Location of physical assets – addressing one of the main data gaps in assessment of climate-related risks

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Abstract

The identification of the exact location of non-financial companies (NFCs) as well as their physical assets is one of the main challenges for the accurate assessment of the exposure to physical risk such as floods, wildfires, or draughts.

National data sources on business statistics might contribute to addressing this data gap, in particular data collected on enterprise and their local units under the European business statistics (EBS) framework looks very promising. Apart from the address, it also offers information on the economic activity and number of employees of each local unit, and in selected countries additional variables such as revenues and total assets. Those attributes can be used to estimate the value of physical assets at different locations – a key element for the assessment of potential losses caused by natural catastrophe.

To assess the data availability the ESCB Statistics Committee Expert Group on Climate and Statistics (STC EG CCS) launched a fact-finding exercise via the Committee on Monetary, Financial and Balance of Payments Statistics (CMFB) among national statistical institutes (NSIs) and national central banks (NCBs).

First, the paper summarises the findings from the exercise elaborating on the key elements: available information, collection modes, potential data quality issues and access modalities across European countries. The initial analysis is re-assuring: overall, the business population seems well covered in most countries. Importantly, enterprises and local units can be identified by standard company identifiers for most of the euro area countries which enables linking information with the ESCB's datasets on financial exposures such as loans, debt securities and equity.

Second, we illustrate the usability of the dataset on the example of French datasets. We quantify the potential mismeasurement of physical risk based solely on the registered address of a company versus assessment based on multiple locations of a company.

Finally, the paper proposes an avenue for expanding the analysis to other countries to better capture the climate-related physical risk in financial and economic studies.

Keywords: *climate physical risk, physical assets' location, local units.*

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1 Introduction

The assessment of physical risks has seen significant advancements, driven by improvements in climate modelling and the increased availability of geospatial data, enabling identification of climate-related risk at precise locations. These advancements are instrumental in identifying potential vulnerabilities and their impact on the economy and financial system, providing insights that can guide strategic planning and risk mitigation efforts.

One important element in such analyses is a better understanding of environmental impacts on businesses and their operations. However, a fundamental gap remains in assessing a company's physical risk because the typical approach relies primarily on the location of a company's registered address, neglecting the broader exposure of key physical assets like plants, distribution centres, and warehouses, which might be situated in hazard-prone locations.

The primary obstacle remains the lack of suitable data. Available sources typically have limited coverage, often confined to specific types of entities, and provide minimal information at the plant level. One notable source is the GeoAsset project by the Spatial Finance Initiative[4], which utilises satellite imagery to identify the locations of emission-intensive plants such as cement, iron, and steel production facilities worldwide. The database includes information on ownership, production processes, and capacity. Although the project is expanding to include other sectors such as waste management, petrochemicals, and paper and pulp, the coverage for these newly added sectors is limited and currently available only for some continents.

In Europe, the availability of data is often better. The European Pollutant Release and Transfer Register (E-PRTR[5]) contains data reported annually by approximately 35,000 individual industrial facilities, covering the largest polluters in the EU. While the reporting focuses on key pollutants such as heavy metals, pesticides, and greenhouse gases, it importantly also provides location information of the facilities. However, it lacks other important details, such as the value of assets or the number of employees.

Datasets offered by private data vendors often suffer from the same limitations, largely because they heavily rely on public sources, complemented by modelling. Unfortunately, the

[4] See https://www.cgfi.ac.uk/spatial-finance-initiative/geoasset-project/geoasset-databases/

[5] See: E-PRTR and the European Industrial Emissions Portal.

methodologies applied by these vendors are not fully transparent, which hampers the interpretation of the data.

Prior studies assessing the euro area's financial sector exposures to physical risks via their non-financial company (NFC) portfolios have primarily relied on the location of the companies' registered addresses. A joint report on climate-related risk and financial stability by the European Central Bank and the European Systemic Risk Board (ECB/ESRB, 2021) highlights a significant data gap: the lack of geo-locational information on facilities and supply chains (refer to its Data Supplement for more details). The most recent report from this group (ECB/ESRB, 2023) provides insights into the amplification of physical risks through supply chain networks. It presents an analysis based on firm-level and macro-level evaluations of cross-country linkages using an input-output model at the sector level.

Another relevant study by Bressan et al. (2023) quantifies the magnitude of the misestimation of losses when using the headquarters' location as a proxy for the location of all productive assets of a company. The methodology is illustrated through an application to Mexico, a country highly exposed to physical risks, covering a sample of 177 listed firms owning 1,820 physical assets. The assessment is conducted for hurricanes and chronic risks under different climate scenarios. The study demonstrates that neglecting asset-level information can lead to significant errors in firms' valuation and respective investor equity portfolio losses. More broadly, such underestimation can result in insufficient investment in resilience-building measures, leaving assets vulnerable to climate impacts.

The important caveat of lacking information on key physical assets of a company is also highlighted in the ESCB publication on Climate change-related statistical indicators (ESCB, 2024), which constitutes a conceptual foundation for our study. This report contributes to enhancing transparency in climate change analysis, by detailing the methodology and application of statistical indicators in three areas: sustainable finance, carbon emissions, and physical risk.

With respect to physical risk, the ESCB indicators are developed based on harmonised public climate datasets for a wide range of hazards. They are developed by integrating firm-level data with climate information and the portfolios of their creditors. In the first step, the impact of natural hazards on firms' financial health is evaluated, specifically their ability to service debt. This information is then connected to the portfolios of euro area financial institutions, providing insights into the exposure to climate risk within the financial system.

In this paper, we expand the ESCB analysis to account for multiple location of companies in the physical risk assessment, utilising a unique French business dataset. The study offers a sample of 250,000 firms with more than one facility, covering approximately 900,000 locations in France. After matching these firms with their financial commitments in the form of loans, equity, and debtor securities, the final sample includes 180,000 multi-facility firms across 700,000 locations. To our knowledge, this is the largest study of its kind.

Although location data is crucial, it is insufficient on its own. For a comprehensive analysis, it is essential to consider the value of key physical assets that are exposed to natural hazards at each location. The financial information, such as total balance sheet and tangible fixed assets, are available only at the company level. However, in our datasets some variables - notably the number of employees and economic activity – are also available for each location. This information is instrumental in distributing the value of physical assets across different locations.

The structure of the paper is outlined as follows: First, we describe the framework of the European Business Statistics (EBS), which forms the basis for the collection of our dataset, with a specific focus on the data pertaining to France. The next section presents various methods for approximating the value of physical assets across different company's locations. Subsequently, we examine the potential inaccuracies in measuring climate risks by applying the ESCB's statistical climate indicators methodology, using two specific hazards as examples: Consecutive Dry Days (CDD), which measures drought conditions, and river flooding. The paper concludes by summarising our findings and outlining avenues for future research.

2 Data on local units in Europe

2.1 Overview of the European Business Statistics (EBS) in the EU countries

The European Business Statistics (EBS) provide information on businesses operating in the EU's industry, trade, and service sectors. They cover, among others, the structure, economic activities and performance of businesses as well as comprise statistics on essential statistical infrastructure such as national statistical business registers. According to Regulation (EU) No 2152/2019[6] concerning EBS, national statistical authorities are required to produce business statistics as well as set up their national statistical business registers, to collect information of their respective

[6] Regulation (EU) 2019/2152 of the European Parliament and of the Council of 27 November 2019 on European business statistics

enterprises and local units[7]. The granular information collected under this legal framework could be of significant relevance for enhancing physical risk analysis.

