

# Climate Risk and Capital Flows in Eastern European Emerging Markets: How Physical and Transition Risks Reshape Foreign Direct Investment Portfolios

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**Abstract:** *This paper looks at how climate-related risks affect Foreign Direct Investment (FDI) in Eastern European Emerging Markets (EEEMs). It separates physical risks, like extreme weather, from transition risks linked to policy changes such as the EU Emissions Trading System (EU ETS) and the Carbon Border Adjustment Mechanism (CBAM). Countries like Poland, Romania, the Czech Republic, and Hungary have long depended on a carbon-heavy economic model, making them especially vulnerable. The findings show that higher carbon prices are temporarily lower than traditional manufacturing FDI, while greater physical risks increase sovereign bond spreads and reduce greenfield investments in at-risk areas. However, these risks also lead to more investment in renewable energy and green technologies. The study suggests that EEEMs need to update their policies to reduce stranded asset risks and attract sustainable investment in a world focused on climate issues.*

**Keywords:** climate risk, foreign direct investment, eastern Europe, physical risk, transition risk.

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## INTRODUCTION

Over the past few decades, climate change has shifted from being seen only as an environmental issue to becoming a major financial risk that can disrupt global capital flows. The Paris Agreement has helped the international community realize that moving to a low-carbon economy will change how assets are valued and how investments are made (UNFCCC, 2015). For international investors, climate risk appears in two main ways: physical risks and transition risks. *Physical risks* are the direct economic losses caused by more frequent and severe extreme weather events, like floods, droughts, and heatwaves. *Transition risks* come from the policy, legal, technological, and market changes needed to address climate change, especially the introduction of carbon pricing (Financial Stability Board, 2020).

Eastern European Emerging Markets (EEEMs) face unique challenges in this changing environment. Countries like Poland, the Czech Republic, Romania, and Hungary have grown quickly by supporting Western European manufacturing as production hubs (wiiw, 2025). This approach relies heavily on energy use and fossil fuels, especially coal, which makes these economies especially vulnerable to transition risks from strict European Union (EU) climate policies. At the same time, their geography and infrastructure leave them open to increasing physical risks (ECB, 2021).

It is now more urgent than ever to address these risks. Global investment trends show that investors are paying much closer attention to environmental, social, and governance (ESG) issues. More institutional investors are required to report climate-related financial risks, which is causing a major rethink of where and how money is invested. In this situation, EEEMs have two main challenges: protecting their economies from the physical impacts of climate change and updating their industries to meet strict transition requirements.

This paper explores how both physical and transition risks are changing Foreign Direct Investment (FDI) in EEEMs. It looks at recent shifts in where capital is going, the effects of the EU Emissions Trading System (EU ETS), and how vulnerable these markets are to extreme weather. The study offers important insights into where investment in the region may be headed. The paper is organized as follows: Section 2 reviews the theory, Section 3 covers physical risks, Section 4 looks at transition risks, Section 5 presents data trends, Section 6 discusses policy issues, and Section 7 concludes.

## **Theoretical Framework and Literature Review**

The links between environmental regulation, climate risk, and foreign direct investment are complicated. Traditional theories about where companies choose to invest often focus on two ideas: *pollution haven*' hypothesis and the 'halo effect.' The pollution hypothesis says that carbon-heavy industries move to places with weaker environmental rules to avoid extra costs, which is called carbon leakage (Climate Policy Info Hub, 2016). On the other hand, the halo effect suggests that multinational companies bring cleaner and more advanced technologies to host countries, which can help improve local environmental standards.

Today, these theories are influenced by the idea of 'regulatory arbitrage,' which happens when climate policy is uncertain. Investors are now factoring climate risk into their decisions. Studies show that climate transition risk has a big impact on how assets are priced, and investors want higher returns for holding carbon-heavy assets (Bolton & Kacperczyk, 2021). This change also affects government debt. Data shows that countries more exposed to climate risks, both physical and transition, face higher bond spreads, especially in emerging markets where governments have less ability to handle climate shocks (IMF, 2025a).

