HONG KONG MONETARY AUTHORITY

Research Memorandum 09/2025

18 August 2025

ASIA-PACIFIC CORPORATES' EXPOSURE AND RESILIENCE TO CLIMATE PHYSICAL RISK

Key points:

- *The Asia-Pacific (APAC) region is highly exposed to climate hazards. For corporates, climate hazards could inflict damages to assets and disrupt production and business activities. This can have ramifications for economic and financial stability, for example through supply chain disruption and increased credit risk. In view of this, this study examines APAC corporates' exposure and resilience to climate physical risk, using firm-level data on climate risk exposure and preparedness.*

- *This study finds that APAC corporates are more prone to climate hazards than their global counterparts. Nearly half of the APAC corporates in the sample are highly exposed to multiple climate hazards. In particular, corporates domiciled in emerging market economies (EMEs) in the region are more exposed. In terms of resilience, ESG scores for aspects related to climate physical risk preparedness reveal that while the majority of APAC corporates have put some form of climate risk management process in place, practices in the more granular aspects, such as climate scenario analysis and physical risk adaptation, are rather rudimentary.*

- *Combining both the exposure and resilience dimensions, this study finds that about 15% of the APAC firms in the sample are subject to high physical risk, as they are highly exposed to multiple climate hazards and have low preparedness for them.*
  - *In general, such high-risk firms are more common in EMEs in the region. This raises concerns about economic and financial stability, as Asian EMEs are integral to the global supply chain and generally have low insurance protection against natural catastrophes.*
  - *By sector, there are more high-risk firms in the materials sector, particularly chemical manufacturers and metals and mining firms. Improving their climate risk preparedness would enhance the supply chain resilience of the materials critical to the green transition and the digitalisation of economies.*

- *With respect to the factors affecting physical risk preparedness, this study finds that the quality of climate-related disclosure in an economy has a positive impact on firms' preparedness. This suggests that regulatory initiatives or peer pressure to improve disclosure may enhance preparedness. In addition, firms' preparedness is influenced by the overall physical risk vulnerability of the economy in which they are based, but not by the physical risk exposure of their own assets. This suggests that firms may not have sufficiently considered their specific physical risk exposure, which could reflect a lack of requisite data and capacity for granular risk assessments.*

- *Overall, this study underscores the importance of strengthening the resilience of corporates to climate hazards, especially those in EMEs. In relation to this, the findings in this study have the following policy implications:*

  - *First, strengthening climate-related disclosure requirements could incentivise corporates to improve climate risk preparedness and step up their adaptation efforts, as better disclosure standards would expose poor practices to the scrutiny of banks, investors and the public. Improved transparency on corporate climate risk exposure and resilience could also help scale up financing for climate adaptation and resilience.*

  - *Second, it is imperative to enhance the capacity of corporates to assess climate physical risk at a more granular level and step up adaptation planning, for example, by making granular physical risk data more accessible, providing relevant training and qualification programmes, and encouraging technological solutions.*

*Prepared by: Steven Kong, Alexander Ying, Chris Tang**

Market Research Division, Research Department

Hong Kong Monetary Authority

* The authors would like to thank Eric Wong for his helpful comments and suggestions.

1. INTRODUCTION

In recent years, the world has witnessed signs of intensifying climate physical risk. Globally, 2024 was the warmest year on record, and climate hazards are projected to further intensify with global warming.[1] The Asia-Pacific (APAC) region is particularly exposed to climate hazards, having experienced more natural disasters than other regions in recent decades (Dabla-Norris et al. 2023).

Intensifying climate physical risk could disrupt business activities and damage corporate assets, with ramifications for economic and financial stability. Acute climate hazards could halt a company's operations and damage its production assets. As the APAC region plays a key role in the global supply chain,[2] negative supply shocks may also occur if firms supplying key materials or production parts are paralysed by climate hazards, as has occurred in recent years.[3] Over the long term, global warming could undermine labour health and productivity. These could also have implications for credit risk, as firms' revenues may be hit by climate events, and the value of assets posted as collateral may decline with increased physical risk (Financial Stability Board (FSB) 2025).