In this paper, statistical units follow the definitions of the Council Regulation (EEC) No 696/93[8]:

- The *legal unit* always forms, either by itself or sometimes in combination with other legal units, the legal basis for the statistical unit known as the 'enterprise'.
- The *enterprise* is the smallest combination of legal units that is an organizational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit.
- The *local unit* is an enterprise or part thereof (e. g. a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified place. At or from this place economic activity is carried out for which - save for certain exceptions - one or more person's work (even if only part-time) for one and the same enterprise.

While EBS provides a European framework for the collection of business statistics, additional data sources might be available nationally. They may also be suitable to fill the existing data gaps for climate-related analysis[9].

The overall data availability for enterprises as well as key information on local units across the EU looks promising. Importantly, enterprises and local units can be identified by standard company identifiers for most of the countries which enables the linking of information with other firm-level datasets. In the context of the ESCB statistical indicators as well as the analysis conducted in this paper, the information is combined with portfolios of euro area financial institutions - a unique datasets comprising instrument level for loans, debt securities and equity. Table 1 provides an overview of the key elements particularly relevant to fill data gaps on enterprise balance sheet and the geographical location of company activities ('local units'), hence, to improve the assessment of potential losses caused by natural catastrophe.

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7 See Annex VIII of the EBS General implementing act No 1197/2020.

8 See Council Regulation (EEC) No 696/93 of 15 March 1993 on the statistical units for the observation and analysis of the production system in the Community

9 The Statistics Committee Expert Group on Climate and Statistics (STC EG CCS) launched in July 2023 a fact-finding exercise among national statistical institutes (NSIs) and national central banks (NCBs) which are members of the Committee on Monetary, Financial and Balance of Payments Statistics[9] (CMFB) for additional information about potentially available data on enterprise and local unit at national level. The CMFB was identified as the most appropriate recipient to the survey as it is a unique forum of statisticians from the national statistical institutes and the national central banks, leading work on various topics including statistics on sustainable finance and climate related risks https://www.cmfb.org.

Table 1. Overview of data available, collection modes, and access modalities across euro area countries as well as data usability of enterprise and local unit information available at national level.

Key aspect	Assessment for euro area countries
Balance sheet data	Company size information in terms of number of employees are broadly available at enterprise and local unit level - turnover is also available for all euro aera countries at enterprise level. Other accounting data, such as total and fixed assets, value added and value of output, are available for half of the countries at enterprise level, only for few at local unit level.
Location data	Address and postal code information are widely available also at local unit level, otherwise NUTS3 region is available.
Identifier	Identifiers of legal units are available for all euro area countries and will enable linking information with the ESCB's RIAD and consequently financial exposures on loans, debt securities and equity. Identification of local units is also possible for most of the euro area countries.
Business population	The business population registered in the national business register is fully covered in most countries. Also, full coverage in terms of NACE economic activities is observed for most of the countries. Almost all countries have data available for all sectors covered by the European framework for statistical business registers. NACE sectors such as energy, services and manufacturing, particularly relevant, are broadly covered[10].
Time series length	Reference periods starting from 2019 are available for most countries.
Collection methods & data sources	Wide heterogeneity across countries. In most cases data are collected as combination of sample survey and administrative datasets (e.g. tax reporting, companies registration office). In few cases data seem collected via census. For missing data imputation methods are applied in some countries.
Data access	Registers data on legal units are public (in full or partially) in some countries. Moreover, data on enterprises are shareable for statistical purposes in most of the countries. For approximately half of the countries also more granular information at local unit level are accessible for this purpose.

Note: Based on a fact-finding exercise by the Statistics Committee Expert Group on Climate and Statistics (STC EG CCS) via the Committee on Monetary, Financial and Balance of Payments Statistics (CMFB), July 2023.

[10] NACE sections B-S; ESA sector S11.

National data sources on business statistics, therefore, could contribute to addressing pressing data gaps. However, the incorporation of this rich dataset in the climate risk assessment at the euro area and EU level would require considerable efforts to harmonise the data, given high heterogeneity identified across countries with respect to availability of information, their granularity collection methods, and modalities of data access. The quality of the information is largely determined by the data sources and data collection methods used to compile the business statistics, as well as the quality assurance applied by individual countries, additionally to the annual assessment performed by Eurostat for aggregated statistics. Although for the majority of the euro area countries the primary sources are administrative data (e.g. tax and social security records), in several cases this information is complemented with sample survey-based data collection, and imputation methods might be applied to missing data.

3 Overview of French dataset with firm-level and local units' information

3.1 Overview of the datasets and key variables

In this paper, we illustrate the usability of EBS data using French datasets as a case study. France serves as a robust example given that is one of the largest countries in the EU, with firm-level data that has a good coverage and with a rich set of variables. Firstly, the dataset contains valuable financial information at the legal unit level, such as total assets, tangible fixed assets, and turnover, as well as at the local unit level, including employment in brackets and NACE sector. Crucially for our analysis, geocoded information on the location of businesses is available for both headquarters and local units. Secondly, the availability of company identifiers allows linkage with the ESCB's Register of Institutions and Affiliates Data (RIAD), which contains information at the level of single institutional units[11]. Subsequently, RIAD is used to link the firms that are debtors of euro area financial institutions with the granular ESCB datasets on loans (AnaCredit[12]) and securities (SHSS[13]).

[11] The Register of Institutions and Affiliates Data (RIAD) serves as the central master data system within the ESCB. It provides reference information (e.g. name, address, legal form, institutional sector) on various types of organisational units, such as legal entities and branches, and on group-level relationships between parent companies and subsidiaries. Further information can be found here.

[12] Analytical credit datasets (AnaCredit) provide information on individual bank loans in the euro area, collected under Regulation (EU) 2016/867 on the collection of granular credit and credit risk data (ECB/2016/13), and complemented by ECB/2017/38 on the procedures for the collection of AnaCredit data from NCBs.

[13] The Securities Holdings Statistics by Sector (SHSS) data, collected on a security-by-security basis, provide aggregate information on securities held by selected categories of euro area investors, broken down by instrument type, holder country and further classifications, following the European System of National and Regional Accounts (ESA 2010) classification system. Holdings data are collected on a security-by-security level based on Regulation ECB/2012/24 concerning statistics on holdings of securities and compiled on the basis of Guideline ECB/2013/7 concerning statistics on holdings of securities.

The French dataset used in this paper comprises the following sources:

- **The SIRENE directory from the French National Institute of Statistics and Economic Studies (INSEE)**[14], which includes administratively reported information on legal and local units. We use the following datasets:

    - *StockEtablissement*, which offers information on local and legal units (be they still active or not) at a given reference date. Snapshots are made available at the beginning of the ongoing month;

    - We also use a historic version of this database (*StockEtablissementHistorique*) to ensure better consistency with respect to the administrative status of local units, which may evolve over time;

    - Finally, we use the geolocalised version of *StockEtablissement*[15] that includes an estimation of the geographical coordinates of local units in France, built by INSEE for statistical purposes.

