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An experiment to measure physical climate risks in FDI between France and Italy

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Mapping FDI vulnerability to physical climate change risks

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Abstract

Economic activity worldwide is increasingly exposed to the adverse effects of climate-related risks. Extreme weather events — such as floodings, heatwaves, wildfires, and rising sea levels — are causing economic losses that in the European Union alone amounted to €208 billion between 2021 and 2024 (European Environmental Agency)[1]. The G20 has emphasised the need to address critical data gaps in related statistics, calling for improved measurement of emissions, exposure to financial and physical climate risks, and indicators to monitor the economic impact of the transition to a low-carbon economy.

Foreign direct investment (FDI), as a key driver of globalisation, is particularly relevant in this context. Assessing its exposure to physical climate risk can offer valuable insights for both policy development and economic analysis. This paper contributes to this effort, by proposing a methodology to quantify the vulnerability of FDI to the associated risks. We apply this framework to a case study involving France and Italy, assessing the exposure of bilateral FDI to current and projected physical climate change risks.

Our contribution builds on the literature examining how external risks affect FDI strategies, a body of work that has primarily focused on political instability and regulatory uncertainty. Few studies have directly addressed the role of physical climate risks in shaping FDI patterns. Our approach establishes an empirical link between FDI and climate risk at both regional and economic activity levels, leveraging firm-level data with detailed locational information shared by Italy and France. The locational data are matched with a geospatial mapping of climate-related physical risks providing a measure of risk exposure of French-owned FDI in Italy and of Italian-owned FDI in France, in the past, present and future under different climate scenarios. We also address methodological challenges related to the application of this methodology to multinational enterprise structures, including issues of indirect ownerships and overlapping affiliations.

While quantifying the effects of erratic and stochastic climate events remains challenging, our framework offers a foundational approach to incorporating physical climate risks into FDI measurement. In doing so, it supports more informed financial decisions and equips policymakers and investors with actionable insights for fostering climate-resilient FDI strategies.

Keywords: climate-related risks, foreign direct investment (**FDI**), physical climate risk, geospatial data, firm-level analysis, bilateral FDIJEL classification: Q56, F21, C81, Q54

[1] https://www.eea.europa.eu/en/analysis/indicators/economic-losses-from-climate-related?

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1. Introduction

In recent decades, the world economy has become increasingly intertwined with the planet's climate system. Climate change has emerged as an active and relevant variable in economic developments, shaping the contours of risk and opportunity across regional, sectoral, and temporal dimensions. The Copernicus Climate Change Service (C3S) reported that 2024 was the hottest year on record[2]. Extreme weather events (heatwaves, droughts, floods, wildfires, hurricanes, and coastal surges) are becoming more frequent and intense, and they do not only cause havoc or disruptions: they are rapidly translating into actual financial losses. In the European Union alone, the cumulative economic damage from climate-related events between 2021 and 2023 is estimated to have reached €162 billion (European Environmental Agency, 2024), a trend which has been on the rise since the last four decades. These impacts are unevenly distributed across time and space. Some regions and economic activities are more exposed than others, albeit reliable data on how exposure varies along these dimensions remains scarce. Understanding which industries and geographies bear the greatest risk is essential for designing effective policy responses and for allowing better investment decisions.

This shifting reality and information needs have prompted growing attention from policymakers, central banks, and multilateral institutions. The G20, among others, has highlighted the need to close data gaps in climate-related statistics, particularly those concerning the physical and financial risks linked to climate change.

Foreign direct investment (FDI) is particularly exposed to this challenge, as it is not only a channel for capital transfer but also a mechanism for technology diffusion, supply chain integration, and firm-level strategy. Unlike portfolio flows, FDI involves long-term commitments, frequently entailing the establishment of physical assets and organizational infrastructure in host countries. Such investment decisions are made with certain expectations about market stability, regulatory frameworks, and — crucially — the viability of operating conditions over time. As those conditions are increasingly shaped by climate events — a flood that disables a logistics hub, a heatwave that strains the power grid, or a wildfire that forces temporary shutdowns — investors and policymakers alike face a new class of uncertainty. A central question hence becomes: how exposed is FDI to these types of risks, and how can we measure that exposure systematically?

To date, most of the empirical literature on FDI and risk has focused on political or institutional uncertainties — regime volatility, regulatory instability, or expropriation threats. While these remain undoubtedly important, they now tell only part of the story. Physical climate risk has remained an underexplored dimension, not because it is unimportant, but because it is hard to measure. Unlike tax incentives or investment treaties, climate hazards are spatially specific, governed by probabilistic risk assessments, and often characterized by stochastic dynamics over time. Their impacts are also mediated by a range of local conditions: infrastructure quality, adaptation capacity, and even firm-level resilience strategies. Yet ignoring these risks amounts to assuming they are negligible — a stance increasingly at odds with reality.

This paper proposes a methodological framework to empirically assess the exposure of FDI to physical climate risk, with an application to a bilateral case study of France and Italy. These two countries are particularly well-suited for such an analysis. Both are major economies within the European Union with deep mutual investment ties and rich statistical systems. Their bilateral FDI relationship spans multiple economic activities — including manufacturing, energy, finance, and services — and features significant firm-level granularity in the available administrative data. Moreover, both countries face growing climate challenges, albeit with regional and climatic variation. France's southern regions are increasingly vulnerable

[2] https://climate.copernicus.eu/copernicus-2024-first-year-exceed-15degc-above-pre-industrial-level

to wildfires and droughts, while its Atlantic and Mediterranean coastlines face rising risks from sea-level rise and storm surges. Italy, on the other hand, confronts repeated flooding in the north, increased landslide risk in the Apennines, and heat-related stress in urban areas and in the southern regions, especially during the summer months. These contrasts offer useful evidence for testing how localized climate risk affect cross-border direct investment.

Our approach integrates firm-level locational and balance-sheet data with high-resolution geospatial information on physical climate hazards — such as flood maps, wildfire probability, and extreme heat projections — both current and under future climate scenarios, opening a new way to quantify the vulnerability of FDI positions to climate risks. By linking the geographic coordinates of firms to spatially granular risk indicators, we can assess the risk exposure of the resident direct investment enterprises and, subject to data constraints, of their local production units.

Crucially, this methodology also addresses technical challenges that often plague empirical work in this space: for instance, how to treat multinational enterprise structures, account for indirect ownership links, and manage overlapping affiliate networks. These are not mere methodological details, but crucial decisions if we are to move from stylized facts to rigorous empirical insight.

The broader aim of this study is to lay groundwork for a climate-informed theory and measurement of FDI. We do not claim to forecast FDI developments under climate change with precision — the underlying uncertainties are far too great, and the phenomena too complex. But what we can do is offer a replicable method to assess exposure, one that helps illuminate which sectors and regions are more at risk, and why, and to track how the exposure evolves over time. This is a first step toward building better risk assessments for investors, more resilient strategies for firms, and more targeted policies for governments concerned with both economic competitiveness and climate adaptation.

The paper is structured as follows: Chapter 2 reviews the literature. Chapter 3 covers the details on the methodology and its main phases. Chapter 4 provides details on the data used in the analysis. Chapter 5 presents and discusses the results for France and Italy. Chapter 6 offers a thorough discussion of the methodological difficulties encountered in the exercise. Finally, Chapter 7 presents some concluding remarks.

2. Literature review

The connection between FDI and climate risks has been a growing concern for investors and policymakers alike. As climate change becomes more evident from extreme weather events to rising sea levels, the related financial impacts also affect corporate financial performance and ultimately decisions about FDI location.

Several theoretical frameworks have been used to relate climate and FDI. The international risk theory, as outlined by Buckley et al. (2016), suggests that multinational enterprises (MNEs) take into account host country risks — including climate vulnerabilities — when making investment decisions. Similarly, Dunning's OLI (Ownership, Location, Internalization) paradigm emphasizes how locational advantages, potentially undermined by climate risks, play a crucial role in shaping FDI flows (see Shear et al. 2023). These frameworks provide a theoretical basis for examining climate risk as one of the determinants of FDI patterns.

The literature has highlighted the influence of climate physical risks both in FDI host countries (where the direct investment enterprises are located) and in FDI home countries (where direct investors are residing). Empirical evidence consistently points to a negative impact of physical climate risks on FDI inflows. Gu and Hale (2023) evaluate the response of FDI to extreme weather events, finding that countries experiencing higher climate vulnerability attract significantly lower investment. Similar patterns emerge from panel studies spanning multiple decades and countries, which show that climatological indicators — such as average annual temperature and precipitation intensity — negatively correlate with inward FDI (see Jihad Ait Soussane et al. 2022). The type of climate hazard also plays a consistent role in deterring investment: floods, landslides, and cyclones have a much stronger negative impact compared to extreme heat and wildfires. This differentiated response underscores the complex relationship between specific climate hazards and FDI decisions.

The literature also shows considerable heterogeneity across economic activities and geographies. Agriculture, forestry, fishing, mining, and manufacturing emerge as the most climate-vulnerable sectors for FDI, with heat stress, water scarcity, and flood risk representing the primary threats. Meanwhile, in manufacturing and construction, increased flood risk from rising sea levels can lead to direct asset damage and indirect operational losses, impacting FDI investments. Such observation regarding sectoral variation reflects key differences in exposure to climate hazards and country adaptive capacity.

From a geographical perspective, FDI in the Caribbean, the Middle East, and Southeast Asia is exposed to the highest levels of climate risks (Li et al. 2022). Developing economies are disproportionally affected, as the negative effects of climate change on FDI tend to be more severe in countries with more agriculture-dependent economies and with limited investment in research and development. This geographical disparity underscores the uneven distribution of climate vulnerability across the global economy.

A relatively innovative concept introduced by Xing et al (2022) is "climate risk distance," defined as the difference in climate risks levels (as measured with Germanwatch data) between the home and the host countries in FDI relationships. Evidence shows that when the climate risk distance is positive (host country has higher risk than home country) FDI is less likely to occur. Conversely, when climate risk distance is negative (home country has a higher climate risk than host country), FDI is not significantly deterred, which the authors interpret as evidence that investors from higher-risk home countries may possess internalized knowledge or experience to manage climate risks. This asymmetric relationship suggests that countries with high climate risks may hold competitive advantages — such as enhanced resilience or adaptive capabilities — that help them overcome climate-related barriers when investing abroad. The concept provides a nuanced understanding of how relative, rather than absolute, climate risk affects cross-border investment patterns.

These finding suggest that investments in climate adaptation and resilience generate not only environmental benefits but also enhance a country's attractiveness to FDI. The potential for policy interventions to mitigate some adverse effects of physical climate risks can play a critical role in improving FDI attractiveness.

The literature has developed diverse methodological approaches to assess the relationship between climate risk and FDI. These include panel econometric models based on climate vulnerability indices (e.g. Shear et al. 2023, Jihad Ait Soussane et al. 2022) and firm-level analyses of investment decisions (e.g. Gu and Hale 2022). Recent advances involve the integration of geospatial climate risk data with facility-level information, allowing for more granular assessments of physical risk exposure (e.g. Li et al. 2022).

Nonetheless, some methodological and measurement challenges persist. Quantifying erratic and stochastic climate events remains difficult, while capturing the complexity of FDI chains — including indirect ownership structures and overlapping corporate affiliations — requires the development of detailed and integrated statistical databases. These limitations are reflected in several outstanding research gaps. In particular, few studies have measured the relationship between FDI and physical climate risk at the firm level, with detailed geographic and sectoral resolution. Our study contributes to closing this gap by proposing a framework that combines firm-level FDI data with geospatial mapping of climate hazards, applied to a case study of bilateral investment between France and Italy. This approach provides an empirical basis for integrating climate risk into FDI analysis.

3. Methodology

This chapter presents the methodological framework developed to quantify the exposure of bilateral FDI between France and Italy to physical climate risks. FDI refers to cross-border investments involving a 'lasting interest', where an investor from one country acquires control (defined as 50% or more of voting rights) or a significant degree of influence over the management (defined as 10% or more of voting rights) of a company located in another country (OECD, 2025). The proposed approach is conceptually organized into three sequential phases, each addressing a key aspect of the measurement strategy. The overarching objective is to construct a granular, replicable, and interpretable measure of physical risk exposure at the level of bilateral FDI positions, by linking firm-level data to climate hazard maps.

The scope is restricted to the non-financial sector. Financial institutions such as banks and insurance companies are excluded, as their climate risk exposure stems primarily from their financial portfolios than from their physical location. An exception is made for financial holding companies, which are retained to preserve the integrity of the ownership chains including non-financial entities. These choices ensure that the resulting measure captures the physical vulnerability of direct investment, rather than intermediated financial risks. In addition, the analysis focuses exclusively on the equity component of FDI, which best reflects ownership structures and avoids potential distortions arising from the debt component. This narrower scope allows for full control over data quality and detail at firm level, providing valuable insights at this early stage of integrating FDI with climate risk metrics.

Phase 1: decomposition of FDI positions

The first phase decomposes aggregate inward FDI positions into elementary units. This involves identifying the Direct Investment Enterprises (DIEs) residing in France (Italy) that are linked to an Italian (French) direct investor, along with their domestic ownership chain, including related establishments or production sites. Branches are also included when treated as DIEs in official FDI statistics. The output of this phase is a list of DIEs associated with bilateral FDI positions, together with their downstream affiliates and establishments in the respective host economy. We shall refer to the elements in this list as the elementary units.