To shed light on the implications of climate physical risk for economic and financial stability, this study examines APAC corporates' exposure and resilience to climate physical risk. Adding to the expanding literature on climate-related financial risks, this study emphasises the need to factor *resilience* into the assessment of a firm's climate risk, e.g. its adaptation efforts to reduce the impact of climate hazards. Specifically, this study explores the following research questions:

(I) To what extent are APAC corporates exposed to climate hazards?

(II) What are the climate physical risk profiles of APAC corporates, taking into account their climate risk preparedness?

(III) What factors drive the improvement of corporates' preparedness for climate physical risk?

In answering these questions, this study makes use of granular firm-level data from a commercial data provider on corporates' exposure to climate hazards and their performance in climate risk management and adaptation efforts, thereby contributing micro-

[1] See reports by the World Meteorological Organisation (2025) and the Intergovernmental Panel on Climate Change (IPCC) (2023).

[2] For instance, in the semiconductor value chain, those more capital- and labour-intensive activities are largely concentrated in East Asia (Yeung et al 2023).

[3] There have been instances where climate hazards have disrupted production, hitting the manufacturing supply chain and firms' revenue. For example, in 2021, flooding in central China disrupted supply chains for commodities such as coal and pigs, and forced the closure of an automobile plant; in the same year, flooding in Malaysia halted production of a number of semiconductor plants, hitting the supply of semiconductors and leading a semiconductor maker to lower revenue outlook. See YaleE360 (2022), Reuters (2021) and TechWire Asia (2021).

level evidence to the literature on climate-related risks.[4] In addition, complementing the increased attention to climate physical risk and adaptation at international forums,[5] this study provides an Asian perspective to the relevant discussions.

The rest of the paper is organised as follows: Section 2 introduces the methodology and data used in this study, Sections 3 to 5 answer the three research questions in turn, Section 6 discusses the policy implications, and Section 7 concludes.

2. METHODOLOGY AND DATA

As in conventional financial stability analyses, the impact of a climate shock on an entity depends on its exposure to the shock and its capacity to mitigate the impact of the shock. A corporate is considered to be resilient to a climate hazard if it can respond to and recover from the hazard effectively, mitigating the hazard's impact on its assets and business operations. For example, adaptation measures could help protect production facilities in hazard-prone areas and climate scenario analysis can inform the planning of adaptation and response measures.

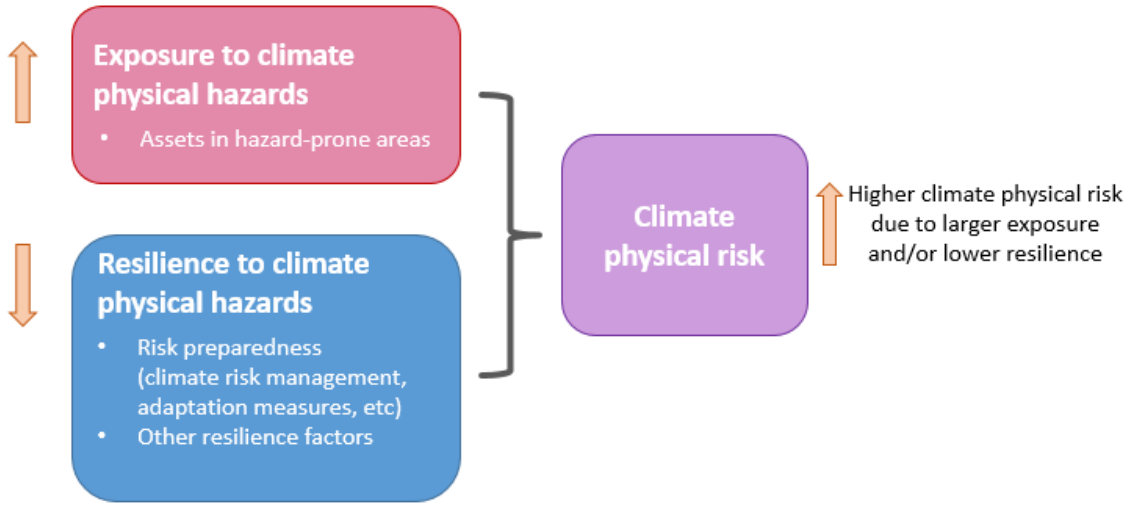
This study assesses the climate physical risk facing corporates by examining both the exposure and resilience dimensions. To assess exposure, we use the *firm-level physical risk exposure scores* computed by S&P Global. The resilience of corporates to climate hazards is assessed based on *scores of the subcomponents related to climate physical risk preparedness under the S&P Environmental, Social and Governance (ESG) framework*. Simply put, corporates with high scores on physical risk exposure and low scores on physical risk preparedness are likely to be subject to high physical risk, as illustrated in **Figure 1**.[6] The subsections below discuss the data in more detail.