The idea of 'flight to climatic safety' means that investors are moving their money away from areas that are more likely to face natural disasters and into safer, usually more developed, countries (Gazzani, 2022). For emerging and developing European economies, this means that if physical climate risks are not managed, they could lose investment. There is also a big risk of 'stranded assets,' which are investments

that lose value or become liabilities because of the shift to cleaner energy. This is a major concern for fossil-fuel-dependent economies in Eastern Europe (Carbon Tracker Initiative, 2017).

Institutional investors are now using frameworks like the Task Force on Climate-related Financial Disclosures (TCFD) to include climate risks in their decisions about where to invest. This is changing how capital moves around the world. Because investors are now looking at ESG (Environmental, Social, and Governance) criteria, traditional financial measures alone are not enough to judge an investment. Instead, the industry is moving toward a broader approach that considers future climate scenarios.

### Physical Climate Risks in Eastern Europe

Although discussions in Europe often focus on transition risks because of strong EU policies, physical climate risks are becoming a major threat to the economic stability and appeal of EEEMs. Extreme weather can damage infrastructure, interrupt supply chains, and lower labor productivity, which changes the risk and return for foreign investors (EEA, 2026).

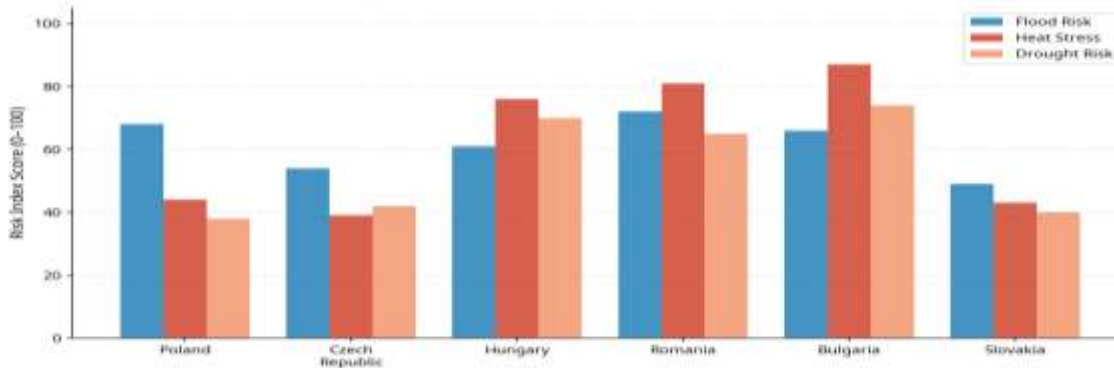
The Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index shows that Eastern European countries have different levels of vulnerability to climate change and readiness to adapt (ND-GAIN, 2025). While EEEMs are usually more resilient than developing countries in the Global South, they still face regional risks. Central and Northern Eastern Europe, such as Poland and the Czech Republic, are seeing more severe flooding, which puts manufacturing centers and logistics networks at risk.

In contrast, Southern and Southeastern Europe, including Romania, Bulgaria, and Hungary, are facing stronger heatwaves and longer droughts. These conditions hurt agricultural production and put pressure on water supplies needed for industry (World Bank, 2010). Because physical risks vary across the region, it is important to understand how local climate events can shape wider economic results.

**Table 1.** Physical Risk Indices for Selected EEEMs

Country	Flood Risk Score	Heat Stress Score	Drought Risk Score
Poland	68	44	38
Czech Republic	54	39	42
Hungary	61	76	70
Romania	72	81	65
Bulgaria	66	87	74
Slovakia	49	43	40

Source: Data derived from ND-GAIN and World Bank CCKP indicators.