With respect to the domestic ownership chain, only controlled entities are included. Specifically, the chain is followed downstream only when the participation link involves an equity share of at least 50%. While minority stakes (e.g. 25%) may confer a degree of influence, they typically reflect arm's-length contractual relationships rather than full vertical integration. The literature on ownership and value chains suggests that effective control – and thus strategic vulnerability to physical shocks – rests primarily with majority-owned affiliates (Grossman and Hart, 1986; Gereffi, Humphrey and Sturgeon, 2005).

Caution is warranted when official FDI statistics are derived from sample-based surveys rather than from a census. This issue is particularly relevant when analysing the relationship between FDI and climate risk, where the geographic location of enterprises plays a crucial role. In sample-based surveys, enterprises are assumed to be representative of the broader population, and their reported values are extrapolated to the national level using expansion coefficients. While this approach is appropriate for estimating aggregate measures (e.g., total FDI values), it is less reliable for capturing granular details, such as the precise geographic distribution of enterprises. For this reason, the dataset used for the analysis should be drawn from comprehensive administrative sources, which provide detailed information on enterprise equity, ownership shares, and the residency status of shareholders.

We focus on immediate ownership, and the DIE list includes only bilateral FDI positions between France and Italy (i.e., French-owned entities in Italy and Italian-owned entities in France) and their respective domestic chain of entities (i.e. non-resident units belonging to the same DIE group are not included). In adopting this approach, we do not adjust for potential round-tripping in the identification of DIEs. Round-tripping refers to situations in which domestic investors route capital through foreign jurisdictions for several strategic or financial reasons, and subsequently reinvest it in their home country, creating the appearance of foreign ownership and potentially benefiting from tax or regulatory advantages.[3] While it is possible that some enterprises in our sample reflect round-tripping structures, the phenomenon is expected to be limited in this bilateral context. Indeed, since France and Italy have broadly similar legal and tax frameworks, the incentives for round-tripping between the two countries are likely to be weak, and the volume of such transactions relatively low.

Phase 2: Geolocation and climate risk mapping

The goal of the second phase in our methodology is to assign a climate risk score to each elementary unit identified in Phase 1. In principle, this would require geolocating each unit – i.e. retrieving its address from national registers and converting the address into geographic coordinates – and overlaying it with high-resolution climate hazard maps to obtain the associated risk score. However, rather than conducting this process independently, we rely on an enhanced version of the ECB's Register of Institutions and Affiliates Database (RIAD+). This version integrates firm-level geographic coordinates and physical climate risk indicators from specialized climate data sources (see Section 4.2 for further details).

RIAD+ allows us to assign the risk scores in two ways. When an elementary unit from our sample appears in RIAD+, we directly use its climate risk score. This applies to about 20% of units, as most establishments lack separate identifiers distinct from their parent companies, and RIAD was originally designed with a focus on financial institutions and large corporates. For the remaining units, we apply a two-step geolocation and spatial interpolation method. Each unit's address is first geocoded with OpenStreetMap to obtain latitude and longitude coordinates.[4] Using these coordinates, each non-RIAD+ unit is matched with its five closest neighbors in RIAD+. Specifically, we compute the median physical risk score of its five nearest neighbors, identified using the haversine distance in combination with a Ball Tree search algorithm (Moore, 1991).[5] Using the median reduces the influence of extreme values, ensuring more robust and representative imputations. This spatial approach is supported by the strong local autocorrelation of climate variables (e.g. temperature, flooding, water stress). As shown in Chart 1, over 95% of matched neighbors are within 1 km.

Phase 2 produces a vector of climate risk scores for each of the elementary units identified in Phase 1. Scores are remapped to their original scales (e.g., probabilities, expected losses) to enable the

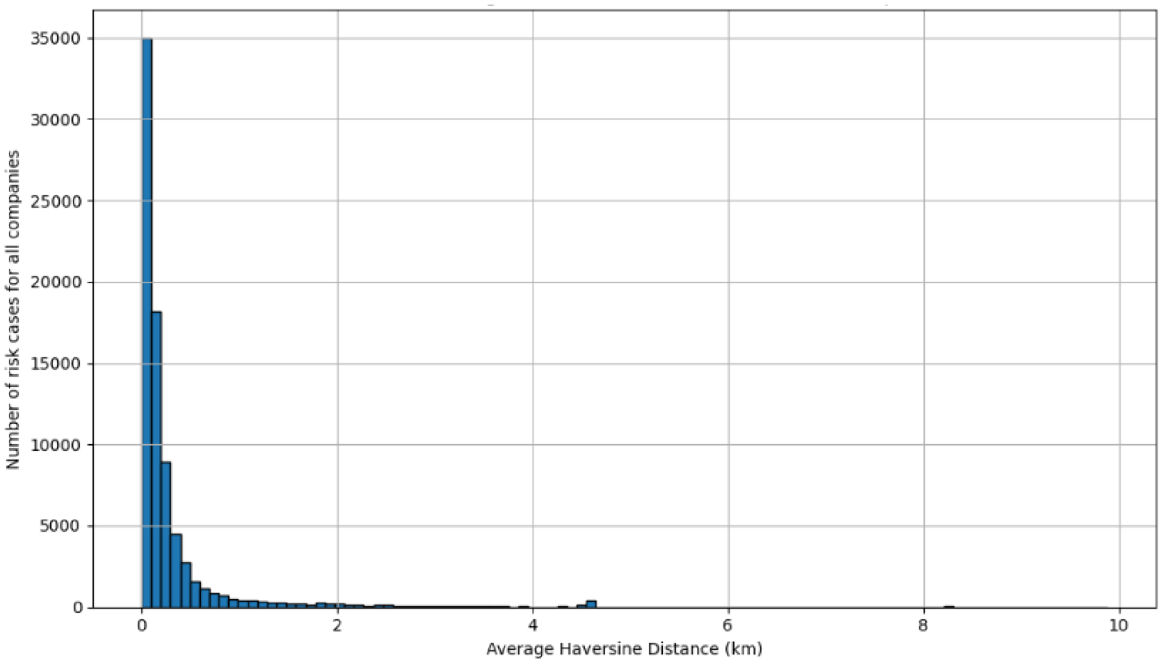
[3] As an illustrative example, consider the case of a DIE residing in Italy with a French direct investor, which is itself ultimately controlled by an Italian entity (round-tripping). This DIE would be included in our analysis, since, under the immediate investor perspective, it is an Italian firm controlled by a French investor.

[4] Most entities are successfully geolocated, while a small number are excluded due to invalid address records or locations outside mainland France. For France, we only consider units located in the "metropolitan France", i.e. we exclude overseas regions, departments, and territories.

[5] The haversine formula calculates great-circle distances between two points on a sphere, making it suitable for geographic coordinates. The Ball Tree is a hierarchical data structure that organizes points into hyper-spherical nodes to enable efficient nearest-neighbor searches. Combined, these methods significantly reduce computational costs compared to brute-force distance calculations and provide a statistically robust approximation for missing climate scores.

subsequent aggregation. Before Phase 3, we exclude entities associated with negative FDI positions to facility the calculations and without any impact on the results.

Distribution of Average Haversine distances (km) for nearest neighbours Chart 1



Sources: authors' own calculation on Italian and French elementary units' dataset

Phase 3: Aggregation of risk scores at FDI-level

The final phase aggregates the unit-level climate risk scores into a consolidated assessment of FDI exposure to physical climate risk. The aggregation process follows a structured, hierarchical approach.

First, climate risk scores assigned to elementary units (establishments or affiliates) are consolidated at the level of the DIE. This step captures how the FDI capital of a single enterprise, potentially spread across multiple locations, is exposed to physical risks. We weight each unit by the number of employees, as a proxy for its operational scale and economic significance.[6]

Second, DIE-level risk measures are aggregated by NACE economic activity, using each DIE's total equity as a weight. This produces sectoral climate risk indicators that combine both the exposure of individual firms and their relative importance within the sector.

Finally, sectoral climate risk indicators are combined into an overall measure of the inward FDI position. Each NACE economic activity is weighted by its share of the total FDI equity, ensuring that the

[6] Tangible capital, such as non-financial assets, would be a relevant basis for weighting the consolidation of risk scores at the DIE level. However, data on tangible capital are limited, especially at the level of elementary units. Employment is therefore used as the preferred proxy, as it is widely available and strongly correlated with value added, effectively capturing the relative economic scale of each unit.

final indicator reflects both the granular exposure of local production units and the economic weight of each unit within the broader investment structure.

Critical assumptions include the availability and consistency of data on the number of employees and equity, as well as the comparability of risk metrics across establishments and sectors. Transparency in these assumptions remains essential for robustness and replicability. Together, the three phases define the complete set of data requirements needed to implement this type of analysis.

4. Data and Descriptive statistics

4.1. National microdata on FDI firms

To implement the proposed three-phase methodology, the following microdata are required:

1. Equity value: pro-rata equity of DIEs.
2. NACE activity: the economic activity classification of DIEs.
3. Number of employees: employment data for all enterprises, including their local subsidiaries and their establishments.
4. Address of all elementary units (DIE, their subsidiaries, and their establishments)

These data were provided by the French and Italian national central banks (NCBs), which sourced them from national business registers. Both French and Italian dataset are methodologically consistent as both countries follow international standards and Eurosystem guidelines to compile FDI data. For example, data are reported at Own Funds at Book Value (OFBV), meaning that equity positions are valued according to the accounting records of the resident enterprise, capturing both initial capital contributions and retained earnings. This accounting-based approach ensures internal consistency across data sources and provides a reliable basis for linking FDI positions to the geographic distribution of productive assets and, ultimately, to their exposure to climate-related risks.

4.1.1 The Italian case

In the case of Italy, the identification of the list resulting from phase 1 relies on national business register and Italian NSI's ASIA-GRUPPI database, which is the Italian contribution to the European Group Register (EGR).

The domestic ownership chains were reconstructed sequentially. Starting with the list of Italian enterprises with French shareholders (Level 0), the affiliated enterprises controlled by these entities (Level 1) were identified using the ASIA-GRUPPI database, and so on. For each enterprise (with French shareholders and reconstructed ownership chains), establishments were also identified and the respective number of employees obtained from the national business register.

For the enterprises under study, official Italian FDI data are derived from sample-based surveys. A comparison between official FDI data and data used for this study (derived from administrative sources and referred to the entire population) is therefore necessary. This comparison based on 2022 data demonstrates a near-perfect overlap in terms of amounts (Table 1).

Comparison between official FDI data and FDI from administrative sources			Table 1
	Number of enterprises	**Sample not grossed up OFBV (M €)**	**Sample grossed up OFBV (M €)**
Sample	132	33,902	42,304
Population	2,626	-	42,316

Sources: Banca d'Italia

4.1.2 The French case

In France, equity capital positions of inward FDI are identified as all non-resident holdings exceeding 10% of the equity capital of resident enterprises. This information is compiled using mainly three administrative sources.

SIRENE is the national business register, maintained by INSEE, the national statistical institute. It provides exhaustive coverage of all enterprises and establishments operating in France, whether public or private, and assigns them unique identifiers. The database includes detailed information on legal form, sector of activity, size, and geographic location, and is continuously updated through administrative sources such as tax records, social security, and commercial court registries.

The identification of corporate groups in France draws on INSEE's *Liaisons financières entre sociétés* (LIFI) database, which records equity links between companies as of December 31 each year. LIFI reconstructs group structures by identifying both DIE parent and its elementary units, relying on multiple sources such as Banque de France's financial data, fiscal records from the Ministry of Finance, and the European Group Register. An algorithm establishes financial control and group heads (including foreign ones). Originally survey-based, LIFI has since evolved into an integrated database covering nearly 190,000 groups in 2023, making it a central tool for mapping ownership structures and multinational linkages in France.

Finally, ESANE (*Élaboration des Statistiques Annuelles d'Entreprises*) integrates accounting, tax, and survey data to produce harmonized indicators on equity, employment, value added, and other financial characteristics of French enterprises.

Together, these sources enable the detailed mapping of inward FDI positions, domestic ownership structures, and the geographic distribution of investments necessary for linking FDI to climate risk exposure.

4.2. Overview of Physical Risk Data

As anticipated in Chapter 3, this study leverages RIAD+, an enhanced version of RIAD that integrates firm-level geolocation with climate physical risk data developed by the ESCB Statistics Committee Expert Group on Climate Change and Statistics (STC EG), in collaboration with the Working Group on Securities Statistics (WGSS)[7]. The physical hazard data were retrieved by the STC EG entirely from public sources such as Copernicus[8] and the European Commission DRMKC RDH[9], and they are developed and maintained by the

7 See SPS https://www.ecb.europa.eu/pub/pdf/scpsps/ecb.sps48~e3fd21dd5a.en.pdf

8 For more information, see https://www.copernicus.eu/en.

9 The Disaster Risk Management Knowledge Centre (DRMKC) Risk Data Hub (RDH): https://drmkc.jrc.ec.europa.eu/risk-data-hub.

Joint Research Centre (JRC). The climate scenarios rely mostly on climate projections developed by the European Coordinated Regional Downscaling Experiment (EURO-CORDEX) – and are based on earlier models expressed in Representative Concentration Pathways (RCPs)[10]. These indicators are built at the firm-level and aim to quantify the exposure of corporations to physical climate hazards (see Table 1 in the appendix for a detailed overview of the different climate scores and how they are computed). Climate risk scores across various dimensions typically range from 0 (low risk) to 5 (high risk). An exception is the risk score associated with the precipitation index, which is distributed between -3 (extremely dry) and 3 (extremely wet).