[4] The literature on firm-level climate physical risk is emerging with the increased availability of granular data and technological innovations, e.g. de L'Estoile et al (2024), Fatica et al (2022) and Li (2025), but the relevant literature on Asian corporates is relatively scant.

[5] For example, the Network for Greening the Financial System (NGFS) set up a Task Force on Adaptation in 2024 and has published papers on adaptation and resilience (NGFS 2024a, 2025); the FSB has conducted an analysis on the impact of climate physical risk on the real estate market (FSB 2025).

[6] This notion is similar to the 'hazard, exposure and vulnerability' (HEV) framework in the climate risk literature. See, for example, NGFS (2024a) and the Adaptation & Resilience Investors Collaborative (ARIC) (2024). For simplicity, this study does not strictly follow the HEV framework and terminology.

Figure 1: Stylised framework for assessing corporate climate physical risk



It should be noted that other factors, such as financial resilience, may also affect corporate resilience to climate hazards (NGFS 2024a). Notably, the availability of insurance protection against natural catastrophes (NatCat) would affect the scale of financial losses borne by corporates. Available estimates suggest that insurance protection against NatCat is generally low in the APAC region, especially in emerging market economies (EMEs).[7] However, there is a lack of granular data on firms' use of insurance against NatCat, which precludes us from taking insurance availability into account in our analysis of individual firms' resilience to climate hazards.

Corporate exposure to climate physical risk

Firm-level physical risk exposure scores are estimated by S&P Global, based on the domestic and overseas locations of a firm's real assets (e.g. offices, power plants, production sites, mining sites, or data centres etc.). The scores at the asset level are computed for: (i) four **scenarios**, with different greenhouse gas (GHG) emission trends and global temperature changes;[8] (ii) seven projected **time horizons** – from 2030 to 2090; and (iii) nine types of **climate hazards**, namely tropical cyclone, costal flood, fluvial flood, pluvial flood, wildfire, drought, water stress, extreme cold and extreme heat. These are forward-looking, scenario-based exposure scores, reflecting different future trajectories of GHG emissions and climate change.