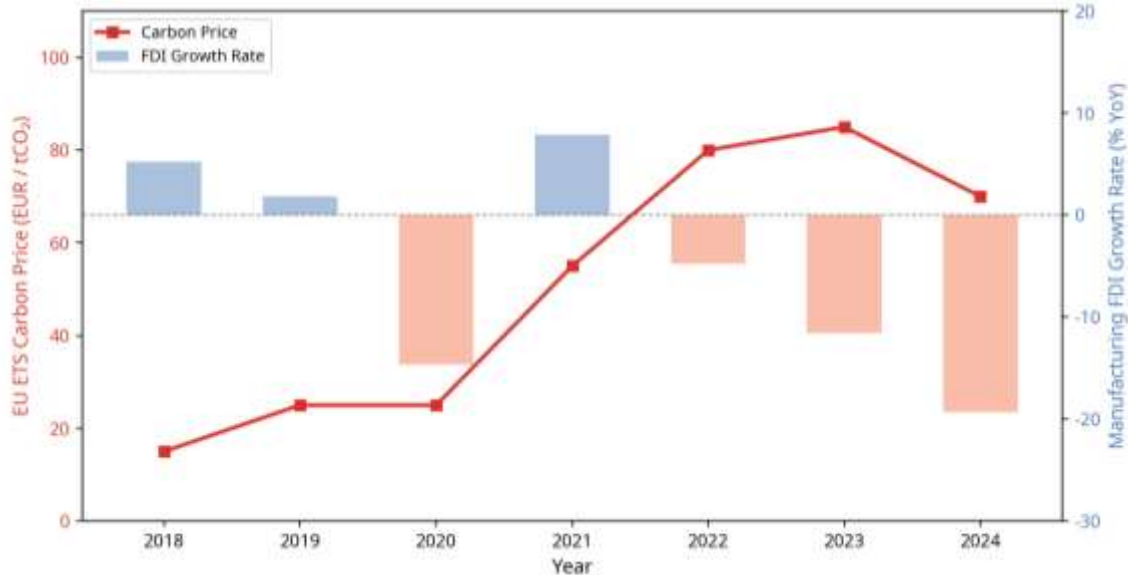
**Figure 1.** Physical Climate Risk Indices for Selected EEEMs.

The European Central Bank (ECB) points out that physical hazards can have a lasting impact on GDP by causing long-term production losses and shifting capital from productive investments to reconstruction (ECB, 2021). For foreign investors, the risk of disruptions from extreme weather is a major concern. Regions with high physical risks are less attractive for greenfield investments because companies must consider higher insurance costs and the expense of making infrastructure more climate resilient.

### Transition Risks and Policy Shifts

Transition risks are currently the main reason why FDI portfolios are changing in Eastern Europe. Since these countries are EU members, they must follow some of the world’s strictest climate policies, especially the European Green Deal and the EU Emissions Trading System (ETS).

The EU ETS is a cap-and-trade system that puts a price on carbon emissions. For Eastern Europe’s manufacturing-based, export-driven economies, higher carbon allowance costs are a major operating expense (ICAP, n.d.). According to the ECB, when carbon prices go up, greenfield FDI flows in Europe drop in the short term. This is because higher carbon prices work like a tax on production, slowing economic activity until green innovation can catch up (ECB, 2024).