These data enable the assessment of both current and future vulnerabilities, with a focus on medium-term time horizons to support climate risk analysis and evaluations. Climate scenarios are inspected, where relevant, to enhance the understanding of potential risks and inform appropriate mitigations strategies.[11]

European firms are exposed to a wide array of climate-related hazards, which can be broadly grouped into acute and chronic risks. Acute risks refer to event-driven hazards such as floods (coastal and river), windstorms, wildfires, landslides and subsidence, which can cause abrupt and severe disruptions to economic activity. By contrast, chronic risks capture long-term, persistent and gradual shifts in climate conditions, notably droughts, water stress, and precipitation anomalies (measured for instance through consecutive dry days or the Standardised Precipitation Index). A recent ECB study (Boldrini et al, 2023) indicates that while acute hazards tend to generate losses concentrated in specific regions or sectors, chronic risks – particularly prolonged drought and increasing water scarcity – affect all Europe, with various degrees of intensity, bearing significant implications for agriculture, energy production, and manufacturing.

4.3 Descriptive Statistics on elementary units

After completing phase 2, we were able to draw the following descriptive statistics for the elementary units in France and Italy and their related FDI positions (Table 2). The figures reported show a coverage slightly above 52% if we consider official total bilateral FDI investments in Italy and France for end-2022 and close to 100% if we consider official FDI data for the corporations covered in our analysis[12] (as explained in Chapter 3). Finally, on average, French DIEs tend to be larger when looking at average employees and median FDI value. However, the largest DIEs in the dataset are located in Italy (larger average FDI value).

10 RCP 4.5: Stabilization pathway. Radiative forcing reaches about 4.5 W/m² by 2100. Emissions peak around mid-century, then decline due to mitigation policies. Leads to moderate warming (~2–3°C by 2100 relative to preindustrial). RCP 8.5: High baseline pathway. Radiative forcing reaches 8.5 W/m² by 2100. Assumes continued high emissions, heavy reliance on fossil fuels, little mitigation. Leads to stronger warming (~4–5°C by 2100).

11 Climate scenarios are standardized projections of future climate conditions based on different assumptions about greenhouse gas emissions and socio-economic developments. Commonly used scenarios include the Representative Concentration Pathways (RCPs) adopted by the IPCC, such as RCP4.5 (moderate mitigation) and RCP8.5 (high emissions). These are widely used by policymakers and institutions (e.g. European Commission, NGFS) to assess physical climate risks under alternative futures.

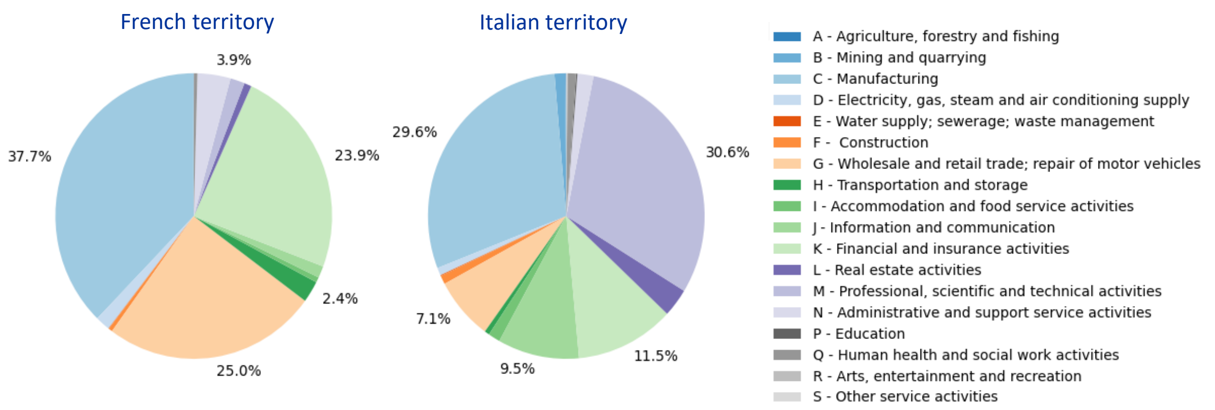
12 That is excluding real estate investments, banks and insurance companies.

Comparison between French and Italian territory (year 2022)		Table 2
	French territory	**Italian territory**
Number of DIEs	1,504	2,580
Total number of employees	332,372	336,241
Bilateral FDI value (M €)	13,898	41,899
Median FDI value (M €)	769.0	89.8
% of official total bilateral FDI	52%	55%
% of official FDI enterprises in the analysis	100%	97%

Sources: authors' own calculation on Italian and French elementary units' dataset

Looking at the economic activity (NACE level 1) breakdown in Chart 2, most of French FDI value in Italy (pie chart on the right) is focused on (M) Professional, scientific and technical activities, which includes also head offices, (C) Manufacturing, (K) Financial and insurance activities and (J) Information and communication. Most of Italian FDI value in France (pie chart on the left) is concentrated in (C) Manufacturing, (G) Wholesale and retail trade and (K) Financial and insurance activities (see also Table 1 in appendix). We should expect companies involved in Agriculture, Manufacturing and Construction to be more exposed to climate risk rather than, for instance, those in Financial and insurance activities (see next section), which in the scope of our analysis only include holding companies.

Distribution of FDI value in French and Italian NACE activities — Chart 2

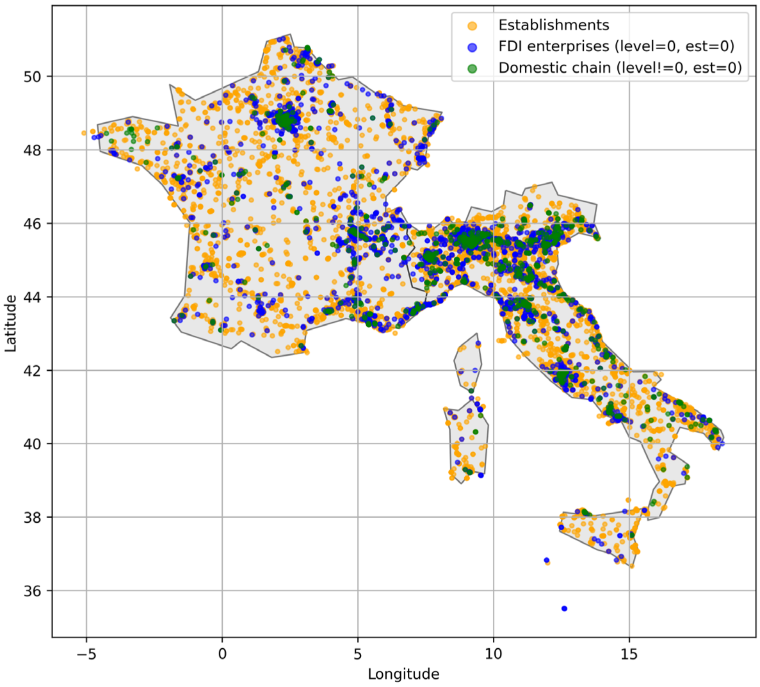


Sources: authors' own calculation on Italian and French elementary units' dataset
Notes: Financial and insurance activities include only holdings as specified in the methodological Chapter 3

An analysis of the geographical distribution of the list of elementary units (i.e. including domestic chain and establishments) reveals that DIEs enterprises are heavily concentrated in major urban centres (Chart 3). In contrast, domestic chain (i.e. local subsidiaries) and establishments are more widely dispersed throughout the territories. This spatial disparity highlights the necessity of incorporating these establishments into FDI-weighted climate score calculations for a more comprehensive assessment.

Geospatial distribution of elementary units

Chart 3



Sources: authors' own calculation on Italian and French elementary units' dataset

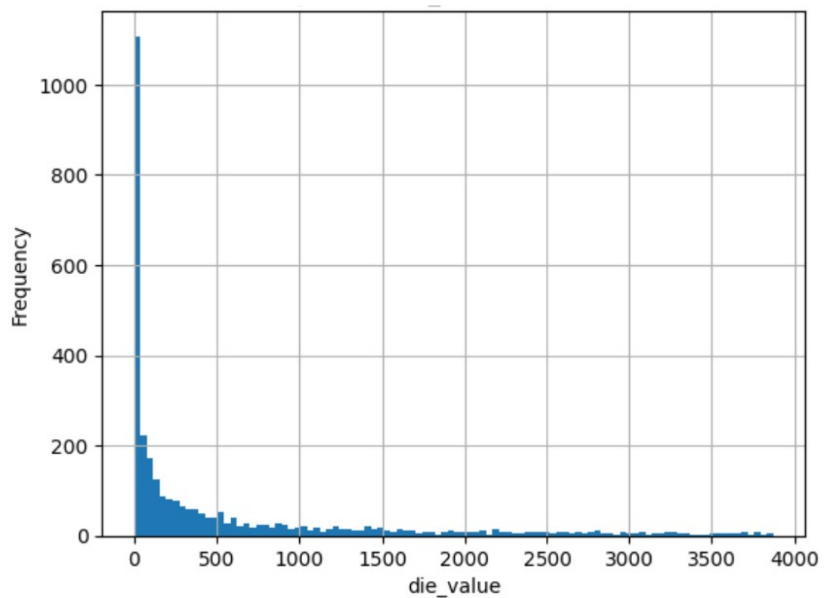
Furthermore, inspecting the distribution across the domestic chain (Table 3), we find that the majority of entities are either DIEs at Level 0 or their local subsidiaries (and their associated establishments) at Level 1. We define "daughter companies" or establishments as being one level down their parent DIE.

Distribution of elementary units along the different levels				Table 3
	French territory		Italian Territory	
	Establishments	Enterprises	Establishments	Enterprises
Level 0	0	1504	0	2580
Level 1	3800	211	4313	751
Level 2	572	70	3787	272
Level 3	126	35	557	67
Level 4	75	7	112	25
Level 5	4	1	56	2
Level 6	0	0	1	0

Sources: authors' own calculation on Italian and French elementary units' dataset

Finally, an examination of the FDI values reveals a highly skewed distribution (Chart 4), where a few companies have extremely large FDI values while the vast majority have very small or even zero values. This is often referred to as a power-law distribution and has significant implications for analysis: this skewness makes a simple average misleading, as it would be heavily inflated by the few large companies, giving a false impression on the overall investment landscape.

Histogram of FDI values in the French and Italian territories (year 2022) — Chart 4



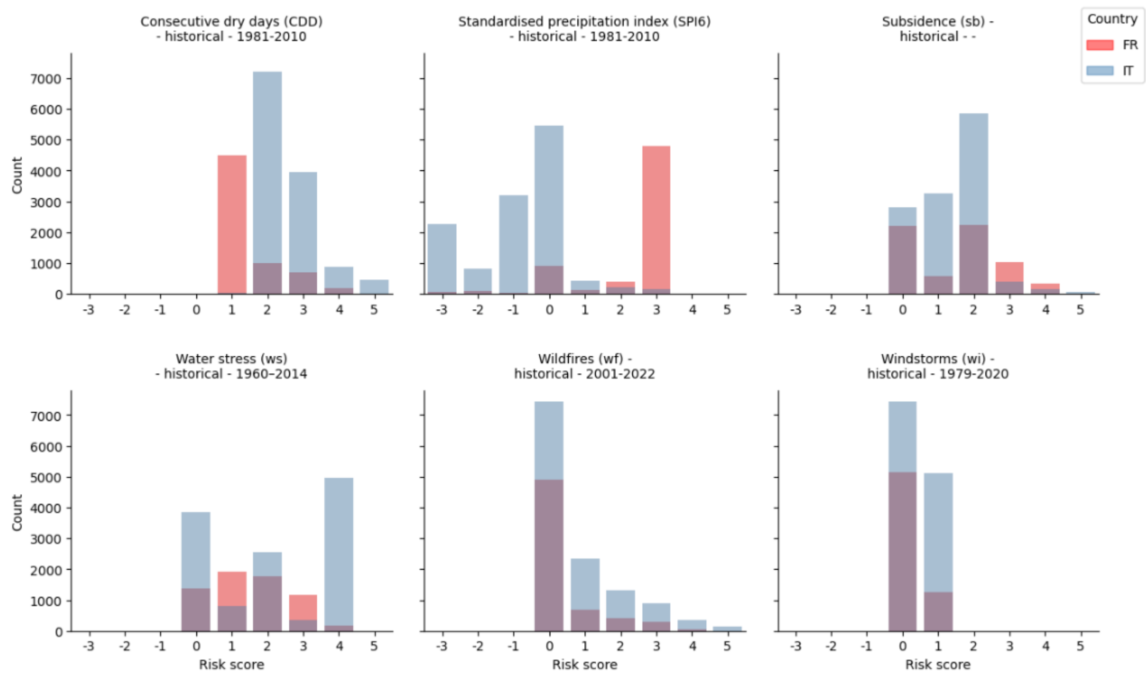
Sources: authors' own calculation on Italian and French elementary units' dataset

4.4 Descriptive Statistics on climate risk scores

The graphs below present the matching results between the full list of identified entities (18,928 units) and the climate physical risk dataset, separately for French and Italian territory. Examining the distribution of enterprises and establishments across different hazard types (Chart 5), we find that French and Italian firms are frequently exposed to hazards related to prolonged climatic stress, such as consecutive dry days, water stress, or precipitation anomalies (standardized precipitation index). Approximately one-third of total entities are highly exposed to prolonged drought conditions and around 18% face a significant risk of wildfire. By contrast, risks such as coastal or river flooding affect only a small number of entities, with most enterprises recording a risk score of zero (see Chart 1 in appendix).