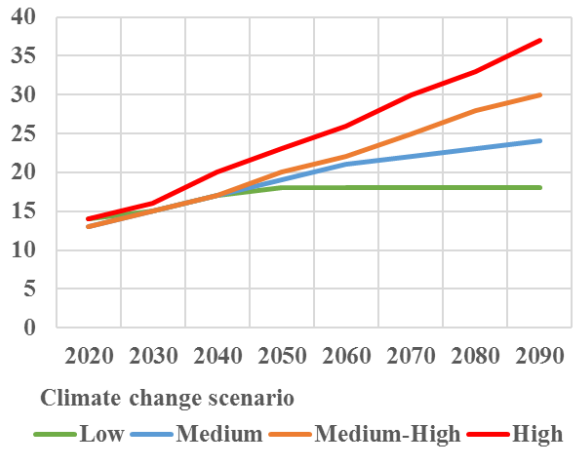
[7] Estimates by reinsurers and some studies suggest that the NatCat insurance protection gap in the APAC region is large and varies across jurisdictions. For example, according to Munich Re, in the 1980-2022 period, the protection gap against weather-related natural disaster losses was 60% in Australia, 53% in Japan and 95% in the rest of APAC; Beirne et al (2021) estimate that for a number of Asian EMEs, only around 8%-27% of the losses from weather-related events during 1993-2018 were insured, implying protection gaps of 70%-90%.
[8] The four scenarios, based on the IPCC Representative Concentration Pathways and Shared Socioeconomic Pathways (SSP), are as follows: High Climate Change Scenario (SSP5-8.5), Medium-High Climate Change Scenario (SSP3-7.0), Medium Climate Change Scenario (SSP2-4.5) and Low Climate Change Scenario (SSP1-2.6). For details, please see Annex 1.

The **asset-level exposure scores** range from 1 (lowest exposure) to 100 (highest exposure). They are relative scores, representing an asset's point-in-time exposure to a hazard relative to global conditions for that hazard across all scenarios and time horizons. The score measures the physical risk exposure of the asset's *location*, but does not take into account the *type* of asset that is located there or how an asset might be affected by the hazard.

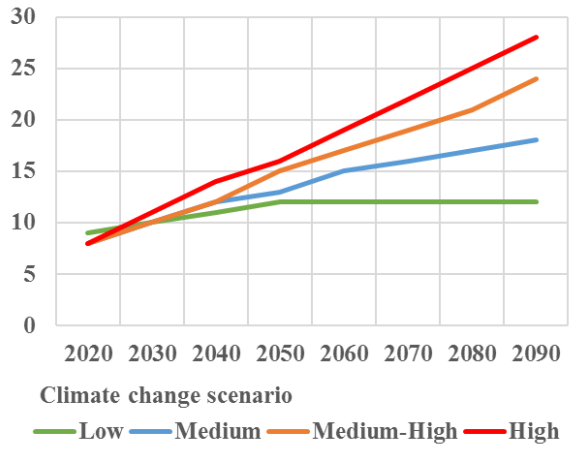
The asset-level exposure scores are aggregated (with weights based on assumed asset values for each asset type) to produce **firm-level exposure scores**. We use the *sensitivity-adjusted* firm-level physical risk exposure scores as they account for the expected sensitivity of companies to each hazard.[9] This study considers only firms for which S&P has undertaken asset-level assessment, based on five or more assets, of their physical risk exposures.[10] **Chart 1** plots the average firm-level physical risk exposure scores for two selected hazards across the projected time horizon. It shows that physical risk increases with the severity of climate change and generally increases over longer time horizons.

Chart 1: Average (median) sensitivity-adjusted physical risk exposure scores, for selected hazards

Panel A: Extreme heat



Panel B: Pluvial (extreme rainfall) flood



Note: The charts are plotted using a sample of listed APAC firms, whose physical risk exposure scores as of 2023 are based on asset-level assessments of at least five assets.
Sources: S&P Global and HKMA staff calculations.

For a prudent assessment, this study selects the High Climate Change Scenario (SSP5-8.5) ('High' scenario hereafter)**, which is the scenario that presents the most severe physical risk.** We focus on the snapshot at 2050, balancing the need to be

[9] Three indicators of sensitivity are used by S&P: (i) tangible asset intensity for physically destructive hazards (i.e. wildfire, fluvial flood, pluvial flood, tropical cyclone and coastal flood); (ii) water intensity for water stress and drought; and (iii) labour intensity for extreme heat and cold.