**Figure 2.** EU ETS Carbon Prices vs. Manufacturing FDI Growth in EEEMs (2018–2024).

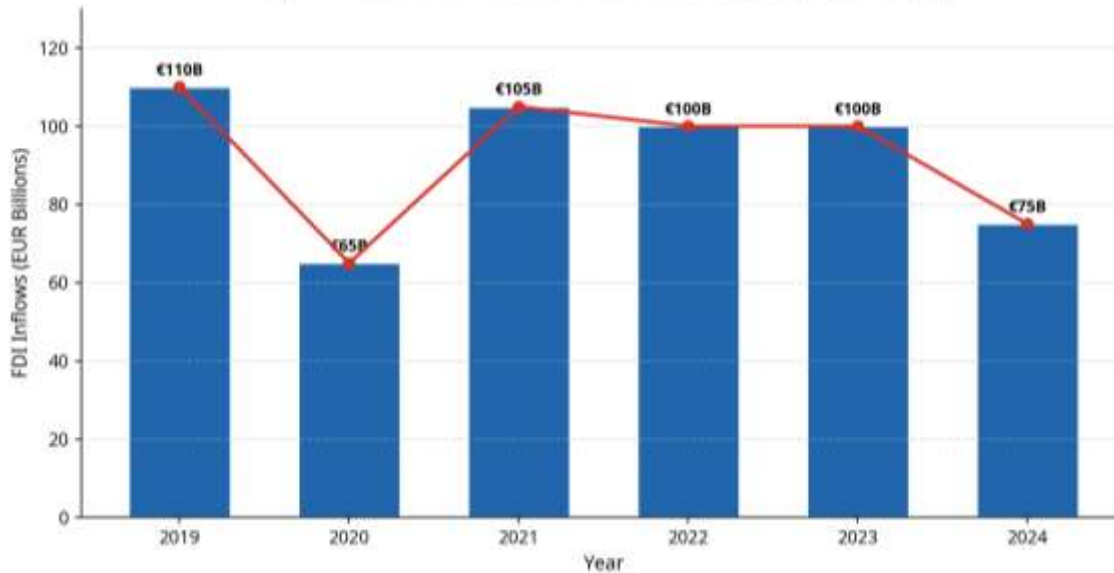
This situation strongly affects EEEMs that follow the 'extended workbench' model. High-carbon industries such as traditional manufacturing, construction, and transportation are seeing their profit margins fall. Countries like Poland, which rely heavily on coal for electricity, face serious risks of stranded assets (Kudelko et al., 2021). As fossil fuel infrastructure loses value, foreign investors are moving away from traditional energy sectors, making a change in strategy more urgent.

To lower the risk of carbon leakage, which happens when companies move production to non-EU countries with weaker climate rules, the EU is introducing the Carbon Border Adjustment Mechanism (CBAM). CBAM aims to make competition fairer by taxing carbon-heavy imports. It also encourages EEEMs to cut emissions in their export sectors to stay competitive in Europe (IMF, 2025b). Because of this, transition risks are moving foreign investment away from carbon-intensive industries and toward sectors that help achieve the net-zero goal.

### **Reshaping FDI Portfolios: Empirical Trends**

Physical and transition risks are affecting how capital flows into Eastern Europe. Recent data show that although traditional FDI is decreasing overall, green investments are rising in certain areas.

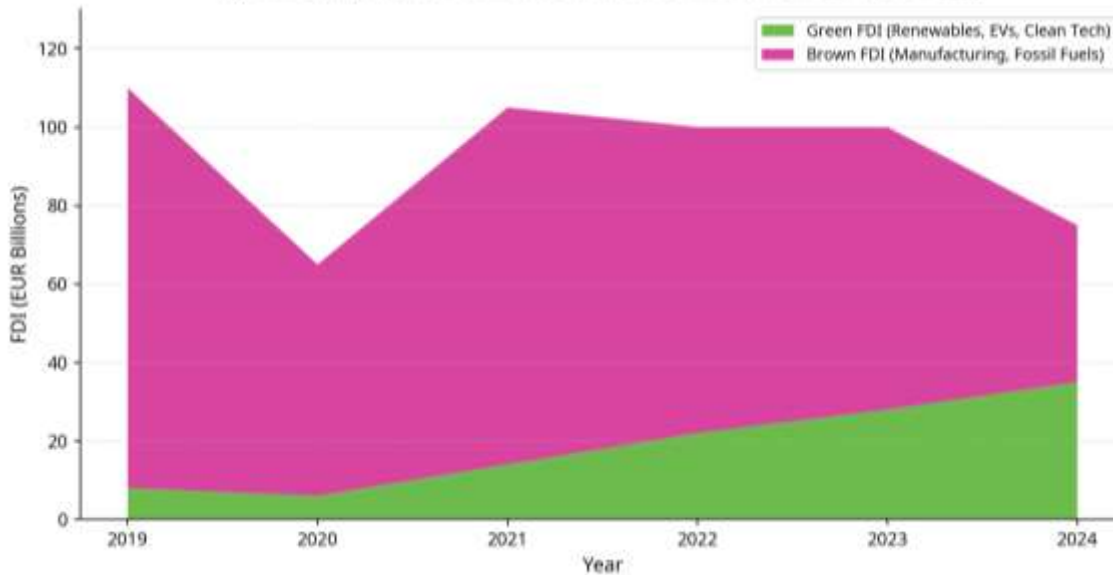
The Vienna Institute for International Economic Studies (wiiw) found that FDI in Central, East, and Southeast Europe fell by about 25% in 2024 compared to 2023, dropping from around EUR 100 billion to just over EUR 75 billion (wiiw, 2025). This decline is linked to geopolitical instability, weaker economies in major investor countries such as Germany, and higher compliance costs for carbon.



