90 percent confidence intervals, whereas blue dashed lines mark the 95 percent confidence intervals.

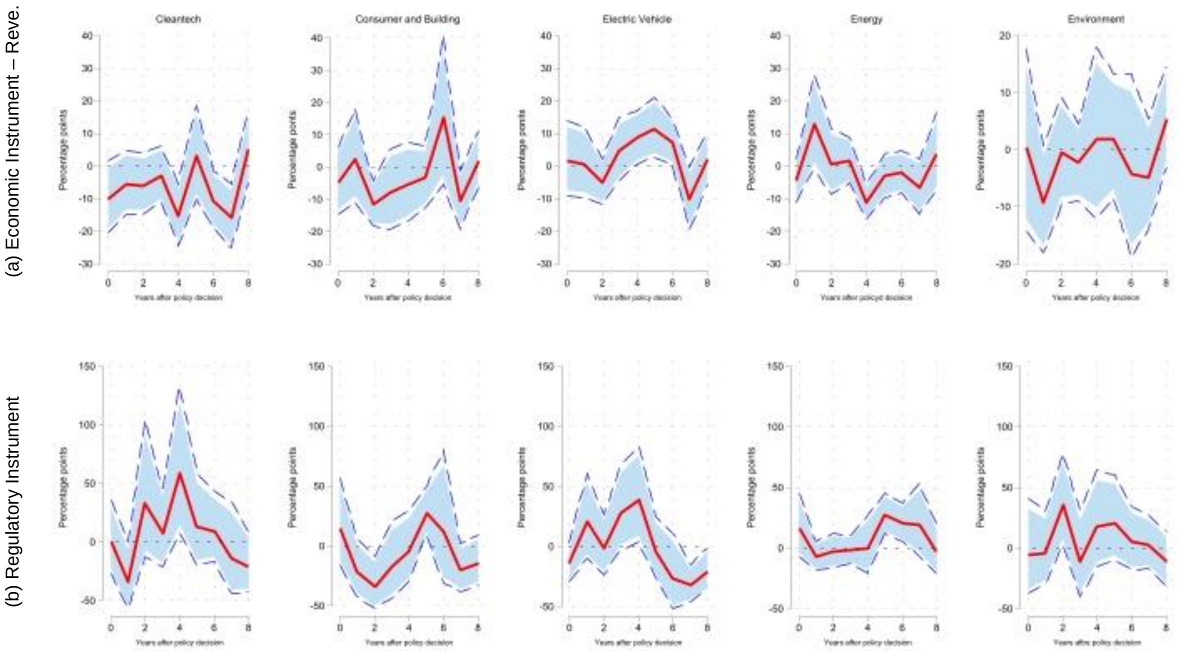

Figure 19. Dynamic effects of different policy instruments on value of sustainable investments for each of the six industries (red solid lines) and the remaining industries (blue dashed lines). Shaded areas are the 90 percent confidence intervals.

5. Conclusion

This paper studies the dynamic effects of different climate policy decisions on (1) inducing sustainable venture investments, (2) the channel of policy transmission, (3) the business outcomes of firms founded in the years after climate policy decisions, and finally, (4) the environmental outcomes following climate policy decisions.

More binding climate policies entail greater impacts on sustainable venture investments. We find that economic instrument that provides revenue or subsidies and regulatory instruments significantly increase the number of sustainable venture investments. Meanwhile, a one standard-deviation increase in economic instrument that incur costs to firms predicts lower level of sustainable venture investments. Policy support, strategy, and target does not have a significant impact on the number of such investments on average.

We examine the channel of policy transmission by delving into the types of companies attracted investments following policy decisions. We find that more stringent policies – such as economic instrument that impose costs and regulatory instruments – promote investments in more mature firms and higher-quality start-ups. On the contrary, while less stringent policy such as policy support, strategy and target foster investments in new start-ups following policy decisions, these policies are also associated with lower exit rate among the firms that receive investments.