[10] Where asset-level data are available, S&P uses asset-based assessments to compute the physical risk exposure score; otherwise, revenue exposure-based assessments or country average assessments are conducted. We consider asset-based assessments to be more appropriate for the purpose of this study. For further details on the dataset, please see S&P Global (2023).

forward-looking with the increasing uncertainties in climate projections as they extend further into the future.[11] All nine types of climate hazards are considered, i.e. we look at individual firms' exposure to each hazard under the High scenario at 2050.

Corporate resilience to climate physical risk

The resilience dimension is assessed using the scores of the subcomponents of the ESG assessments related to climate physical risk preparedness in the S&P database.[12] The 'E' category encompasses a range of environmental criteria, including climate strategy, biodiversity, waste and pollutants. This study looks at three subcomponents under the 'climate strategy' criterion that are highly relevant to corporate preparedness for climate physical hazards – namely '**climate risk management**', '**climate-related scenario analysis**' and '**physical climate risk adaptation**'.

- '**Climate risk management**' is an assessment of a firm's overall climate risk management processes, e.g. whether the firm has any climate risk management process, the types of climate-related risk included in the process, and the time horizons considered in the process.
- '**Climate-related scenario analysis**' asks whether a firm has conducted climate-related scenario analyses, whether these analyses are qualitative, quantitative or both, and what scenarios are used.
- '**Physical climate risk adaptation**' examines the physical risk adaptation plan of a firm, e.g. whether it has any plan to adapt to the identified physical risk, whether the plan is context specific, the percentage of existing or new operations covered by the plan, and the time frame to implement the adaptation measures.[13]

These three subcomponents cover the identification, analysis and mitigation of climate physical risks, and are complementary to each other. While 'climate risk management' reflects how a firm approaches and manages climate risks broadly, 'climate-related scenario analysis' and especially 'physical climate risk adaptation' delve into more specific and granular aspects of climate physical risk preparedness.[14] The subcomponent scores range from 0 to 100, with a higher score indicating better performance. We confine our sample to firms that have responded to these questions in the S&P ESG

[11] 2050 is often the time horizon used in the analysis and assessment of climate-related financial risk (e.g. HKMA's 2023-2024 Banking Sector Climate Risk Stress Test, NGFS (2024b)).
[12] S&P Global's ESG scores are informed by S&P's corporate sustainability assessment (CSA), which engages companies directly using industry-specific questionnaires, which allow firms to submit in-depth data and supporting evidence.
[13] For details, please see Annex 2 and S&P Global (2025).
[14] A caveat is that the subcomponent scores on climate risk management and climate-related scenario analysis relate not just to physical risk but also to other climate-related risks such as transition risk. The scores are not broken down to separate physical risk from other types of risk.

surveys or firms that make the information publicly available, allowing S&P to assess their performance.[15]

Data sample

The sample used in this study consists of 4,037 firms headquartered in 12 economies in the APAC region,[16] for which we have the data required for this study, i.e. both the physical risk exposure scores (as of 2023) and the three ESG subcomponent scores (as of 2024 if available, and 2023 otherwise). Around two-thirds of the firms are from advanced economies (AEs), and a third are from EMEs (**Chart 2**). The firms come from a range of economic sectors, the largest of which are the information technology, capital goods, consumer discretionary and materials sectors (**Chart 3**). The sample used in this study accounts for about one-fifth of the listed firms domiciled in the sample economies.