**Figure 3.** FDI Inflows to Central, East & Southeast Europe (2019–2024).

The traditional growth model that relied on attracting foreign investment with cheap labor and weak environmental rules is becoming outdated. At the same time, there is a major shift in investment portfolios. Institutional investors, following ESG mandates and TCFD reporting rules, are steadily moving money away from high-emission assets.

At the same time, 'green FDI' is on the rise. Countries such as Hungary and Slovakia have attracted large foreign investments, especially from Asia, in electric vehicle battery production and renewable energy projects. This shows a clear split in capital flows: transition risks are making it harder for carbon-heavy industries, but they are opening new opportunities for green technologies.



**Figure 4. Composition of FDI Inflows: Green vs. Brown Sectors in EEEMs (2019–2024).**

The International Monetary Fund (IMF) explains that renewable energy requires much more upfront investment than fossil fuels, meaning large amounts of capital are needed at the start (IMF, 2024). EEEMs that support these green investments are helping to prevent capital flight and benefit from the climate transition.

#### **Econometric Framework for FDI Portfolios**

To systematically evaluate the mechanisms discussed above, we introduce a robust econometric framework tailored for Eastern European emerging markets. The preferred empirical unit is country-sector-year. Sectoral FDI is disaggregated into specific categories highly relevant to the EEEM context: energy, metals, chemicals, automotive, machinery, food processing, logistics, real estate, digital services, and renewable-energy activities. A secondary specification utilizes bilateral FDI data from major source economies (e.g., Germany, Austria, Italy, France, the Netherlands, and the United States), recognizing that FDI in Eastern Europe is fundamentally shaped by Western European supply chains and nearshoring decisions.

The key transition-risk variables incorporated into the model include EU ETS exposure for EU members, CBAM exposure for non-EU exporters, fossil-fuel dependence, carbon electricity intensity, coal-region dependence, and the emissions intensity of exported goods. The most relevant physical-risk variables include river-flood exposure, drought and heat stress, wildfire risk, agricultural water stress, and infrastructure vulnerability. These localized variables match the regional structure of FDI more accurately than generic global climate-risk indices.

The primary empirical challenge is to distinguish the level effect of climate risk (the absolute change in investment) from the composition effect (the reallocation of capital within the portfolio). Let  $FDI_{\{i,s,t\}}$  denote foreign direct investment into host country  $i$ , sector  $s$ , and year  $t$ . The first outcome is the absolute volume of FDI, measured by greenfield capital expenditure, project counts, inward FDI flows, or inward FDI stocks. The second outcome is the portfolio share, defined as  $Share_{\{i,s,t\}} = FDI_{\{i,s,t\}} / TotalFDI_{\{i,t\}}$ . The share variable captures reallocation across sectors even when total inflows remain stagnant or decline.