Number of entities in each risk bucket in French and Italian territories

Chart 5



Sources: authors' own calculation on Italian and French elementary units' dataset

5. Results

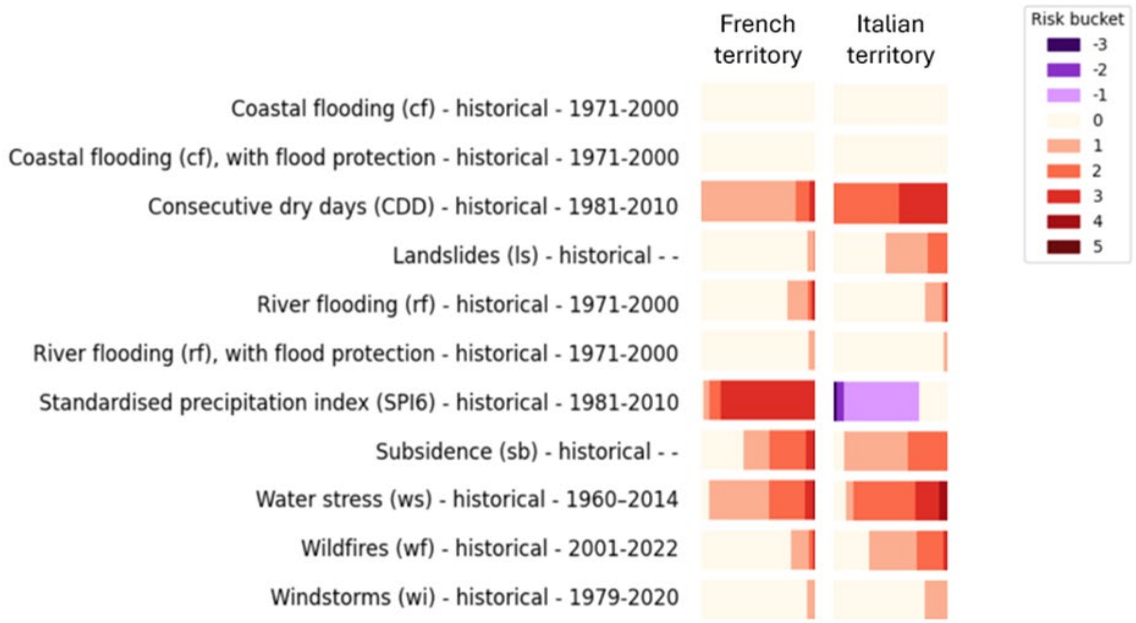
Our results provide a detailed understanding of the variability in climate risk exposure across different hazards, sectors, and countries. They also shed light on the spatial and economic distribution of these risks. Unless otherwise specified, the following charts display weighted risk scores, based on the methodology outlined in Chapter 3. In evaluating the results, we consider a qualitative assessment of climate hazard exposure, because, at this stage, we are not able to quantify the financial impact of climate risks, i.e. to express the risk in terms of expected losses. Additionally, we do refrain from adding climate risk assessment across different risk categories; due to the way we build scores, comparisons across different hazard types are not meaningful.

5.1 Aggregate Climate Risk Exposure

Chart 6 shows the distribution of weighted climate risk scores for FDI in the French and Italian territory. Climate risk scores at the level of bilateral FDI positions reveal significant variability across different hazards and regions. Some hazards affect only a few firms, but risks such as water stress, wildfires, consecutive dry days, subsidence and the SPI index show greater variability.

Distribution of weighted climate risk scores for DIEs

Chart 6



Sources: authors' own calculation on Italian and French elementary units' dataset and climate scores from STC EG

While France is more exposed to extreme wet conditions, for Italian inward FDI the opposite is true (Standardised precipitation index is negative). The same picture is showed by the consecutive dry days score, since both the measures are capturing the intensity of draughts. French direct investment in Italy is also more exposed to wildfires, water stress, landslide, subsidence, windstorm and coastal flooding.

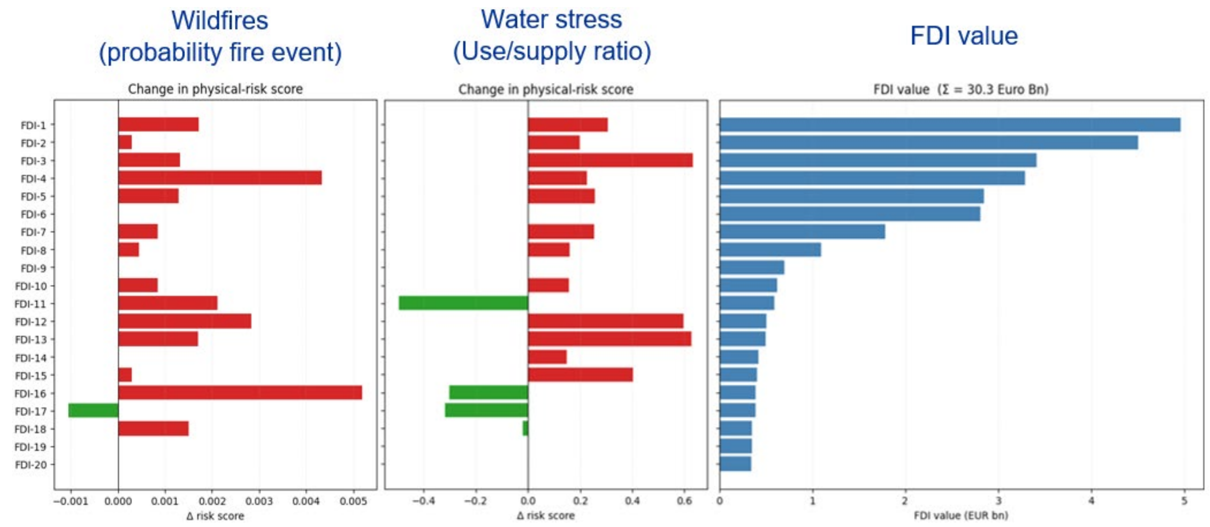
5.2 The importance of domestic subsidiaries and local establishments

The twenty largest foreign investors in our sample account for €30.3 billion, roughly 55 percent of the entire inward FDI equity stock that Italy and France reported at year-end 2022. Because these conglomerates dominate the aggregate position, any mismeasurement of their exposure to climate hazards can contaminate macro-level indicators and the risk assessments used by regulators and policy makers.

A frequent shortcut in the empirical FDI literature is to proxy an enterprise's physical-risk exposure with the hazard score of its legal domicile or head-office location. Our results show that this simplification produces a pronounced downward bias. FDI parent companies are typically located in capital regions or major business centres that enjoy better infrastructure and lower climate vulnerability than the peripheral sites where production takes place. By extending the analysis to the full domestic corporate ownership chain, we reveal a more comprehensive and heightened assessment of climate risk exposure.

Chart 7 illustrates the point for two relevant hazards, based on score variability: (i) wildfires and (ii) water stress risk. For most firms, and particularly for the ten largest investors, the score associated with the domestic corporate ownership chain is markedly higher than the score associated with the DIE only. The implication is two-fold. First, climate risk is systematically under-estimated in conventional FDI datasets that stop at the parent-company address. Second, policy interventions, such as targeted adaptation support, should focus on the geographical footprint of corporate groups rather than on their legal seats.

Change in climate risk scores after including subsidiaries and establishments Chart 7



Sources: authors' own calculation on Italian and French elementary units' dataset and climate scores from STC EG

As a confirmation of this result, we also compare the raw climate risk scores between entities that are establishments and those that are not, finding a statistically significant difference for most indicators. As expected, establishments tend to be exposed to higher climate risks than their parents, given their more diverse geographical distribution. A similar pattern is also observed in another recent study on euro area firms (Rang, 2025).

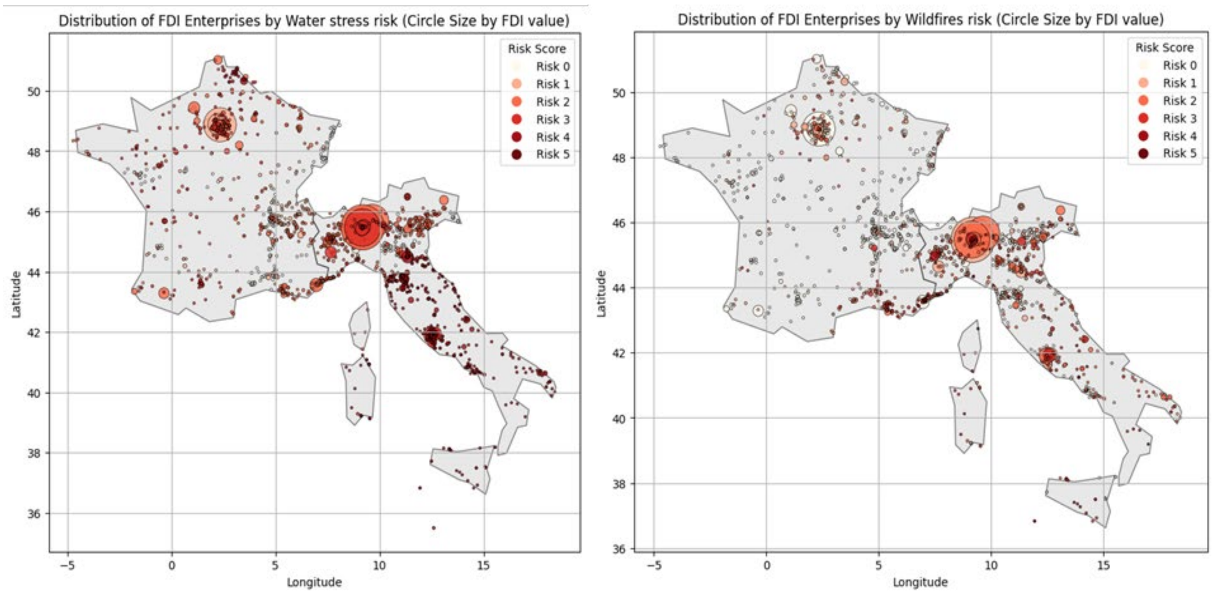
5.3 Geographic distribution of physical risks

Inspecting the geographic distribution of the elementary units in our sample and their risk scores, we observe the localized nature of certain hazards. Acute risks, such as wildfires, are concentrated in specific geographic areas, while chronic risks, such as consecutive dry days, exhibit a broader distribution but with less intensity. Furthermore, large enterprises (in terms of FDI value) tend to be less exposed to risks compared to smaller ones.

Chart 8 shows where high-risk FDI enterprises are located, with bubble size reflecting FDI value and bubble colour reflecting risk class. We observe that regions with higher climate risk exposure often host less FDI value overall. Another point is that firms located in the same area can still record different scores, depending on where their subsidiaries are spread.

Geospatial distribution of FDI and climate risk scores

Chart 8



Sources: authors' own calculation on Italian and French elementary units' dataset and climate scores from STC EG

5.4 Distribution of physical risk across sectors of economic activity (NACE)

Our analysis also uncovers differences in the climate risk exposure of economic activities. Certain industries, such as manufacturing and agriculture, are disproportionately exposed to specific types of physical risks due to their geographic concentration and reliance on climate-sensitive resources. By aggregating risk scores at the level of DIEs and further consolidating these scores by activity, we can inspect which economic activities are more exposed to specific type of risks.

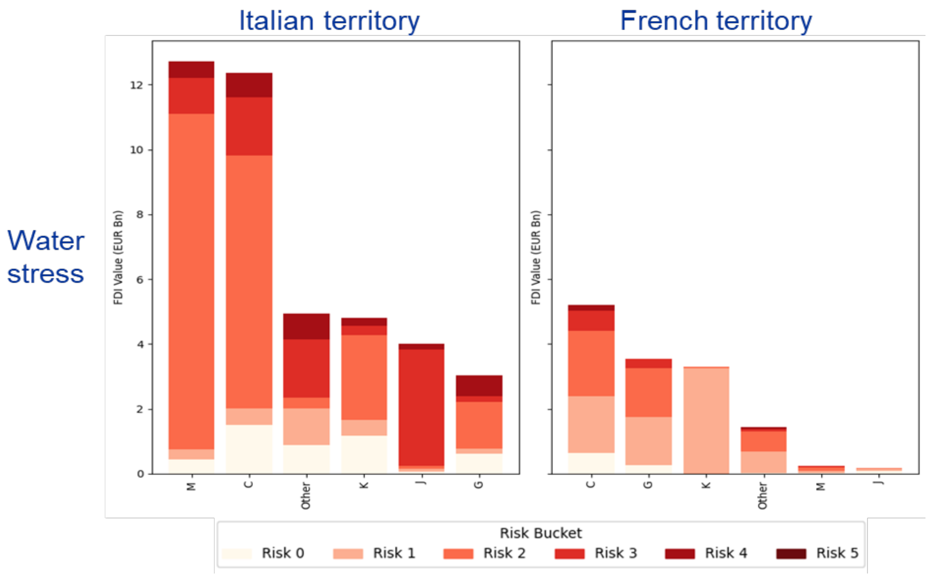
FDI is mostly concentrated in a few key activities: Professional, scientific and technical activities (M), Manufacturing (C), Financial holdings (K)[13] and wholesale (G) (Chart 9). These activities are also

[13] Since the financial sector was originally excluded from this analysis, this group should be interpreted as a 'miscellaneous' sector, as it is made up by holdings whose domestic chains are not related with financial services.

associated with lower physical risk scores on average, reflecting the fact that they are made up by a few large FDI firms.