Chart 2: Sample firms by economy

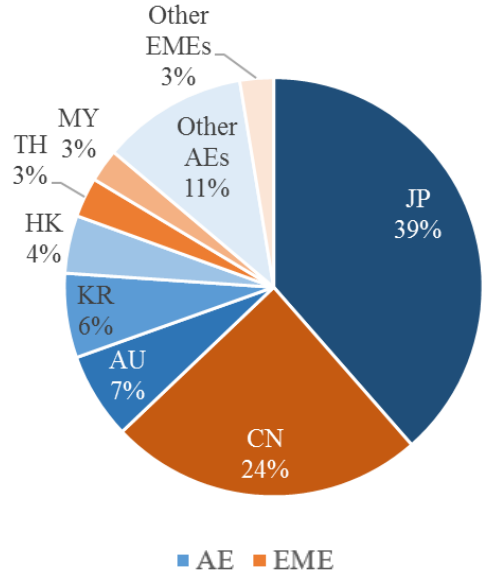
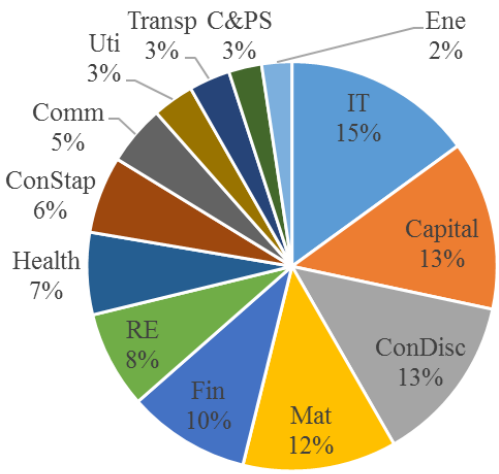


Chart 3: Sample firms by sector



Note: IT = information technology, Capital = capital goods, ConDisc = consumer discretionary, Mat = materials, Fin = Financials, RE = real estate, Health = health care, ConStap = consumer staples, Comm = communication services, Uti = utilities, Transp = transportation, C&PS = commercial and professional services, and Ene = energy. Sources: S&P Global and HKMA staff calculations.

[15] In the absence of responses or disclosures, S&P estimates the scores based on modelling approaches. In this study, we do not include the modelled scores.

[16] The 12 economies include both AEs and EMEs. The AEs are Australia (AU), Hong Kong SAR (HK), Japan (JP), New Zealand (NZ), Singapore (SG), South Korea (KR) and Taiwan, China (TW); the EMEs are Chinese Mainland (CN), Indonesia (ID), Malaysia (MY), the Philippines (PH) and Thailand (TH).

3. TO WHAT EXTENT ARE APAC CORPORATES EXPOSED TO CLIMATE HAZARDS?

Using the physical risk exposure score for 2050 under the High scenario, we count the number of climate hazards to which a firm is highly exposed. A firm is deemed highly exposed to a hazard if its physical risk exposure score for that hazard is in the *top quintile* of a global sample of listed firms. For example, if a firm's physical risk exposure scores with respect to tropical cyclone, coastal flood and extreme heat are all in the respective top quintiles of the global sample of firms, it is deemed highly exposed to three climate hazards.

The physical risk exposure scores reveal that APAC corporates, especially those domiciled in EMEs, are more likely to be highly exposed to climate hazards than their global counterparts. Nearly half (47%) of the APAC firms in the sample are highly exposed to multiple hazards (i.e. two or more types of physical hazards), higher than the 40% globally (**Chart 4**). In particular, firms domiciled in APAC EMEs are more exposed, with 57% of them highly exposed to multiple hazards. These findings corroborate the broad picture that the APAC region and EMEs in particular are generally more exposed to physical risk (e.g. Beirne et al. 2021; Dabla-Norris et al. 2023).

Heterogeneity is observed with respect to the types of hazards to which firms are exposed. For instance, one of the top hazards for firms in Hong Kong, Japan and the Philippines is tropical cyclones, whereas for firms in New Zealand, Singapore and South Korea, the top hazard is pluvial flood. Meanwhile, Chinese Mainland firms are exposed to a broader range of hazards, possibly reflecting the diverse geographical landscapes of the Chinese Mainland.