- **The FIBEN database** from the Banque de France**,** which provides detailed legal unit-level balance sheet data and is mainly based on firms' accounting statements, supplier and customer trade bill payment incidents, bank loans reported by credit institutions and firm legal information. Contrary to the SIRENE database, which is in open access, information coming from this database is confidential. For our analysis we use FIBEN annual firm accounting data (with the reference year 2022). We kept in our sample companies with a minimum turnover of EUR 0.75 million that fulfilled their obligation to provide accounting statements to the Banque de France, and SMEs that provided their accounting statements to the Ministry of Finance. In our approach, the FIBEN database is especially used to improve the accuracy of the 'tangible fixed assets' variable at a legal-unit level, deriving it from accounting statements data.

[14] Based on Sirene des entreprises et de leurs établissements (SIREN, SIRET) - data.gouv.fr

[15] Géolocalisation des établissements du répertoire SIRENE-pour les études statistiques - data.gouv.fr

Table 2 ***Overview of data sources comprising French datasets.***

Database and provider	Number of legal/local units	Scope of variables	Access
SIRENE (INSEE)	• 16,2M legal units • 24,7M local units (reference date 31/03/2023)	Location data + administrative info. No financial information, but employee bracket information	Open access
Geocoded version of **SIRENE** (INSEE)	Local units with geocoded information		Open access
FIBEN (BdF)	Legal units with revenue > 750 M€ → around 300k entities	Database with most detailed financial information	Confidential, but feeds RIAD and iBach[16]

The SIRENE and FIBEN data were merged with French NFCs recorded in RIAD, to be consistent with the sample of companies used for the ESCB statistical climate indicators. All the local units in SIRENE which do not have a corresponding French legal unit in RIAD are dropped from the analysis. A negligible amount of RIAD codes (0.07%) cannot be matched to the SIRENE database – stemming from the use of different data reference periods, which is December 2022 for the ESCB dataset versus March 2023 for SIRENE.

3.2 Geographical, size and sectoral distribution of local units in the sample

Nearly 2.5 million firms in France are single-establishment firms, operating from a single headquarters location. These firms constitute approximately 90% of all legal entities, making their exposure to climate risks relatively straightforward based on their location. Although multi-establishment firms represent a smaller proportion, around 10%, their financial impact is significant. In the portfolios of French financial institutions, multi-establishment firms account for approximately 37% of the total financial exposure. This is particularly notable in the context of debt securities and equity, where they comprise about 50% of the firms issuing securities (Table 3).

[16] Individual Bank for the Accounts of Companies Harmonized (iBACH).

Table 3 Distribution of single and multi-establishments firms in the sample by instrument type

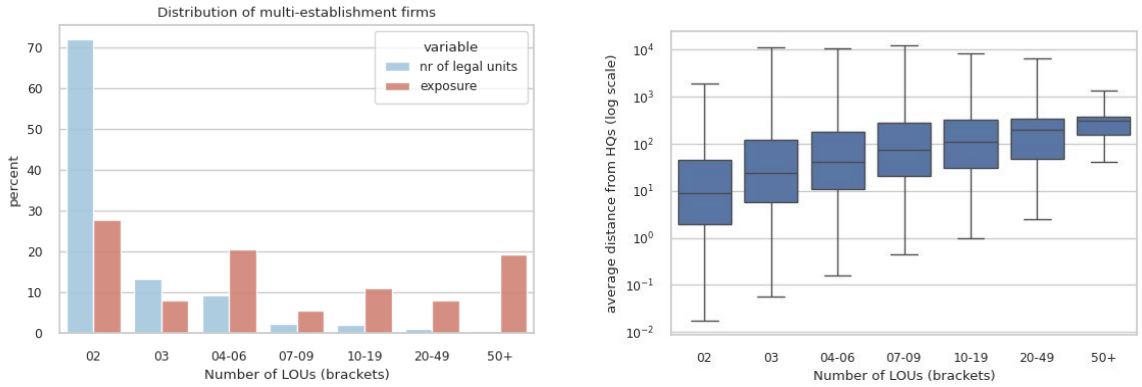
	Debt securities		Equity		Loans		All instruments	
	nr of LEs	exposure	nr of LEs	exposure	nr of LEs	exposure	**nr of LEs**	**exposure**
Single establishment	51%	39%	52%	45%	90%	71%	**90%**	**63%**
Multi-establishment	49%	61%	48%	55%	10%	29%	**10%**	**37%**
All legal units (LE)	100%	100%	100%	100%	100%	100%	100%	100%

Sources: Own calculations based on SIRENE, FIBEN, AnaCredit, SHSS, RIAD.

Investigating further into multi-establishment firms, we observe that firms with more than three local units (including the headquarters) constitute a relatively low share in terms of numbers. However, their financial exposures are not negligible. For firms with at least 50 local units, these exposures account for almost 20% of all exposures among multi-establishment firms in France (Figure 1, left panel).

Additionally, from a physical risk perspective, the local units of these firms are, on average, much further away from their headquarters, often situated in areas potentially exposed to different hazards. For firms with only one additional location besides the headquarters, the units are located within 10 km for half of the firms. In contrast, for those with at least 10 local units, the median distance from the headquarters is 100 km, and this distance increases further with the number of establishments (Figure 1, right panel).

Figure 1 Distribution of multi-establishment firms (number of firms, exposure and average distance from the headquarters)



Sources: Own calculations based on SIRENE, FIBEN, AnaCredit, SHSS, RIAD.
Notes: Sample based on headquarters of French NFCs with multiple locations.

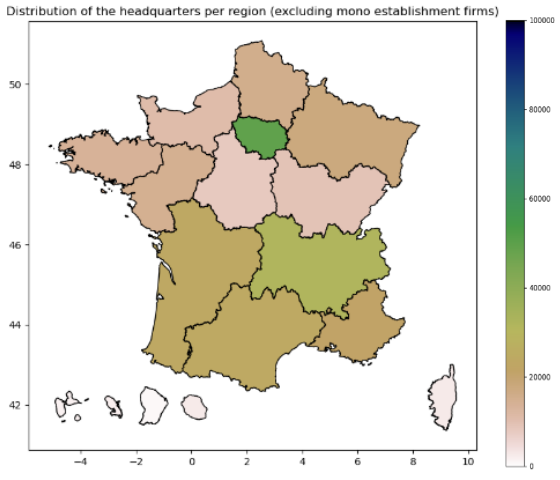
Thus, assessing the physical risk exposure of firms with multiple local units is more challenging; estimations may be affected by varying exposure to hazards depending on the location, as well as varying financial exposure depending on the economic importance of each local unit.

Disregarding exposure to physical hazard risks for plants situated further away from their headquarters can introduce bias into the risk assessment. The magnitude of this bias depends on the geographical distribution between the local units and the headquarters, as well as their relative sizes, which in our analysis is captured by employment.