FDI and climate risk distribution across NACE activities

Chart 9



Sources: authors' own calculation on Italian and French elementary units' dataset and climate scores from STC EG

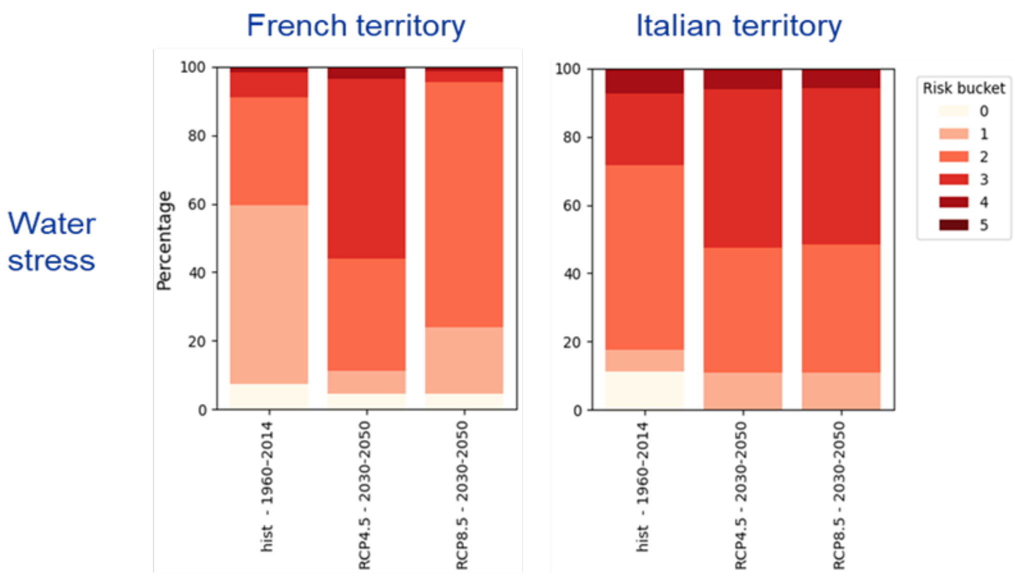
Disregarding the FDI absolute value, the NACE activities most exposed to climate risks show a clear territorial variation. For example, French FDI in Italy exhibits significantly greater historical wildfire risk exposure across sectors like Agriculture, Mining, and Transportation compared to Italian FDI in France within those same activities (see Appendix, Chart 2).

5.5 Risk evolution under RCP 4.5 and RCP 8.5

To evaluate the potential evolution of risks and its impact on FDI under different climate scenarios, the analysis incorporates projections based on the IPCC's Representative Concentration Pathways (RCP4.5 and RCP8.5). These scenarios imply an increase in risk exposure under moderate and high-emission pathways.

Water stress risk evolution under RCP 4.5 and RCP 8.5

Chart 10



Sources: authors' own calculation on Italian and French elementary units' dataset and climate scores from STC EG

As an example, Chart 10 shows the projected evolution of the exposure to water stress under the two scenarios. For French FDI in Italy, the results indicate an increasing exposure to this risk, following a similar trajectory under both the moderate- and high-emission pathways. In contrast, for Italian FDI in France, the exposure is higher under the moderate-emission scenario than under the high-emission scenario. This outcome aligns with the findings reported in the climate physical risk data developed by the Statistics Committee Expert Group on Climate Change and Statistics (STC EG), in collaboration with the Working Group on Securities Statistics (WGSS)[14].

6. Main challenges and future prospects

While this study provides valuable insights into the exposure of bilateral FDI to physical climate risks, several limitations and sensitivities must be acknowledged. One primary challenge stems from **data gaps**, particularly in climate score calculations, geolocation accuracy, or the availability of fixed assets and precise employment data at the establishment level. These gaps introduce uncertainties in the aggregation of risk metrics, potentially leading to overgeneralizations or underestimations in specific regions or sectors. Furthermore, the comparability of risk metrics across hazard types, economic activities, and geographies requires careful interpretation, as the climate scores do not accurately depict the FDI expected losses in the case of adverse climate events.

An additional limitation is that an integrated view of the climate risk exposure of FDI requires considering also the **banking and insurance sectors**, which are exposed to risks through a different channel: not through their geographical location but through the composition of their balance sheet

[14] See SPS https://www.ecb.europa.eu/pub/pdf/scpsps/ecb.sps48~e3fd21dd5a.en.pdf

assets. Similarly, FDI includes real estate, which is also subject to physical risks but has been excluded from this analysis due to both its modest share on total FDI and to the lack of information on its geographical location.

Another relevant caveat for our analysis is that it does not account for risk mitigation measures. For instance, a firm located in a high-risk area may be hedged or insured, making it less exposed than a non-insured firm in a medium-risk region. Moreover, hazard maps often account for physical mitigation measures only with a significant lag. This is particularly relevant for risks such as flooding or wildfires, where prevention actions (embankments, levees, firebreaks), albeit expensive, can be very effective in reducing risk exposure.

A minor limitation, which is nonetheless worth mentioning, involves the temporal misalignment between the snapshot of FDI values (captured at the end of 2022) and the historical or projected climate indicators used in the analysis. This mismatch may distort the relationship between FDI exposure and climate risks. A more rigorous approach would involve linking FDI values to climate risk data from corresponding time periods, ensuring a temporally consistent representation of FDI exposure and associated risk distributions.

The findings highlight the challenge of creating aggregate hazard scores that can serve as the best Expected Loss Assessment (ELA) for all hazards. Such scores could then be used to calculate expected losses from FDI assets due to physical hazards. This requires further development of robust and comprehensive climate indicators.

Another area worth exploring is differentiating between immediate and ultimate perspectives in FDI climate risk analysis. Immediate perspectives focus on the direct exposures of FDI enterprises, while ultimate perspectives consider the broader economic and operational linkages between FDI investors and their enterprises. Future research could also calculate the "FDI climate distance" measuring the gap in climate risk exposure between FDI investors and their enterprises. This metric could provide insights into the alignment (or misalignment) of climate resilience strategies across value chains.

Finally, future extensions of this work could explore integrating transition risks, such as firm-level carbon emissions, to complement the analysis of physical climate risks.

7 Concluding remarks

This study presents a rigorous framework for assessing the vulnerability of FDI to physical climate risks, leveraging firm-level locational data and granular geospatial climate hazard indicators. By examining bilateral FDI positions between France and Italy, it demonstrates the feasibility of linking FDI statistics to climate risk data, addressing critical gaps in the literature and advancing our understanding of climate-related vulnerabilities in FDI. The findings underscore significant disparities in exposure to acute risks, such as geographically concentrated wildfires, and chronic risks, like more broadly distributed water stress.

Methodologically, the structured aggregation approach ensures that the resulting metrics are both granular and economically relevant, enabling more robust and replicable assessments of FDI exposure to climate risks. At the same time, the analysis highlights key limitations, particularly related to data availability for detailed physical risk score calculations, which, if addressed, could further enhance the reliability and depth of these findings.

By bridging the intersection of FDI statistics and climate risk assessment, this study lays the foundation for a more detailed and statistically robust understanding of how climate change influences international investment patterns. It also demonstrates the feasibility of calculating FDI climate risk statistics, particularly for inward FDI and outlines an empirical methodology for doing it. Future research should focus on expanding these datasets with additional transitional risk scores, improved geolocation accuracy, and dynamic risk metrics over time to allow a further refinement of these statistics. These advancements will equip both policymakers and researchers with the information and the analytical insights needed to address the challenges at the nexus of international economics and climate change.

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Appendix

Appendix Table 1 – Physical climate risks and their groupings

Hazard	Short description	Score scale groupings
Coastal flooding	Risk based on water level rise (meters) due to extreme events intensities (per return period). Climate scenarios: 1971-2000 (baseline), 2021-2050, 2071-2100 under RCP 4.5 and RCP 8.5. Return period: 10, 30, 100, 300,1000 years.	Based on expected annual loss (EAL)[15]: *Low risk* (scores 0-1): EAL<20% of maximum EAL *Medium risk* (scores 2-3): 20%<EAL<60% of maximum EAL *High risk* (scores 4-5): EAL>60% of maximum EAL
River flooding	Risk based on water level rise (m) due to extreme events intensities (per return period). Climate scenarios: 1971-2000 (baseline), 2021-2050 under RCP 4.5 and RCP 8.5. Return period: 10, 30, 100, 300,1000 years.	Based on expected annual loss (EAL)**Error! Bookmark not defined.**: *Low risk* (scores 0-1): EAL<20% of maximum EAL *Medium risk* (scores 2-3): 20%<EAL<60% of maximum EAL *High risk* (scores 4-5): EAL>60% of maximum EAL
Windstorms	Risk based on wind gust speed (meters/second) due to extreme events intensities (per return period). Climate scenarios: 1979-2020 (baseline). Return period: 10, 50,100, 500 years	Based on expected annual loss (EAL)**Error! Bookmark not defined.**: *Low risk* (scores 0-1): EAL<20% of maximum EAL *Medium risk* (scores 2-3): 20%<EAL<60% of maximum EAL *High risk* (scores 4-5): EAL>60% of maximum EAL
Landslides	Risk based on terrain characteristics and daily maximum precipitation (score 1-5). Return period: 10, 50, 100, 500 years.	Based on expected annual loss (EAL)**Error! Bookmark not defined.**: *Low risk* (scores 0-1): EAL<20% of maximum EAL

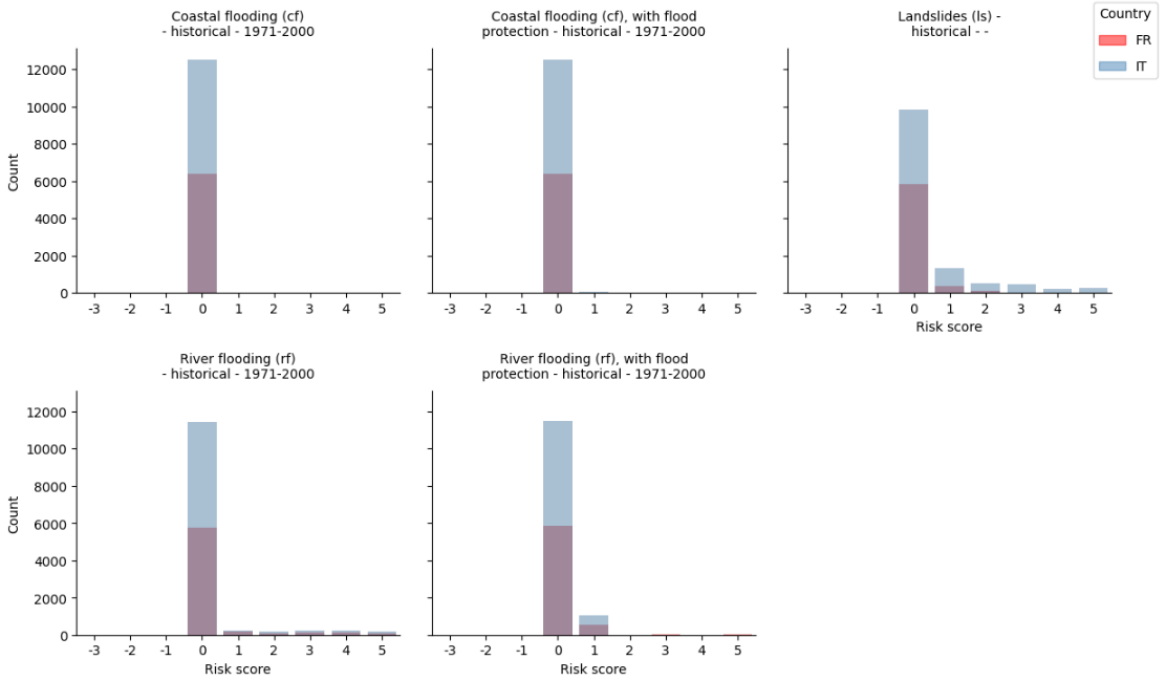
15 As computed in SPS Annex 6.4 https://www.ecb.europa.eu/pub/pdf/scpsps/ecb.sps48~e3fd21dd5a.en.pdf

		Medium risk (scores 2-3): 20%<EAL<60% of maximum EAL *High risk* (scores 4-5): EAL>60% of maximum EAL
Subsidence	Risk based on soils' clay content.	*No risk*: Coarse soil texture (clay < 18% and sand > 65%) *Low risk*: Medium (18% < clay < 35% and sand >= 15%, or clay > 18% and 15% < sand < 65%) *Medium risk*: Medium fine (clay > 35% and sand < 15%) *High risk*: Fine (35% < clay < 60%) and very fine (clay > 60%)
Wildfires	Risk based on the probability of a fire event using Fire Weather Index, land cover, and burned areas. Climate scenarios: 2001-2022 (baseline), 2023-2050 under RCP 4.5 and RCP 8.5.	*No risk*: <0.001 (frequency less than every 1,000 years) *Low*: 0.001-0.002 (between 500 and 1,000 years) *Medium*: 0.002-0.004, 0.004-0.01 (between 500 and 100 years) *High*: 0.01-0.02, >0.02 (more frequent than every 50 years)
Water stress	Risk based on the ratio of water demand and water supply. Climate scenarios: 1960-2014 (baseline), 2030-2050 under RCP 4.5 (SSP2) and RCP 8.5 (SSP3).	*No risk*: Arid and low water use, ratio of water demand to water supply <10% *Low*: 10-20% *Medium*: 20-40%, 40-80% *High*: >80%
Consecutive dry days	Risk based on the maximum number of consecutive dry days (precipitation < 1mm/day). Climate scenarios: 1986-2005 (baseline), 2021-2040, 2041-2060 under RCP 4.5 and RCP 8.5.	*No risk*: < 15 days *Low*: 15-20 *Medium*: 20-30, 30-40 *High*: 40-50, >50 days
Standardized Precipitation Index (SPI)	Risk based on cumulative precipitation for 6 months compared to long-term precipitation distribution. Climate scenarios: 1986-2005 (baseline), 2021-2040, 2041-2060 under RCP 4.5 and RCP 8.5.	*No risk*: -1 to 1 *Low*: (-1.5 to -1), (1 to 1.5) *Medium*: (-2 to -1.5), (1.5 to 2) *High*: <-2 (extremely dry), > 2 (extremely wet)

Notes: RCP stands for Representative Concentration Pathways. RCP 4.5. corresponds to radiative forcing of 4.5 W/m^2 by the end of the century and is considered a moderate scenario. RCP 8.5 assumes a high GHG emissions scenario, leading to radiative forcing of 8.5 W/m^2 by 2100, and is considered a worst-case scenario.