Chart 4: APAC firms' exposure to climate hazards by region

Breakdown of sample firms by the number of hazards they are highly exposed to

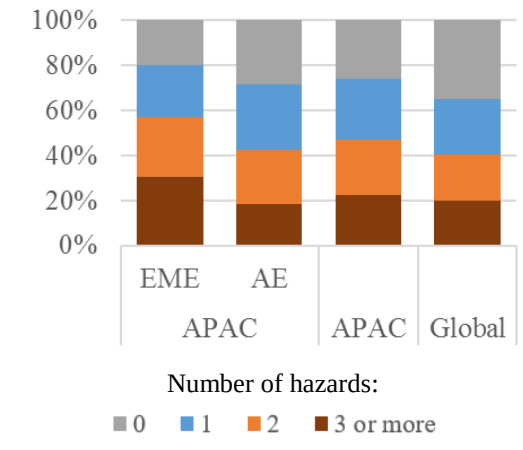
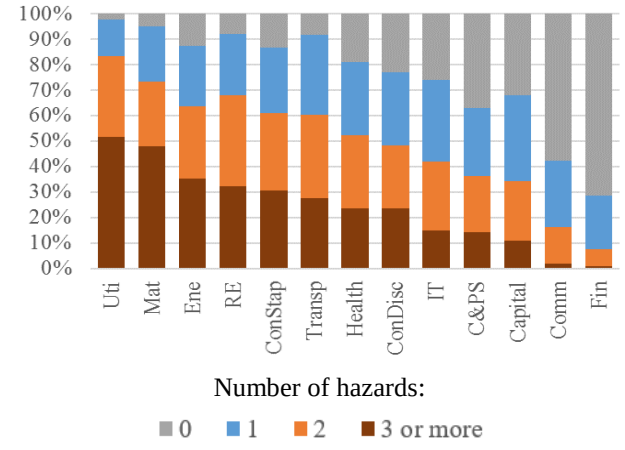


Chart 5: APAC firms' exposure to climate hazards by sector

Breakdown of sample firms by the number of hazards they are highly exposed to



Note: A firm is deemed highly exposed to a hazard if its physical risk exposure score for that hazard is in the top quintile of a global sample of listed firms.
Sources: S&P Global and HKMA staff calculations.

Exposure to climate hazards varies across sectors and is particularly high in some of the sectors supplying key commodities. Over 60% of the firms in the utilities, materials, energy, real estate, consumer staples and transportation sectors are highly exposed to multiple hazards (**Chart 5**). These sectors are important for the economy in various ways. For example, consumer staples firms supply essential food produce and materials firms supply raw materials that are essential for various electronic products. This underscores the importance of the resilience of corporates to climate hazards, which is examined in the next section.

4. WHAT ARE THE CLIMATE PHYSICAL RISK PROFILES OF APAC CORPORATES, TAKING INTO ACCOUNT THEIR CLIMATE RISK PREPAREDNESS?

While the majority of APAC corporates have put some form of climate risk management process in place, practices in the more specific and granular aspects – climate scenario analysis and physical risk adaptation – are rather rudimentary (**Chart 6**)**.** Nearly 60% of the APAC firms in the sample score above 50 in climate risk management, indicating relative maturity in the overall climate risk management process.[17] Another 11% of the firms – with scores between 11 and 50 – have less mature climate risk management processes. However, 53% of the APAC corporates score zero in scenario analysis, suggesting that they have not done any such analysis. Similarly, 52% of the APAC corporates score zero in physical risk adaptation, suggesting the absence of adaptation planning. Relatively speaking, EME firms exhibit weaker preparedness than AE firms across all three aspects of climate risk management.