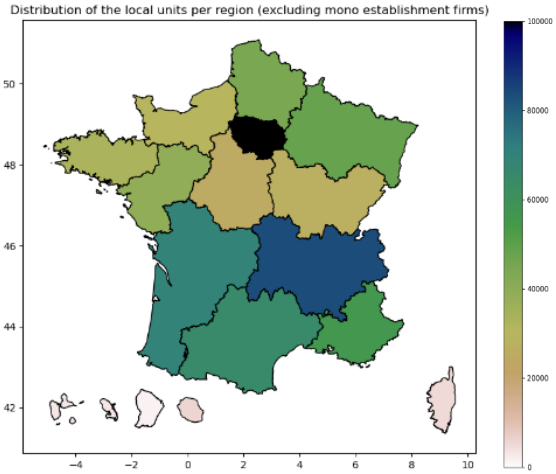
Thus, we analyse the locations of firms across French regions more closely. Both headquarters and local units are concentrated in the Île-de-France region and Auvergne-Rhône-Alpes (Figure 2). Paris and its suburbs (Île-de-France) account for 18% of the national active workforce, followed by the Auvergne-Rhône-Alpes and Nouvelle-Aquitaine regions, which respectively represent 11% and 10% of the total number of employees. However, when examining the regional distribution among solo-establishment firms, headquarters of multi-establishment firms, and their local units, we observe a similar share of each region in terms of number and employment across these three types of entities (Figure 3). The only exception is the Paris and its suburbs (Île-de-France), which unsurprisingly tends to have a higher number of headquarters compared to local units. This is particularly true for multi-establishment headquarters, which also tend to be larger in terms of employment.
This feature suggests limited differences between a headquarters-only approach and an approach that assigns equal weights to local units.

Figure 2 Distribution of multi-establishments firms by NUTS1 regions

Number of headquarters

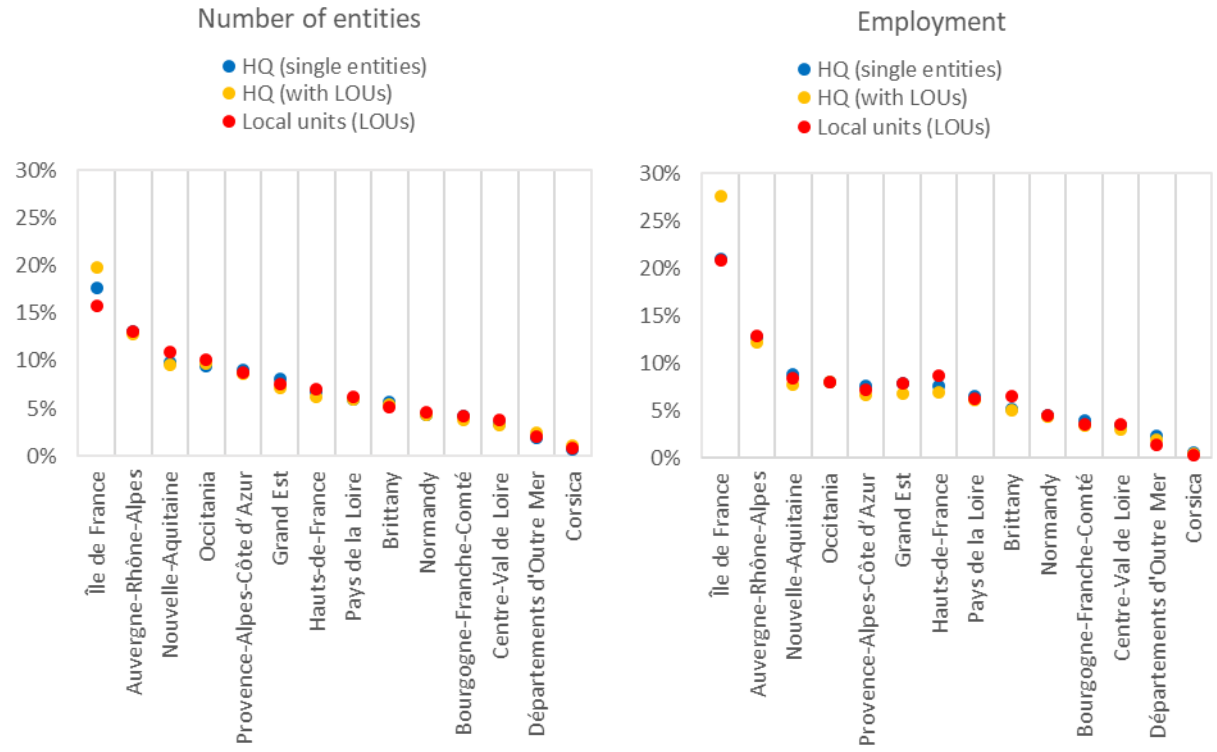


Number of local units



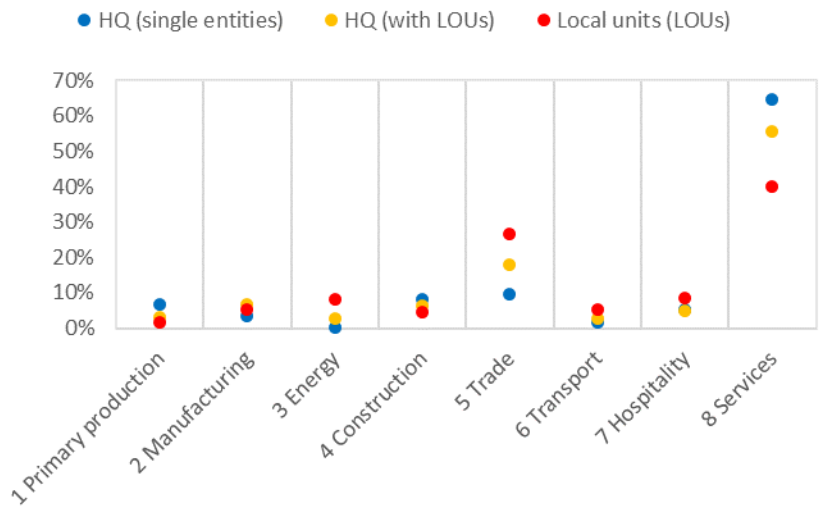
Sources: Own calculations based on SIRENE.

Figure 3 Distribution of the entities by NUT1 regions and entity type (number of entities, employment)



Sources: Own calculations based on SIRENE.

Figure 4 Distribution of the entities by NACE sector and type of entity (number of entities)



Sources: Own calculations based on SIRENE.

Finally, we examine the sectoral distribution, considering the use of this data in the weighting process (Figure 4). Local units are overrepresented in trade activities and underrepresented in the services sector. This is unsurprising given that the trade sector often includes retail stores, distribution centers, and other facilities that are spread across various locations to serve different markets. In contrast, headquarters, which handle administrative and strategic functions, are included under services and are typically centralised.

4 Construction of weights for allocation of assets across local units

Assessing the exposure of French NFCs to climate risks involves making various assumptions about the location and distribution of activities and assets, especially for firms with multiple local units. Due to the absence of local unit-level data at the euro area level, the ESCB physical risk indicators assume that all activities and tangible assets are situated at the headquarters. To address this, we construct proxies to distribute the assets across local units based on employment and sectoral data. Additionally, we include a simple weighting method that allocates assets equally across all local units within a firm.

These different approaches are presented below, ordered from the lowest to the highest data requirements.

4.1 Equal distribution of weights across local units

The first approach implemented is to derive **equal weights for each local unit within a legal unit** ("weight equal"). The assumption of equal distribution of weights is very straightforward to implement as no additional data except the location and number of local units per firm is required. This approach allows also to clearly identify the impact of considering a different geographical distribution of entities, without additional assumptions and data quality issues associated with using other proxy variables. A natural drawback of this approach's simplicity is the very strong assumption that all local units within a same company have the same amount of tangible fixed assets.