In terms of the business outcomes, we find that more stringent policy instruments such as cost-imposing economic instrument and regulatory instrument are associated with higher number of funding rounds secured, higher rate of exits, and lower share of inactive firms among the start-ups founded in the years after policy decisions. Meanwhile, less stringent policies reduce the share of firms with desirable business outcomes. This is corroborated by firm-level evidence: policy support, strategy and target decisions predict lower odds of exit. Finally, in terms of the environmental outcome, we find that stringent policies such as cost-imposing economic instrument and regulatory instrument decisions lead to more renewable energy generation. The results presented in this paper thus suggest that more stringent policies, such as carbon taxes and regulations, outperform less stringent ones, such as subsidies and climate strategies, in both efficacy and efficiency in driving the energy transition.

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Appendix A. Sample Country

List of Advanced Economies (AEs)

Australia	Austria	Belgium	Canada
Cyprus	Denmark	Finland	France
Germany	Greece	Iceland	Ireland
Israel	Italy	Japan	Luxembourg
Netherlands	New Zealand	Norway	Portugal
Singapore	South Korea	Spain	Sweden
Switzerland	United Kingdom	United States	

List of Developing and Emerging Market Economies (DEMEs)

Albania	Argentina	Bahrain	Bangladesh
Belarus	Benin	Brazil	Brunei Darussalam
Bulgaria	Burundi	Cambodia	Cameroon
Chad	Chile	China	Colombia
Costa Rica	Croatia	Czech Republic	Democratic Republic of Congo
Egypt	Estonia	Georgia	Ghana
Guatemala	Guinea	Guyana	Hungary
India	Indonesia	Iran	Jamaica
Jordan	Kenya	Lao PDR	Latvia
Lebanon	Lesotho	Liberia	Lithuania
Macedonia	Madagascar	Malawi	Malaysia
Mali	Mauritius	Mexico	Morocco
Mozambique	Myanmar	Namibia	Nepal
Nicaragua	Niger	Nigeria	Pakistan
Panama	Paraguay	Peru	Philippines
Poland	Qatar	Romania	Russian Federation
Rwanda	Saudi Arabia	Senegal	Serbia
Sierra Leone	Slovakia	Slovenia	South Africa
Sri Lanka	Tanzania	Thailand	Togo
Trinidad and Tobago	Tunisia	Turkey	Uganda
Ukraine	United Arab Emirates	Vietnam	Zambia
Zimbabwe			

Appendix B. Sustainable Investment Classification

B.1 Investment Grouping and Keywords

We group investments into five categories based on organization industry labels associated with each deal. One deal can have multiple industry labels. For example, a deal can have both "renewable energy" and "electric vehicle" as its industry labels. We therefore classify each deal based on whether it contains industry labels associated with the following five industries, in the order of (1) electric vehicle, (2) energy, (3) environment, (4) consumer and building, and (5) cleantech. The table below summarizes the industry labels based on which we classified each deal.

Table B1: Classification of Sustainable Investment by Industry

Category	Industry Labels	Count
Electric Vehicle	"electric vehicle", "vehicle", "battery", "batteries", "automotive"	3,427
Energy	"solar", "renewable energy", "wind energy", "clean energy", "biofuel", "biomass", "geothermal energy", "hydroelectric"	9,298
Environment	"environmental engineering", "pollution control", "recycling", "waste management", "water purification", "natural resources", "wildlife"	4,226
Consumer and Building	"green building", "consumer", "organic"	2,402
Cleantech	"cleantech", "carbon capture", "energy efficiency", "greentech", "sustainability"	4,399

Appendix C. Business Outcomes of Firms

Table C1: Business Outcomes of Firms Received Investments

	Exit = 1	Exit = 0			Total
Industry		Active	Inactive	Total	
Cleantech	217	1200	528	1728	1945
Consumer and Building	111	772	357	1129	1240
Electric Vehicle	214	711	374	1085	1299
Energy	697	2123	1691	3814	4511
Environment	345	1260	771	2031	2376
Total	1584	6066	3721	9787	11371

Notes: Exit = 1 means the firm has been acquired or undergone IPO, and exit = 0 means otherwise. Inactive means the firm has not had any funding rounds and has not exited in the since 2019.