Number of entities in each risk bucket in French and Italian territories

Appendix Chart 1

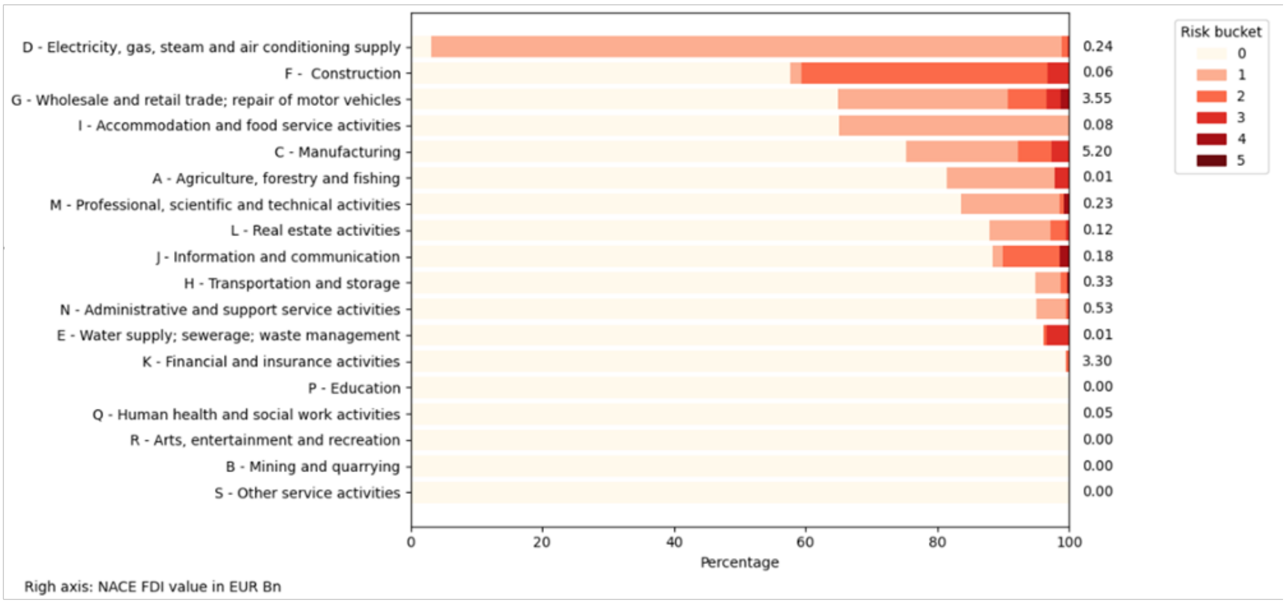


Sources: authors' own calculation on Italian and French elementary units' dataset

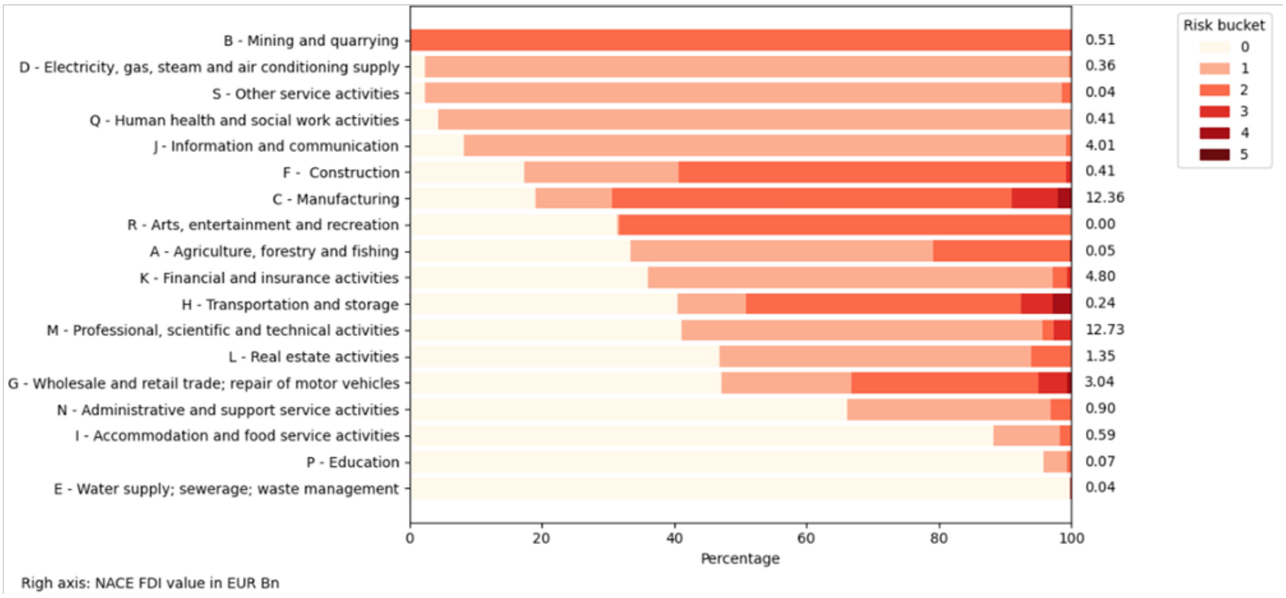
Wildfires risk distribution across NACE activities

Appendix Chart 2

French territory



Italian territory



Sources: authors' own calculation on Italian and French elementary units’ dataset and climate scores from STC EG

BANQUE DE FRANCE
EUROSYSTÈME

BANCA D'ITALIA
EUROSISTEMA

EUROPEAN CENTRAL BANK
EUROSYSTEM

An experiment to measure physical climate risks in FDI between France and Italy

Mapping FDI vulnerability to physical climate change risks

04/10/2025

Chiara Torri, Daniele Di Pietro, Francois Robin, Giacomo Oddo, Jorge Diz Dias, Nadia Accoto, Rocco Incardona, Veronique Genre

Motivation

Climate change impact

- Increasing exposure to extreme weather events (floods, heatwaves, wildfires) causing significant economic losses (€162 billion in EU between 2021-2023).

FDI relevance

- Foreign Direct Investment (FDI) is a key driver of globalization, involving long-term investment commitments. Physical climate risks threaten the long-term viability of FDI. Implementing active climate-resilient strategies help mitigate risks.

Data gaps

- G20 Data Gaps initiative emphasizes need to improving measurement of climate change statistics (physical and transition risks, green house gas emissions).

Research gap

- Limited empirical literature on the role of physical climate risks in shaping FDI patterns.

Main objective

- Develop statistical methodological framework, with case study to test it

Our contribution

Main innovations

- **First firm-level framework to map FDI exposure to physical climate risks** (floods, wildfires, heat) using geospatial hazard data.
- **Addresses FDI domestic ownership chain complexity** in host country: considering affiliates and establishments
- **Links FDI firms' geo location with high-resolution climate risk maps** with risk assessments (historical projections contrasted with future climate scenarios).
- **Cross-sectional analysis**: economic activities (e.g. agriculture, manufacturing, mining) and regional climate disparities (e.g., French mediterranean wildfires vs. Italian northern floods) regarding FDI.

Policy-relevant insights

- Identifies more climate vulnerable economic activities/regions, guiding climate-resilient FDI strategies.
- Supports information on targeted policy interventions (e.g., adaptation investments).

Why this matters for statistical community

- Develop extensible statistical framework: showcase the feasibility to develop relevant FDI climate change indicators applicable to EU countries
- Actionable evidence: Moves beyond theoretical frameworks to empirical, data-driven insights.

Methodology (1)

Objective: measuring the exposure of bilateral FDI positions between FR and IT to physical climate risks.

Scope: Financial corporations excluded, except financial holding companies and head offices

- Indirect “balance sheet” exposure vs direct physical exposure
- Real estate is also excluded, due to data constraints (geolocation).

Focus: equity component of FDI

Structure: three phases:

- (1) decomposition of FDI enterprises into elementary units;
- (2) risk assessment of elementary units, based on geolocation;
- (3) aggregation of risk score at FDI level.

Methodology (2)

Phase 1: Top-down decomposition of inward bilateral FDI into elementary units

Identification of Direct Investment Enterprises (DIEs, >10% voting power), based on national business register (NBR).

→

Identification of their domestic ownership chains, based on National Business Registers, considering only the *controlled* affiliates (>=50% voting power)

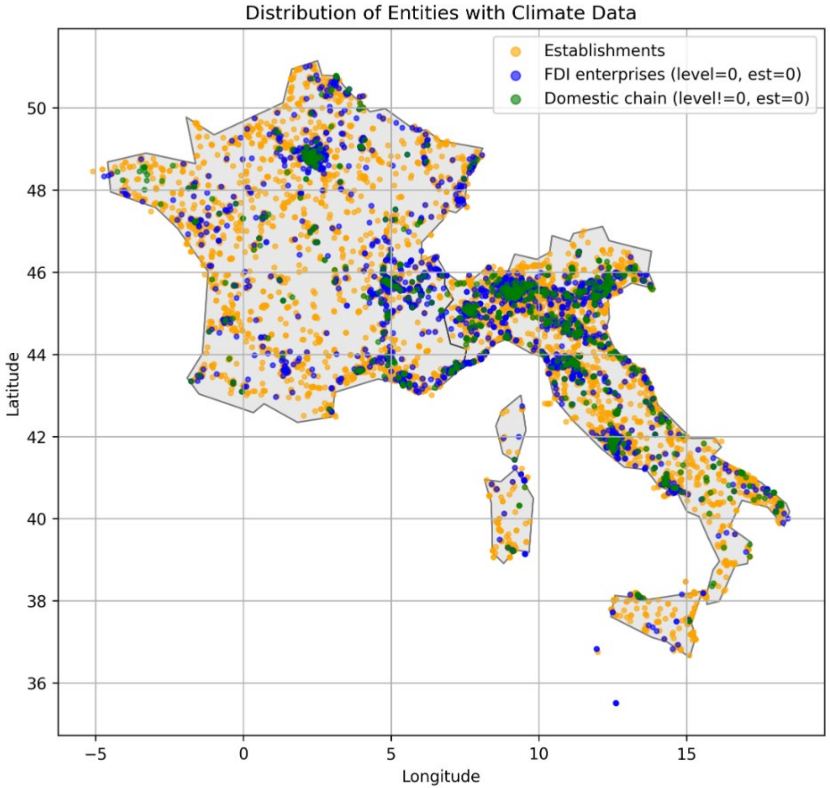
- Justification: physical risk exposure of the firm's value chain → vertical integration

→

For each DIE, subsidiaries and related establishments, we collect address (location) and employees

Phase 1 output: **list of elementary units** (DIE + subsidiaries + establishments), including their addresses and number of employees

Distribution of entities in the dataset



Country	French territory	Italian territory
Nr of DIE	1,545	2,413
Employees (total)	324,528	332,274
Bilateral FDI value (EUR mln)	13,811	41,521
% of total bilateral FDI (end 2022)	52%	55%

- DIEs and domestic chain units tend to cluster in big cities
- Establishments are more equally spread across the territories

Methodology (3)

Phase 2: assign climate risk scores to each elementary unit identified in phase 1.

Geocoding

For each elementary unit, use the address and OpenStreetMap to obtain latitude and longitude coordinates

Mapping each location with risk scores

Leverage the innovative dataset developed by the ESCB STC Expert Group on Climate Change, which enriched ECB's RIAD (Register of Institutions and Affiliates Dataset) with physical hazard data from Copernicus, EC Risk Data Hub, Delft University of Technology, IPCC, Aqueduct WRI.