4.2 Weighting with region-sector level proxies from Eurostat

The two approaches presented below leverages on aggregate Eurostat information (region-sector level) on the number of employees, number of local units, and total wages to derive weights at the local-unit level. The objective is to assess how this type of aggregated proxy - which might be more accessible to countries lacking local-unit level employment data - compares to more granular data.

a) Sector-region level information on average number of employees per local unit ("weight sector-region employment")

The approach is the following:

- The average **number of employees** per local unit is derived from Eurostat for each NUTS2 region and NACE2 sector;
- Then, those average figures are assigned to each local unit depending on the NUTS2 region they are located in and the NACE2 sector they belong to;
- The weight of each local unit is computed according to its share of employees within the company, as proxied by the average figures assigned to each local unit at the previous step:

$$Weight_i = \frac{Average\_nb\_employees_{r_i,s_i}}{\sum_{j \in local\ units\ within\ legal\ unit} Average\_nb\_employees_{r_j,s_j}}$$

with:

- i a local unit

- r_i the NUTS2 region of local unit i
- s_i the NACE2 sector of local unit i

This approach leverages on aggregate Eurostat data and could thus be applied to all the European countries that report such data (and have access to geolocation data of local units).

However, the assumption that the variations across region and NACE sectors within the local units of a given legal entity is a predictor of their relative weights in terms of number of employees is very strong. This is combined with the other assumption that there is constant capital intensity *(= tangible fixed assets / number of employees*) in between the local units of a legal unit. That last assumption allows to interpret those weights as a distribution of tangible fixed assets.

a) Sector-region level information on average total wages per local unit ("weight sector-region wages")

The approach is similar to the one above, but instead of using aggregated regional data for employment, total wages are used:

- Average **total wages** per local unit are derived from Eurostat for each NUTS2 region and NACE2 sector;
- Then, those average figures are assigned to each local unit depending on the NUTS2 region they are located in and the NACE2 sector they belong to;
- The weight of each local unit is computed according to its share of total wages within the company.

$$Weight_i = \frac{Average\_total\_wages_{r_i,s_i}}{\sum_{j \in local\ units\ within\ legal\ unit} Average\_total\_wages_{r_j,s_j}}$$

with:

- i a local unit
- r_i the NUTS2 region of local unit i
- s_i the NACE2 sector of local unit i

The assumption is that total wages are a better metric for total labor than number of employees, and might thus be more strongly correlated with capital.

4.3 Weights derived from local-unit level employee data in SIRENE ("weight LOU employment")

In this approach, employment brackets at the local-unit level are used as direct weights for distributing tangible fixed assets. This method relies on local unit data and requires fewer assumptions than when using aggregated regional data. However, the assumption of constant capital intensity between the local units of a legal unit still applies.

Given that the employment is provided in brackets, we test approaches (see Table 4):

- The **lower bound** of employee brackets, with 1 added to account for a non-salaried entrepreneurs and to avoid dropping the associated local unit from the sample (**'weight LOU employment (lower bound)**').
- the **mid-point** of employee brackets (with 1 added to account for a non-salaried entrepreneurs and to avoid dropping the associated local unit from the sample), except for the biggest bracket (over 10 000 employees), where the lower bound is applied instead **("weight LOU employment (mid-bracket)").**

The approach for both is the following, for a given local unit *i* :

$$Weight_i = \frac{Lower\_or\_midpoint\_in\_employee\_bracket_i}{\sum_{j \in local\ units\ within\ legal\ unit} Lower\_or\_midpoint\_in\_employee\_bracket_j}$$

4.4 Capital intensity proxies based on BdF company-level data ("weight HQ capital intensity")[17]

In this approach, a weight is built by combining information about the number of employees per local unit and the capital intensity at a legal unit-level.

This derivation is broken down into several steps:

- Capital intensity, defined as the quantity of tangible fixed assets per unit of labor, is computed at the legal unit level, based on the average capital intensity by class of employees and by NACE2 sector. The data used to construct these proxies are based on

[17] While this approach is considered from conceptual perspective, it is not yet incorporated in the analytical part of the paper and is left for future work.

financial data with reference date of December 2022 at company level from the FIBEN database of the Banque de France.

- The capital intensities obtained are then multiplied by the number of employees of each local unit – estimated following the mid-point approach above - to obtain an approximation of the fixed tangible assets for each local unit. The number of employees at the local unit level is calculated according to the employee class and sector of each local unit.

- This proxy for tangible fixed assets is normalised by the total tangible fixed assets at the legal unit level, ensuring that the weights sum to 1.

$$Weight_i = \frac{Midpoint\_employee\_bracket_i \times Average\_capital\_intensity_{e_i,s_i}}{\sum_{j \in local\ units\ within\ legal\ unit} Midpoint\_employee\_bracket_j \times Average\_capital\_intensity_{e_j,s_j}}$$

with:

- i a local unit in the sample
- s_i the NACE2 sector of local unit i
- e_i the employee class of local unit i

and:

$$Average\_capital\_intensity_{e,s} = \frac{\sum_{l \in e,s} Tangible\_fixed\_assets_l}{\sum_{l \in e,s} Nb\_of\_employees_l}$$

with *l* a legal unit in FIBEN.

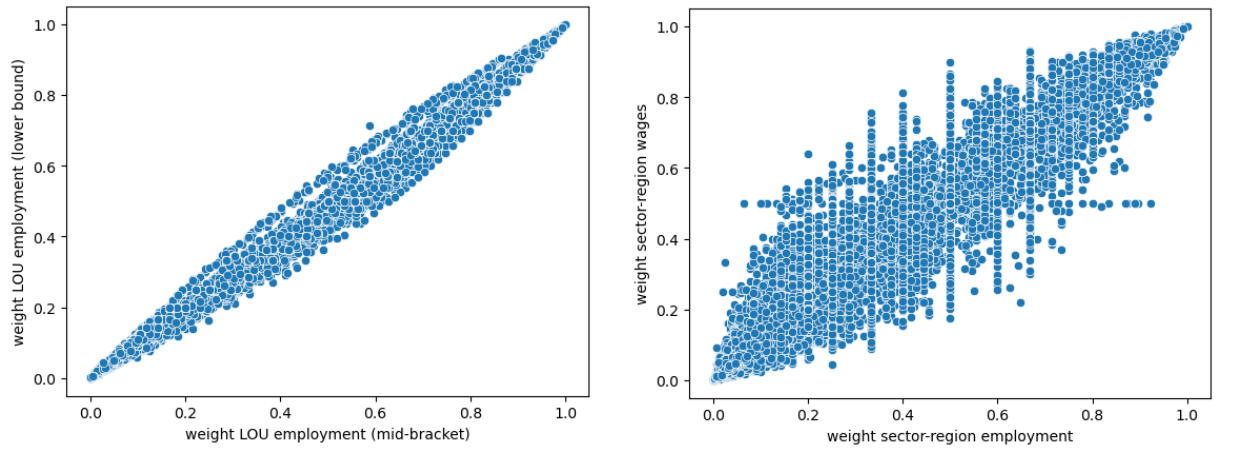
This approach assumes homogeneity of capital intensity within employment bracket and sector, and the feasibility of applying these capital intensities at the local unit level. A key feature of this approach is its consideration of differences in capital intensity between sectors and company sizes, as well as the non-linearity between the size of local units and tangible fixed assets. For instance, if capital intensity decreases with higher employment in a given sector, local units with larger employment in that sector would be assigned a lower weight than with the previous approach based solely on employment brackets.