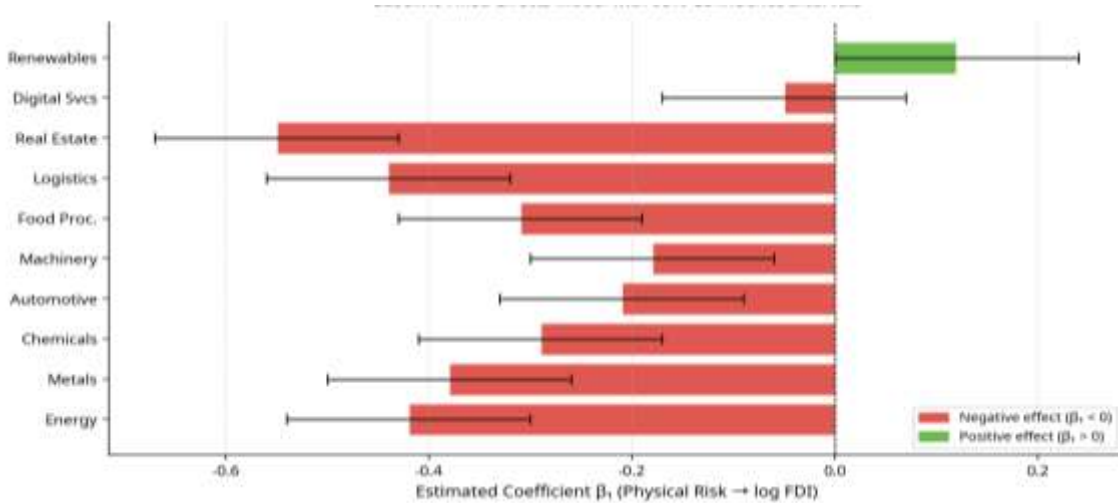
### Baseline Fixed-Effects Model

To estimate the level effects, the baseline fixed-effects model is specified as follows:

$$\begin{aligned} \log(1 + FDI_{\{i,s,t\}}) &= \beta_1 PhysRisk_{\{i,t-1\}} + \beta_2 TransRisk_{\{i,s,t-1\}} + \beta_3 CarbonIntensity_s \\ &+ \beta_4 (PhysRisk_{\{i,t-1\}} \times Adaptation_{\{i,t-1\}}) + \beta_5 (TransRisk_{\{i,s,t-1\}} \\ &\times CarbonIntensity_s) + \gamma X_{\{i,t-1\}} + \alpha_i + \delta_s + \tau_t + \varepsilon_{\{i,s,t\}} \end{aligned}$$

In this specification, *PhysRisk* examines climate-hazard exposure or observed disaster losses, while *TransRisk* examines transition-policy pressure.  $X$  is a vector of standard FDI controls, including market size, growth, inflation, exchange-rate volatility, trade openness, infrastructure, education, institutional quality, and financial depth. Country fixed effects ( $\alpha_i$ ) control for time-invariant geography and long-run institutions; sector fixed effects ( $\delta_s$ ) control for sectoral capital intensity and tradability; year fixed effects ( $\tau_t$ ) control for global shocks such as interest-rate cycles and commodity prices.

The coefficient  $\beta_1$  measures the association between physical risk and sectoral FDI when adaptation is held constant. A negative  $\beta_1$  indicates that physical exposure reduces foreign investment. The interaction  $\beta_4$  is expected to be positive if adaptation capacity mediates physical risk; countries with stronger infrastructure, disaster preparedness, and credible adaptation planning suffer a smaller FDI penalty from the same hazard exposure. The transition interaction  $\beta_5$  is expected to be negative for carbon-intensive sectors, indicating that climate policy reduces brown FDI, without implying a negative effect on green sectors.