RIAD+ allows to assign scores in various risk dimensions (wildfires, water stress…) to our set of firms in two ways:

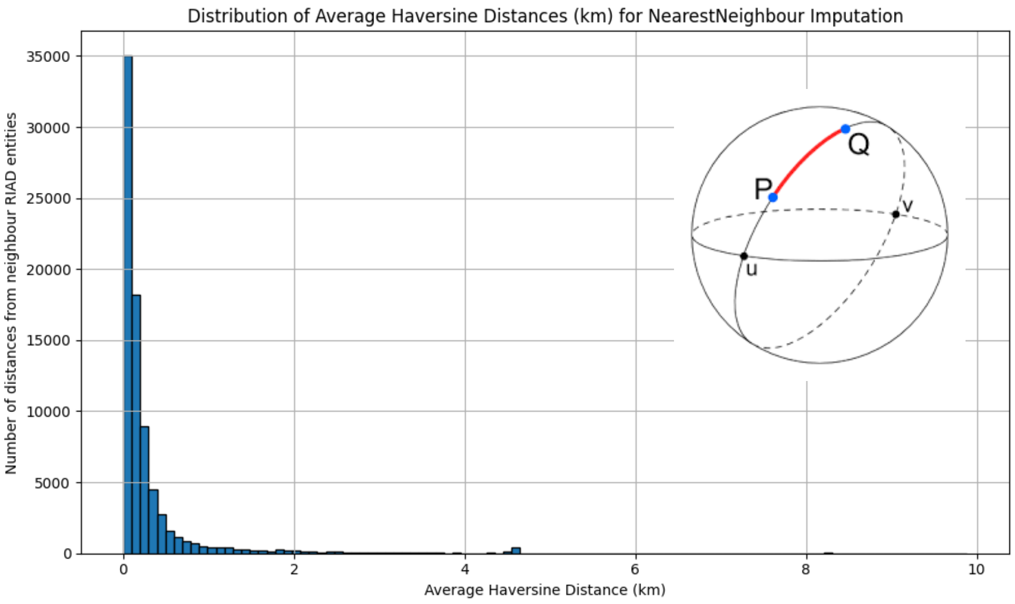
- *Directly*: If the elementary unit is included in RIAD+, its risk scores are directly retrieved (~ 20% of entities are covered)
- *Indirectly*: if the unit is not included, its risk scores are assigned through **spatial interpolation**, using 5 nearest neighbors in RIAD+

ECB SPS: Climate change-related statistical indicators

Methodology (4)

Spatial interpolation for missing risk scores:

- We compute haversine distance of potential neighbors. Through Ball Tree algorithm we select the nearest 5 and take their **median** score
- Justification: strong spatial autocorrelation of climate hazards and high density of RIAD+:
- Average haversine distance of nearest neighbors is very small. In 95% of cases is less than 1 km.



Phase 2 output: **Risk scores computed at the elementary unit level**, remapped to their original scales (probabilities, expected annual losses, etc.) to enable Phase 3 calculations.

Methodology (5)

Phase 3: aggregation of elementary units' risk scores into FDI positions.
Bottom-up, hierarchical consolidation of risk scores

Elementary unit → DIE:

- DIE's score is the weighted average of risk scores of establishments and affiliates, weighted by the relative number of employees

DIE → Economic activity (NACE)

- Industry score is the weighted average of its DIEs, weighted by their relative equity

NACE → FDI inward position

- Combine NACE risk indicators into overall FDI exposure weighting each sector by its share of total FDI equity

Phase 3 output: Climate physical risk scores of FDI positions, with scores reassigned to their original ordinal values and detailed breakdowns.

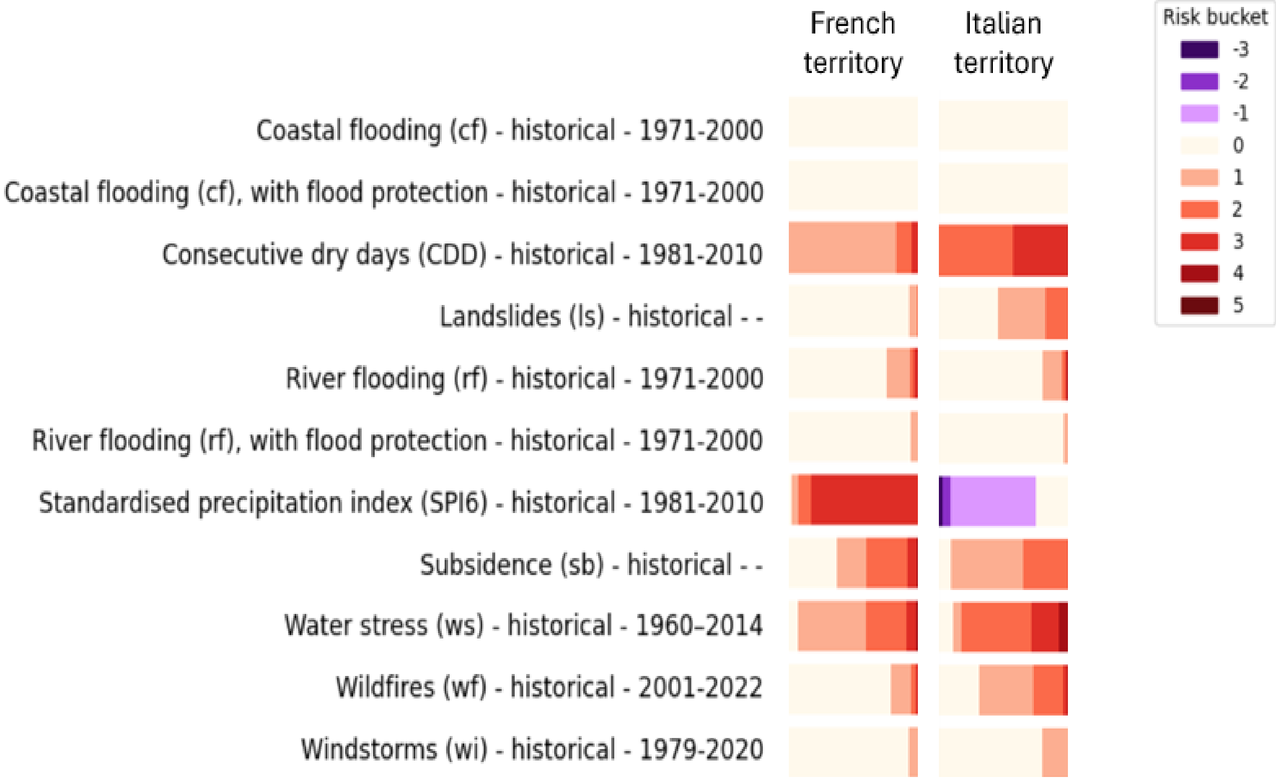
Results: Exposure of bilateral FDI to climate risk dimensions

- Several climate scores have been computed both for historical and Representative Concentration Pathways (RCP) 4.5 and 8.5 scenarios

- Scores typically range: **0 (low risk) to 5 (high risk),** except for Standardized precipitation index

- Bilateral FDI investments in France and Italy are exposed to different type of risks

- e.g. **French FDI in Italy is exposed to higher risk of drought** (negative SPI6 and higher nr of consecutive dry days)



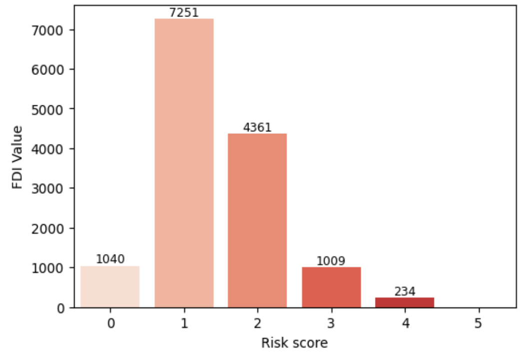
Results: FDI distribution by buckets of risks

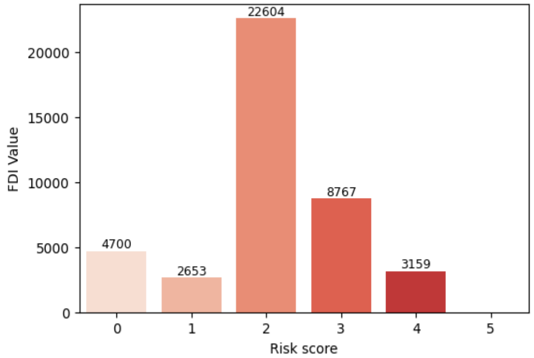
- FDI bilateral stocks allocated to different **buckets of risks**
- Some hazards affect very few enterprises
- **Scores with widest distribution across risk categories**: water stress, wildfires, consecutive dry days, subsidence, SPI

French territory

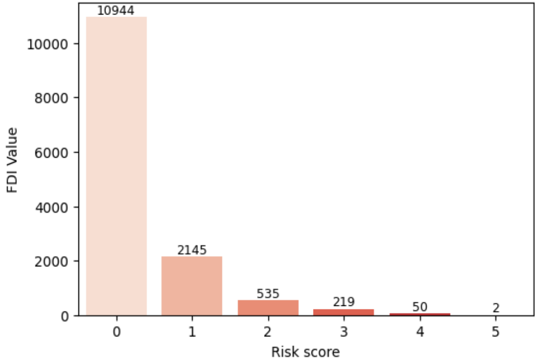
Italian territory

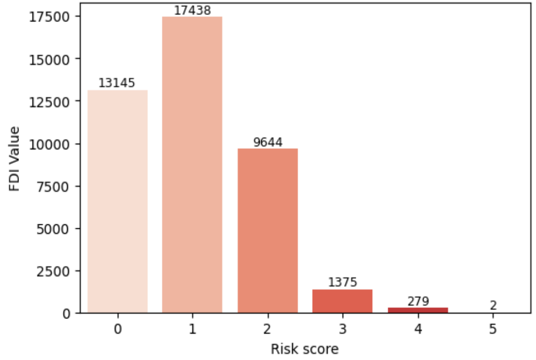
Water stress





Wildfires





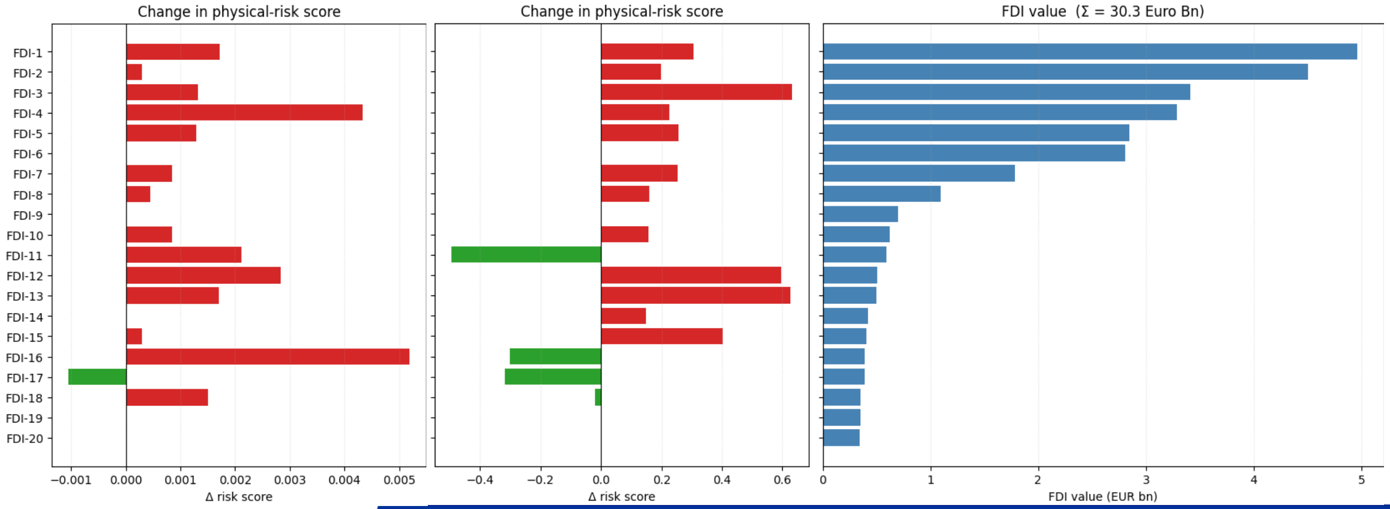
Results: The impact of subsidiaries and establishments

- Including subsidiaries and establishments **increases,** on average, the risk scores of the top 20 FDI enterprises (by FDI value)
- The top 20 FDI enterprises account for 55% of the total FDI value in the dataset (end-2022)

Wildfires
(probability fire event)