4.5 Distribution of constructed weights

Given the similarity in methodology and data used for the weights, we investigate the correlation between them to select the most distinct ones for further analysis. We observe that some sets of weights exhibit strong collinearity. Unsurprisingly, the weights based on the lower bound and mid-employment bracket show the strongest correlation (0.99). That is also the case for both weights based on Eurostat regional data (correlation of 0.91).

Therefore, in the analytical part, we present the results for the following subset of weights: i) equal weights, ii) sector-region wages, and iii) LOU employment (mid-bracket).

Figure 5 ***Correlations between different types of weights***



Sources: Own calculations based on SIRENE, FIBEN.
Notes: Sample based on all local units of French NFCs with multiple locations (single-establishment firms are excluded).

5 Methodology and results

5.1 Methodology for calculations of the climate indicators and adjustments to account for local units

The ESCB publication provides a comprehensive methodology and references public sources for climate data. It presents two types of indicators that capture risk in different terms: i) risk scores that categorise exposure from low to high, and ii) expected losses, which measure potential impact in monetary terms. The latter are only available for selected hazards due to higher data requirements for computations.

The indicators cover a wide range of hazards, both for historical baselines and projections under different climate scenarios. They are computed for various breakdowns, including creditor institutional sector, NACE sector of a debtor, and instrument type.

To illustrate the impact of accounting for locations, we select two hazards with distinct characteristics and geographical scopes: i) river flooding, analysed at a high granularity of 100m, and ii) Consecutive Dry Days (CDD), which capture drought conditions at approximately 12 km resolution. We use the historical baseline for both, noting that while the intensification of these hazards is expected under climate scenarios, the geographical scope remains similar to current at-risk areas.

For the expected loss indicator, we select the normalised exposure at risk (NEAR), which estimates anticipated losses in a financial institution’s portfolio if a firm is unable to repay its debt following a natural disaster. This baseline indicator is conceptually expanded to account for collateral pledged by a debtor, known as the collateral-adjusted exposure at risk (CEAR). However, CEAR relies on the location of physical collateral reported at the NUTS3 regional level, not linked to the debtor's location, making it less relevant for our analysis.

The ESCB methodology assesses risk at a company's registered address, assuming all physical assets are located at the headquarters. This approach does not necessarily lead to underestimation of physical risk exposures. For example, if a headquarters is in a flood-prone area while its local units are not, the assumption that all assets are at the HQ can lead to overestimation of risk. We introduce a "weight HQ" based on the ESCB concept as a benchmark for the analysis.

The ESCB statistical indicators focus on the physical risk exposures of financial institutions. Therefore, we restrict our sample to French firms with loans, debt securities, and equity held by French financial institutions. Only domestic local units are included, excluding French overseas territories not covered by the European hazard maps used by the ESCB. Local units with missing location data were assigned an average risk calculated from the remaining locations of the firm. If data was unavailable for at least half of the local units, the entire firm was removed from the analysis. Consequently, the analysis covers large firms, ensuring that those with potentially significant financial exposures are included, even if some locations are missing.

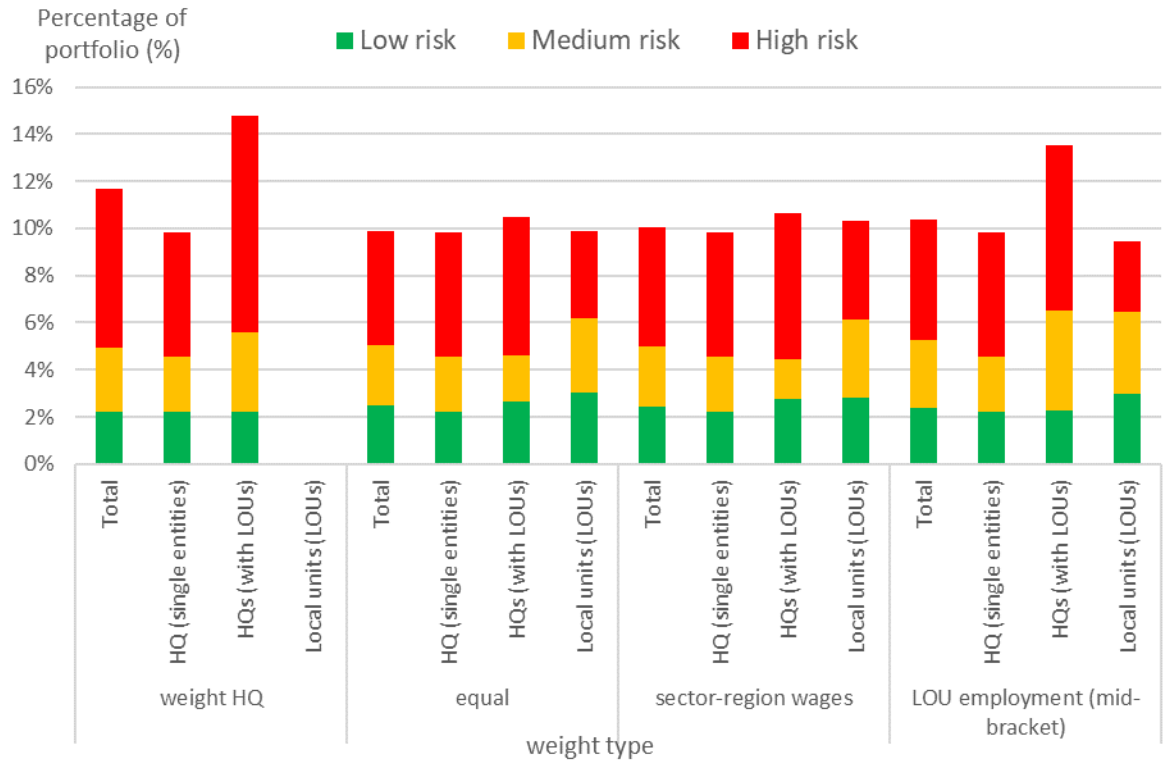
5.2 Results

To assess the impact of accounting for multiple locations, we compute the score and expected loss indicators by type of entity: i) entities with a single location that is the HQ, ii) HQs of multiple locations, and iii) local units of these HQs. The first category is identical across all weights, as each entity is assigned a weight of 1. The remaining two categories focus on entities with multiple locations and reveal the distribution of physical risk between local units (LOUs) and their HQ. Results applying equal weight present the effect of the purely geographical distribution of risk, while the remaining weights also show the impact of accounting for the size of local units and their physical assets, as proxied by wages and employment (see Section 4.1 for details).

Looking at river floods, HQs appear to be located slightly more frequently in flood-prone areas than their local units (Figure 4). Applying weights constructed from aggregated regional data yields very similar results, indicating little variation between regions. Using employment weights at the LOU level shows an even more pronounced risk at the HQs, suggesting higher employment levels at the registered address compared to local units. These findings are consistent for both risk scores and expected loss indicators (Figure 6).