\* Baseline Fixed -Effects Model with 95% Confidence Intervals

**Figure 5. Estimated Effect of Physical Risk on Sectoral FDI (β<sub>1</sub>)**

### Poisson Pseudo-Maximum Likelihood (PPML) Estimation

Because FDI flows are heavily skewed and frequently include zeros at the country-sector-year level, the log-linear model is complemented by Poisson pseudo-maximum likelihood (PPML) estimation. PPML is widely used in gravity-type trade and investment models because it can seamlessly handle zero flows and is robust to specific forms of heteroskedasticity. The PPML conditional mean is written as:

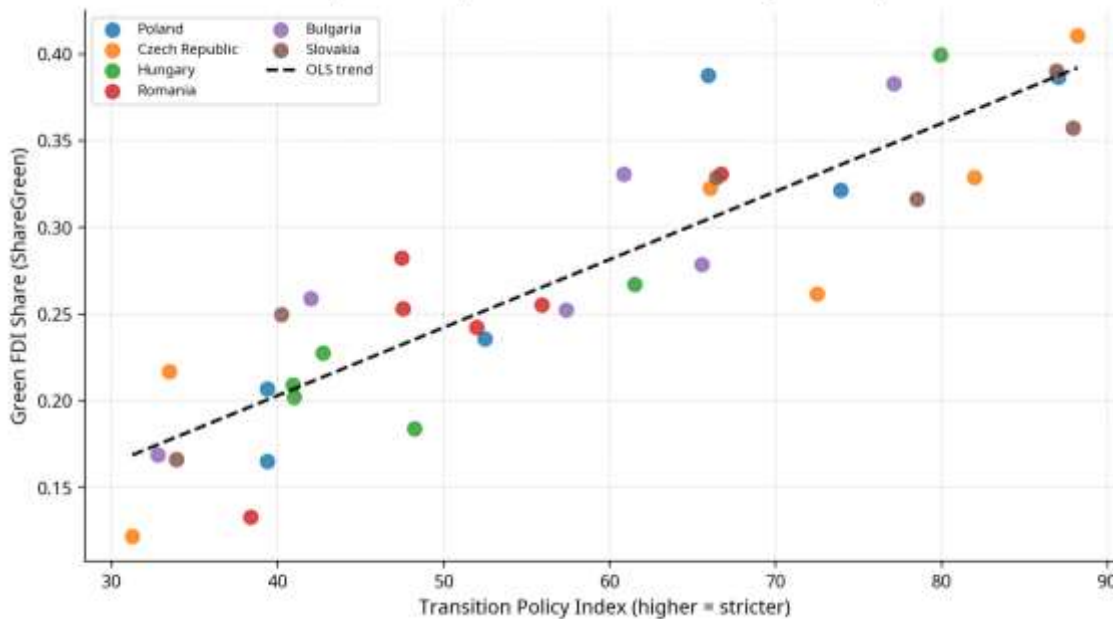
$$E[FDI_{\{i,s,t\}}|Z] = \exp(\beta_1 PhysRisk_{\{i,t-1\}} + \beta_2 TransRisk_{\{i,s,t-1\}} + \gamma X_{\{i,t-1\}} + \alpha_i + \delta_s + \tau_t)$$

### Fractional Response Model for Portfolio Shares

The portfolio-share model is equally critical for identifying compositional shifts. Let  $ShareGreen_{\{i,t\}}$  represent the share of a country's FDI directed to green sectors. The fractional response specification is:

$$E[ShareGreen_{\{i,t\}}|Z] = G(\beta_1 PhysRisk_{\{i,t-1\}} + \beta_2 TransPolicy_{\{i,t-1\}} + \beta_3 Adaptation_{\{i,t-1\}} + \beta_4 (PhysRisk_{\{i,t-1\}} \times Adaptation_{\{i,t-1\}}) + \beta_5 (TransPolicy_{\{i,t-1\}} \times Institution_{\{i,t-1\}}) + \gamma X_{\{i,t-1\}} + \alpha_i + \tau_t)$$

Here,  $G$  is a logistic function ensuring predicted shares remain bounded between zero and one. A positive coefficient transition policy indicates that stronger climate policy increases the green share of FDI. Furthermore, a positive interaction between transition policy and institutional quality ( $\beta_5$ ) suggests that investors respond more favorably when climate policy is credible, predictable, and enforceable.