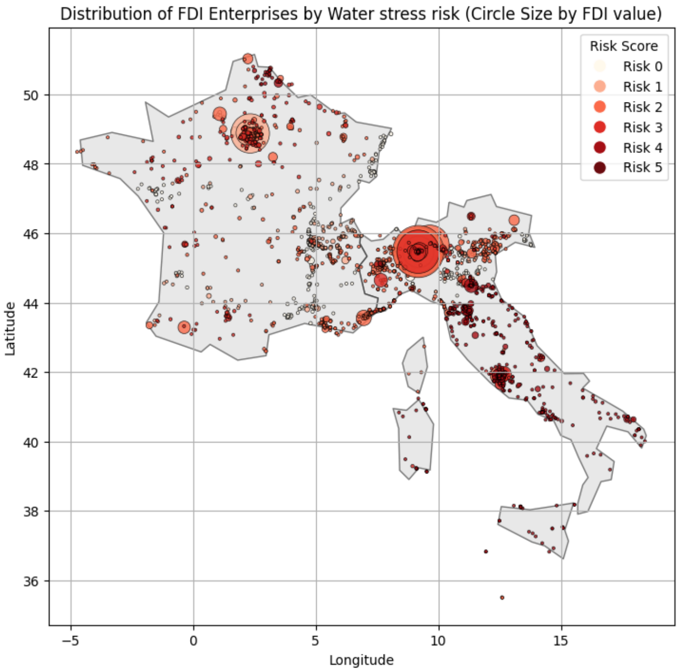
Water stress
(Use/supply ratio)

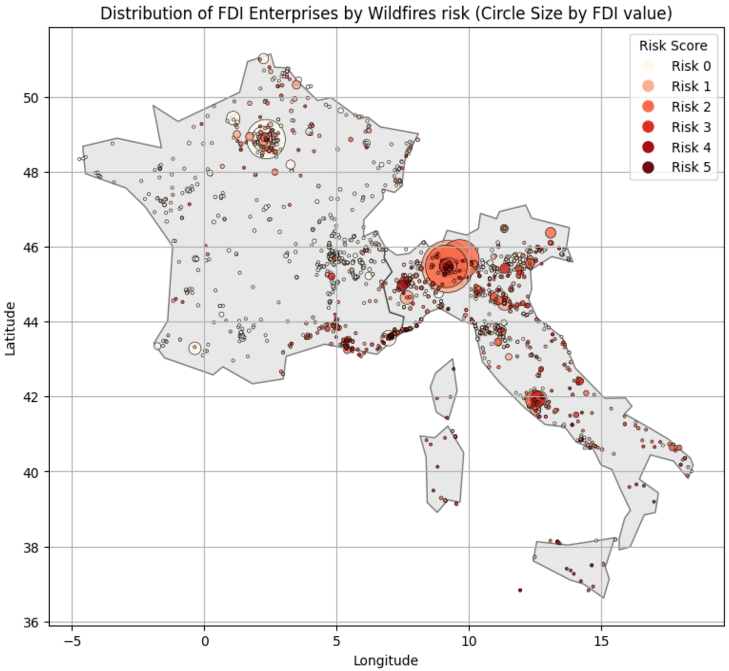
FDI value



Results: Geographic distribution of risks

- In this dataset, regions where DIEs are exposed to higher risks tend to have lower FDI investments
- FDI enterprises located in the same area might have different risk scores due to the different distribution of subsidiaries or establishments





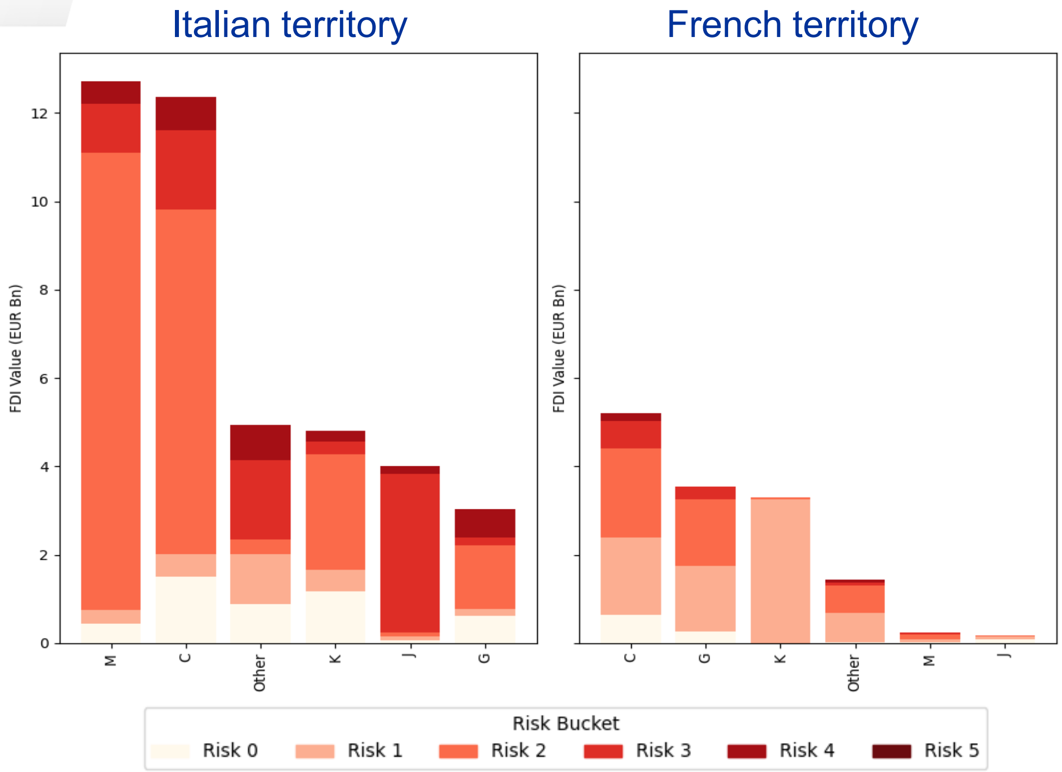
Results: Risk distribution across NACE activities

- NACE activities like agriculture or mining are highly exposed to water risk but account for a relatively small share of total FDI.

- The **most relevant activities** in terms of FDI and risk exposures are Manufacturing (**C**), Professional, scientific and technical activities (**M**), Wholesale and retail trade (**G**) and Information and communication (**J**).

- Financial and insurance activities (K) include financial holding companies and head offices.

Water stress

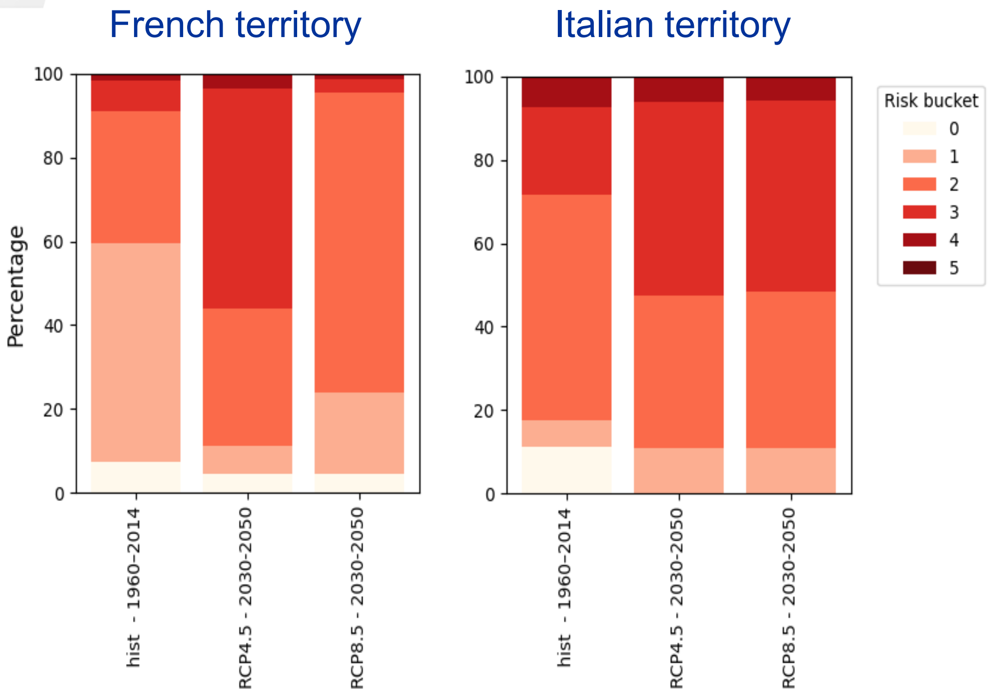


Results: Risk evolution under RCP 4.5 and RCP 8.5

- For French FDI in Italy, the results show increasing exposure to water stress on both RCP 4.5 and 8.5 pathways.

- In contrast, for Italian FDI in France, the exposure is higher under the moderate-emission scenario than under the high-emission scenario.

Water stress



Conclusions and next steps

Key takeaways

- **Innovative methodological framework**: First firm-level methodology quantifying FDI exposure to physical climate risks (floods, wildfires, water stress) using geospatial hazard data.
- **Considering the domestic chain and establishments** is critical for accurate climate physical risk assessment.
- Applied to France–Italy bilateral FDI: reveals geographic concentration of acute risks (e.g. wildfires) and broader distribution of chronic risks (e.g. water stress).
- **Economic activity heterogeneity**: Some NACE activities like agriculture or mining are highly exposed to physical risk but account for a relatively small share of total FDI.
- **Policy Implications**: High-risk regions and specific industries require targeted adaptation strategies to protect FDI stocks. Investors must account for climate risks in long-term strategy, prioritizing resilience in vulnerable activities/locations.

Limitations and challenges

- Data gaps in geolocation accuracy, firm-level asset/employment data, and effects of erratic and stochastic climate events remains challenging to address.
- Indirect exposure of FDI in financial sector (banking and insurance).
- Local hazards maps for acute risks are usually delayed with respect to updates of the global climate models.

Future directions

- Pursue climate experts to develop expected annual losses for physical hazard risks and link it with FDI for composite physical risk statistics expressed in probability monetary losses.
- Directly link the location of FDI elementary units and detailed physical hazard maps (by-passing the use of RIAD).
- Explore "FDI climate distance" to assess misalignment of resilience strategies between direct investors and direct investment enterprises.
- Perform the analysis for several years (timeseries perspective).

Thank you!

Appendix

Literature review

Theoretical FDI frameworks

- International risk theory (Buckley et al., 2016)
- Dunning’s ownership, location and internalization (OLI paradigm) (Shear et al., 2023)

Empirical evidence

- Negative impact of physical climate risks on FDI inflows (Gu and Hale, 2023; Jihad Ait Soussane et al., 2022)
- "Climate risk distance" (Xing et al., 2022): home vs. host risk matters with FDI flows higher when home country has greater climate risk
- Economic activity heterogeneity: Agriculture, forestry, fishing, mining, construction and manufacturing most vulnerable
- Geographical disparities: Higher risks in Caribbean, Middle East, Southeast Asia (Li et al. 2022) and in other developing countries

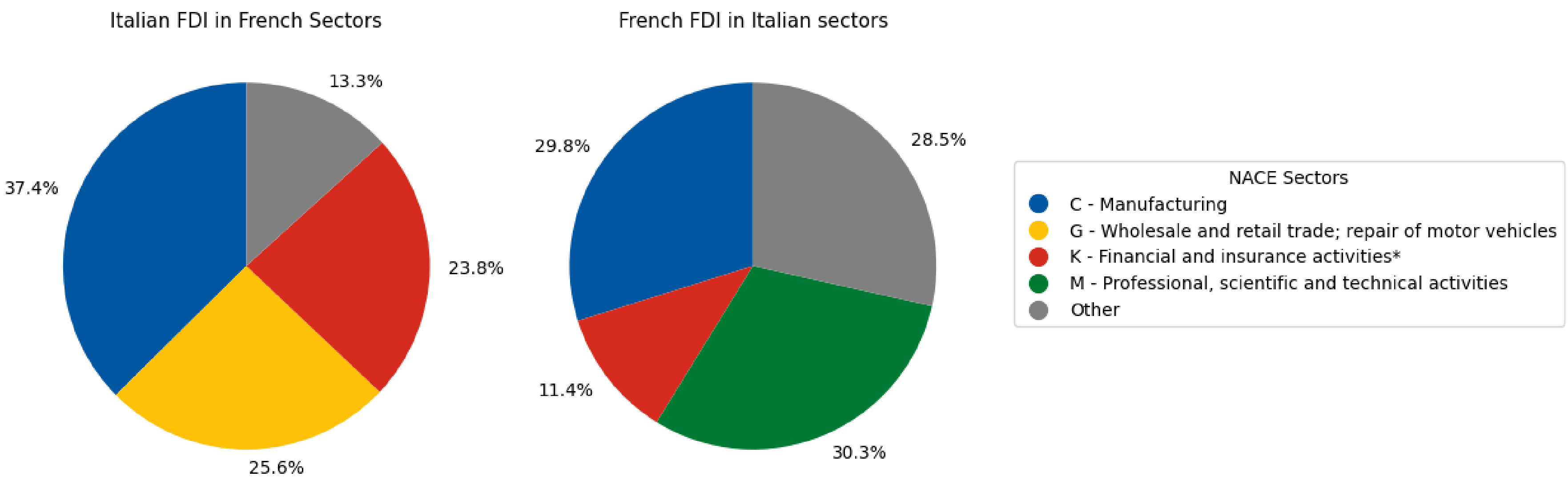
Methodological approaches

- Panel econometric models
- Limited firm-level analyses
- Integration of geospatial climate risk data with facility-level information

Research gaps

- Limited firm-level measurement between FDI and physical climate risks at geographical and economic activity levels

Results: Descriptive statistics on FDI



Results: Clustering

- Wildfire risk seems to affect similarly small and large FDI enterprises (localized risk)
- Water stress is affecting smaller FDI enterprises proportionally more than larger ones