For drought-related indicators, the risk scores show low variability (Figure 5) that arises from the lower resolution of the applied map and the fact that droughts typically affect larger areas than river floods. Headquarters with multiple locations encounter a slightly higher percentage of low-risk category, which seems to be consistent with the higher risk of flooding. This is because lower precipitation generally reduces the probability of flood risk.

Figure 6 ***Risk scores, river flooding by weights and entity type***

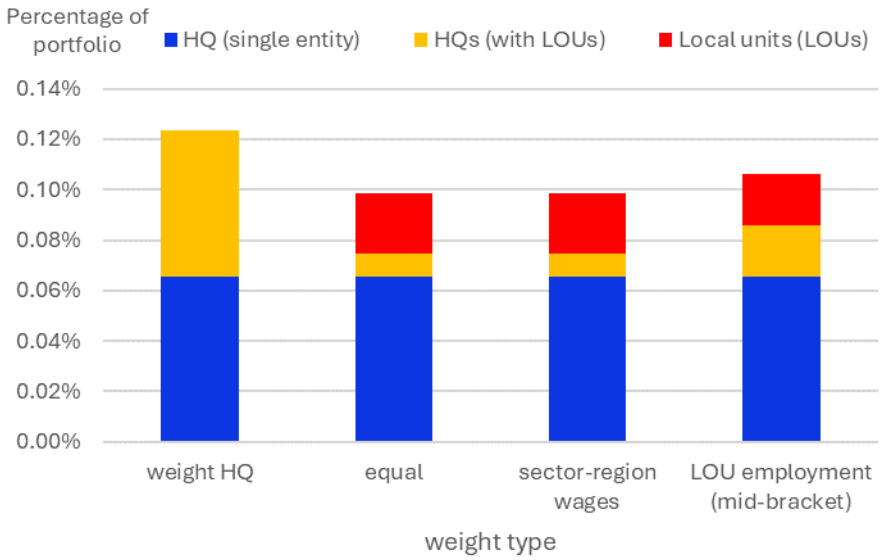


Sources: Own calculations based on SIRENE, FIBEN, AnaCredit, RIAD, SHSS and Delft University of Technology (TUD). December 2022 reference period. Hazard data refer to historical baseline (1971-2000).
Notes: Indicators cover Deposit-taking corporations except central banks (S122), Non-Money market funds investment funds (S124), Insurance corporations & Pension funds (S128, S129) and all instruments (debt securities, equities, loans). Sample restricted to French firms with loans, debt securities, and equity held by French financial institutions. Only domestic local units, excluding French overseas territories not covered by the European hazard maps.

Figure 7 ***Risk scores, consecutive dry days (CDD) by weight and entity type***

Sources: Own calculations based on SIRENE, FIBEN, AnaCredit, RIAD, SHSS, IPCC Interactive Atlas. December 2022 reference period. Hazard data refer to historical baseline (1986-2005).
Notes: Indicators cover Deposit-taking corporations except central banks (S122), Non-Money market funds investment funds (S124), Insurance corporations & Pension funds (S128, S129) and all instruments (debt securities, equities, loans). Sample restricted to French firms with loans, debt securities, and equity held by French financial institutions. Only domestic local units, excluding French overseas territories not covered by the European hazard maps.

Figure 8 ***Expected loss (annualised): Normalised exposure at risk (NEAR) indicator for river flooding***

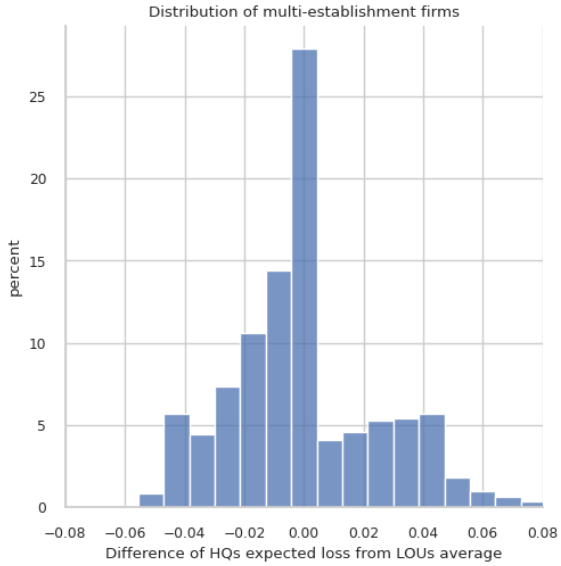


Sources: Own calculations based on SIRENE, FIBEN, AnaCredit, RIAD, SHSS and Delft University of Technology (TUD). December 2022 reference period. Hazard data refer to historical baseline (1971-2000).
Notes: Indicators cover Deposit-taking corporations except central banks (S122), Non-Money market funds investment funds (S124), Insurance corporations & Pension funds (S128, S129) and all instruments (debt securities, equities, loans). Sample restricted to French firms with loans, debt securities, and equity held by French financial institutions. Only domestic local units, excluding French overseas territories not covered by the European hazard maps.

While France has the largest territory in the EU, the exposure to physical hazards is relatively homogeneous across its European territory. Additionally, the distribution of local units across regions is similar to that of headquarters (see Figure 3). Therefore, at an aggregated country level, assigning physical risk identified at the headquarters to the entire firm leads to similar results as accounting for each location, particularly for temperature-related hazards that affect larger areas.

At the same time, there can be significant dispersion across firms, and individual locations cannot be disregarded when assessing risk at the individual firm level (Figure 9).

Figure 9 Distribution of share of expected loss of headquarters and their local units for river floods (historical baseline)



Sources: Own calculations based on SIRENE, FIBEN, Delft University of Technology (TUD).
Notes: The sample is based on the headquarters of French non-financial corporations (NFCs) with multiple locations. The histogram includes firms where the difference between the headquarters' risk and the average risk across their local units is nonzero. Positive values indicate that the expected loss at the headquarters' location is higher than the average expected loss calculated at the local units.

Further investigations can shed more light on firms' location choices. The datasets contain information on the economic activity of local units. It may help validating whether firms operating in industries with a high reliance on water for production processes are located near rivers, and if these locations correspond to their headquarters, while their distribution centers might be situated in different areas. We leave this for future work.

6 Conclusion and future work

Our analysis of the geographical distribution of French firms indicates limited inaccuracies when assessing physical risk based solely on the registered address of a company. While hazards affecting the HQ are not indicative of all company locations, there is no evidence of a structural underestimation of physical risk, and the direction of mismeasurement (underestimation or overestimation of risk) depends on the relative risk levels between the HQ and other locations.

The aggregated country results suggest the reliability of the statistical methodology of the ESCB climate indicators, which is based on a large sample of firms. However, the robustness of these findings should be validated across a broader set of countries. We outline several areas for future research.

Firstly, an important factor in potential underestimation of physical risk in France is the exclusion of overseas territories, which have distinct natural disaster profiles. The ESCB statistical indicators primarily focus on hazards that are highly relevant in Europe[18]. Although the number of local units outside the European continent is limited, including these overseas locations might significantly alter the risk profiles for some larger companies. In France, approximately 4,000 local units (0.6% of the sample of firms) are located over 1,500 km from their headquarters. In this paper we rely on European hazard maps, which offer higher granularity than their global counterparts. However, incorporating these global maps into our analysis could enhance our understanding of physical risks in overseas territories, and we envision this as a direction for future research.