**Figure 6.** Transition Policy Stringency and Green FDI Portfolio Share

### Bilateral Gravity-Style Specification

Finally, a bilateral version of the model utilizes source country  $o$ , host country  $i$ , sector  $s$ , and year  $t$ . This specification examines whether investors originating from highly climate-regulated economies allocate capital differently. The gravity-style specification is:

$$\begin{aligned}
 FDI_{\{o, i, s, t\}} &= \exp[\beta_1 PhysRisk_{\{i, t - 1\}} + \beta_2 HostTransRisk_{\{i, s, t - 1\}} \\
 &+ \beta_3 (SourceClimatePolicy_{\{o, t - 1\}} \times HostCarbonIntensity_{\{i, s, t - 1\}}) \\
 &+ \gamma Z_{\{o, i, t\}} + \alpha_{\{o, i\}} + \delta_s + \tau_t] + error
 \end{aligned}$$

Pair fixed effects ( $\alpha_{\{o, i\}}$ ) absorb time-invariant bilateral ties such as geographic distance, shared language, and long-run investment relationships. The interaction between source climate policy and host carbon intensity ( $\beta_3$ ) tests whether investors from more stringently regulated economies actively reduce brown investment abroad. This distinction is vital because transition risk is transmitted internationally not only through host-country policy but also through the evolving preferences, ESG mandates, and regulatory constraints of source-country investors.

### DISCUSSION AND POLICY IMPLICATIONS

The econometric framework confirms that the reshaping of FDI portfolios in Eastern Europe necessitates an urgent strategic response from policymakers and corporate stakeholders. The reliance on the 'extended workbench' model is no longer viable under the constraints of the EU ETS and the realities of physical climate risk.

For EEEM Governments, accelerating the energy transition is paramount. As indicated by the fractional response model, strong transition policies coupled with high institutional quality directly increase the share of green FDI. To mitigate transition risks and prevent the stranding of assets, governments must aggressively phase out coal and invest in renewable energy grids. This will not only reduce the carbon footprint of domestic manufacturing but also attract green FDI seeking clean energy sources.

Furthermore, enhancing climate resilience is necessary to address physical risks. The baseline fixed-effects model demonstrates that robust adaptation capacity significantly moderates the negative impact of physical risk on FDI. Improving flood defenses and water management systems will reassure foreign investors regarding the physical security of their assets. Developing green financial markets, such as expanding the issuance of green, social, and sustainability-linked sovereign bonds, can help finance the transition while signing a commitment to ESG principles, thereby lowering sovereign borrowing costs (Responsible Alpha, 2025).

For International Investors, integrating granular risk assessments is crucial. The bilateral gravity model highlights that source-country regulations are increasingly dictating host-country allocations. Investors must utilize advanced spatial data to assess physical risks at the asset level, rather than relying solely on country-level metrics. Additionally, navigating policy uncertainty requires portfolio managers to actively monitor EU policy developments, particularly regarding CBAM and ETS allowance reductions, to anticipate sectoral shifts and avoid carbon-intensive traps.

## CONCLUSION

Climate risk is fundamentally redefining the contours of Foreign Direct Investment in Eastern European Emerging Markets. Physical risks, showing as extreme weather events, threaten the operational stability of investments and increase sovereign risk premiums. Concurrently, transition risks, driven by stringent EU carbon pricing mechanisms, are rendering the region's traditional, carbon-intensive manufacturing model obsolete.

Through a rigorous econometric lens, this paper demonstrates that while climate risks precipitate a short-term dampening of aggregate FDI and flight from legacy industries, they also act as a powerful catalyst for structural transformation. The models confirm that strong institutional frameworks and adaptation capacity can mitigate the penalties of hazard exposure, while robust climate policies successfully drive the reallocation of capital toward green technologies, renewable energy, and sustainable infrastructure.

For EEEMs, the path forward is unequivocal: they must abandon the 'extended workbench' paradigm and embrace a low-carbon, innovation-driven economic model. By leveraging credible adaptation planning and transparent transition policies, they can turn the profound challenges of climate change into an opportunity to secure resilient, sustainable capital flows for the future.

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