Secondly, another avenue to explore is the use of alternative weighting schemes for allocating physical assets across local units. Most methods used in this study (with the exception of equal weights) rely on employment data, albeit with some variations where employment is combined with other variables such as wages, economic activity, and their regional distribution. Further investigations could examine other approaches, such as estimating asset exposures based on nightlight intensity and population data[19] (Eberenz et al., 2020).

Ultimately and most importantly for the further work at ESCB level, the analysis needs to be extended to other European countries. Country-specific factors might influence the geographic distribution of headquarters and their local units and it remains to be seen whether the French result that at aggregated level results are rather similar whether information on local units is used or not also holds for other countries. The French case study provides a foundation for making assumptions in countries where less information is available, such as those where employment data are not reported at the local unit level, or where locations are identified only by postal code or municipality level.

Overall, the enterprise and local-unit data collected under EBS regulation provide a rich source of firm-level information. Regarding environmental assessment, the geographical distribution of production plants would allow for the evaluation of the impact of industrial activities on local ecosystems. Additionally, this data can be utilised beyond climate impact studies, including in

[18] Notably, they do not account for tropical cyclones that impact Caribbean territories like Guadeloupe and Martinique, Indian Ocean territories such as Réunion and Mayotte, and Pacific territories including New Caledonia and French Polynesia. These islands, along with French Guiana, are also susceptible to sea level rise and, in some cases, to river floods due to seasonal heavy rainfall. Additionally, the Pacific territories are vulnerable to tsunamis, while landslides are a concern in the mountainous regions of Réunion, Guadeloupe, and Martinique.

[19] However, this methodology shows limitations when it comes to the disaggregation within a metropolitan area or sector-specific assets such as power plants or mines in unpopulated areas.

supply chain analysis (which assesses the importance of proximity to suppliers, transportation hubs, and markets), regional economic development, and local labour market trends. Regrettably, the lack of standardisation of data across countries presents a significant challenge, necessitating considerable effort to ensure a fully harmonised analysis at the EU level. However, we firmly believe that these efforts are worthwhile as they will unlock a wide range of analytical applications.

7 References

Bressan, Giacomo and Duranovic, Anja and Monasterolo, Irene and Battiston, Stefano, Asset-level assessment of climate physical risk matters for adaptation finance (March 20, 2022).

Eberenz, S., Stocker, D., Röösli, T., and Bresch, D. N.: Asset exposure data for global physical risk assessment, Earth Syst. Sci. Data, 12, 817–833, https://doi.org/10.5194/essd-12-817-2020, 2020.

ECB/ESRB. (2021, July). *Climate-related risk and financial stability*.

ECB/ESRB. (2023, December). Towards macroprudential frameworks for managing climate risk.

ESCB, 2024. Climate change-related statistical indicators, ECB Statistics Paper Series, No. 48, April 2024.

8 Annex

8.1 Description of French local-unit level data and quality checks (SIRENE directory)

The SIRENE directory provided by INSEE registers identification data for all businesses and economic entities. It notably provides information at local unit level on administrative status, location, NACE sector and on employment ranges.

8.1.1 Legal/local units identifiers and administrative status

In France, every business legal unit is identified by a SIREN number (9 digits), and each of its local unit – establishments, plants – is identified by a complementary local unit identifier ("nic", 5 digits). The juxtaposition of a SIREN number and a complementary identifier results in a SIRET number (14 digits), which identifies local units within the general population. Such identifiers allow to merge all administrative information available at firm and local unit level in France.

The SIRENE dataset provides information both on administratively active and closed local units. The companies in the scope of this study – *i.e.* French non-financial companies that are a debtors of French financial institutions as of 31/12/2022 – correspond to around 3.40 million open and 2.15 million closed local units in the SIREN database. Closed local units have a similar sectoral structure with respect to the full sample. Even though administratively closed local units may reopen in the future, we decided to exclude all closed local units from the sample, considering that open local units were of most interest for physical risk impacts and that information on closed local units was more likely to be outdated. . In addition, we have removed the legal units for which half or more LOUs have no location information (around 60 thousand firms corresponding to around 73 thousand local units). This led to a final sample of 3.39 million local units, 81% of which are headquarters (see Section 3.2 for the distribution of number of local units per legal unit).

8.1.2 Geolocation of local units

The computation of geographic coordinates (X, Y) of local units by INSEE is based on a two-step approach.

- First, an estimation of coordinates is attributed to plants depending on the most granular level of location information available, thanks to an automatic application developed by INSEE. This application relies on an address referential built using parcel and / or cadastral information.
- In a second step, manual checking is applied to larger units (units with more than 200 employees) or to smaller units (between 20 and 199 employees) for which automatic geocoding is considered as uncertain.

As shown in Table 4 below, for 82% of locations, the geocoding is very precise in our sample and is based on street and house number.

Table 4 ***Quality of geolocation for local units in the sample***

Geolocation approach	Frequency	Percentage
Correct road is certain, house number is found	2 694 121	81,9%
Correct road is certain, random position in the road is applied	317 433	9,6%
Correct road is likely, house number is found	73 295	2,2%
Correct road is likely, random position in the road is applied	55 442	1,7%
Unknown road, random position in the municipality is applied	149 417	4,5%

8.1.3 Information on employee and sector of activity

Financial variables at firm level suffer from low coverage, while at local units level such information is not available at all, in particular tangible assets that are of key interest for physical risk assessment. However, the SIRENE database includes information on sectors and employee classes. This information is used to derive assumptions on the distribution of tangible assets across local units within a same legal unit, and thus to compute weighting scheme for the implementation of physical risk indicators methodology (see Section 4 and 5.1).

The SIRENE database includes employee information at local unit level in the form of brackets only, shown in Table 4. There are 16 brackets, from non-employer establishments to local units with more than 1 000 employees.

Sector information in SIRENE uses the French “NAF2” classification, which is interoperable with level 2 of the NACE Rev. 2 classification; we thus consider level 2 NACE sectors in the analysis.

Table 5 ***Distribution of employee classes in the sample with lower and mid-point brackets for weight calculation***

Employee classes	Frequency	Percentage	Lower bound	Mid-point
Non-employer establishment	1 643 358	30%	1	1
0 employee (at least 1 employed during the year but not at the end of the year)	133 929	2%	1	1
1 or 2 employees	432 057	8%	2	2,5
3 to 5 employees	355 790	6%	4	5
6 to 9 employees	213 333	4%	7	8,5
10 to 19 employees	172 792	3%	11	15,5
20 to 49 employees	111 407	2%	21	35,5
50 to 99 employees	43 955	1%	51	75,5
100 to 199 employees	19 021	0%	101	150,5
200 to 249 employees	3 328	0%	201	225,5
250 to 499 employees	5 987	0%	251	375,5
500 to 999 employees	2 159	0%	501	750,5
1,000 to 1,999 employees	889	0%	1001	1500,5
2,000 to 4,999 employees	402	0%	2001	3500,5
5,000 to 9,999 employees	61	0%	5001	7500,5
10,000 or more employees	10	0%	10001	10001
NA	2 399 248	43%	1	1