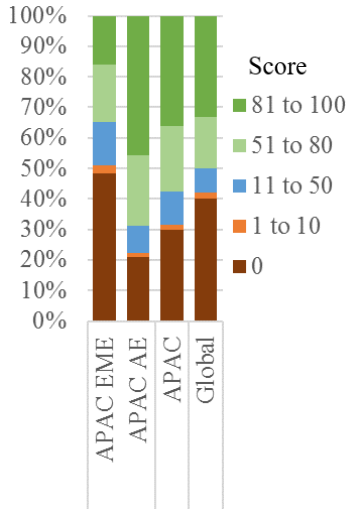
Nevertheless, over 40% of the APAC corporates have sophisticated practices in scenario analysis (scoring above 80), although only a small portion achieve high scores in adaptation.[18] In general, APAC corporates' physical risk preparedness is better than the global picture, with a lower share of firms scoring zero, and at least the same, if not a higher share of firms scoring above 50 across the three aspects of climate risk management.

[17] Firms with scores over 50 in climate risk management have a climate risk management process in place and make fuller disclosure of the types of risks, value chain stages and time horizons covered by these processes.
[18] For instance, some firms that score above 80 in both climate-related scenario analysis and physical climate risk adaptation have conducted quantitative and/or qualitative climate scenario analysis; and have set up context-specific adaptation plans covering substantial shares of its current (and possibly new) operations.

Chart 6: APAC firms' climate physical risk preparedness – ESG subcomponent scores

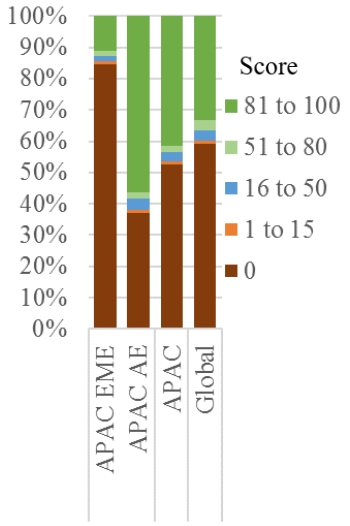
Panel A: Climate risk management

Share of firms



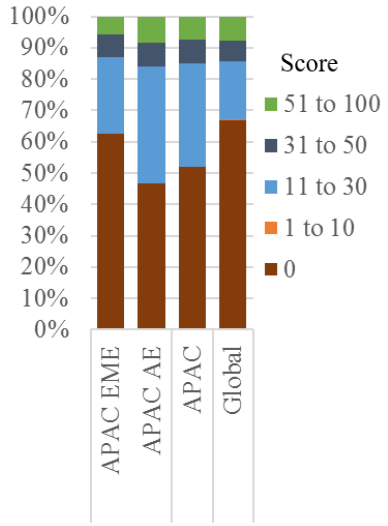
Panel B: Climate-related scenario analysis

Share of firms



Panel C: Physical climate risk adaptation

Share of firms



Sources: S&P Global and HKMA staff calculations.

From a risk assessment perspective, we are more concerned about firms with weak climate risk preparedness, as they are unlikely to be resilient to climate shocks. We define firms with low resilience as firms with the *lowest scores across all three components of climate risk preparedness* in the ESG assessment, i.e. scoring 10 or below for climate risk management and physical risk adaptation, and 15 or below for scenario analysis.[19] These 'least resilient firms' account for 30% of our sample of APAC firms.

Combining the exposure and resilience dimensions, we find that about 15% of the APAC firms are subject to high climate physical risk, with EMEs having a higher proportion of high-risk firms (**Chart 7**). These firms are *highly exposed to multiple hazards* but have *weak preparedness*, characterised by rudimentary practices in (or the absence of) climate risk management processes, physical risk adaptation and scenario analysis. Their capacity to respond to climate hazards and to mitigate their impacts is in doubt. Over a quarter of the firms domiciled in EMEs in APAC are subject to high physical risk, which is larger than the corresponding proportion in AEs and globally. This picture raises concerns about economic and financial stability, as Asian EMEs are integral to the global manufacturing supply chain and generally have low insurance protection against NatCat. A tropical cyclone and its rainbands, for instance, could sweep through several Asian economies and cause widespread damage to production assets and halt business operations if firms are not well prepared for it.

[19] The different thresholds reflect the different rating schemes in the S&P ESG assessment criteria.

Chart 7: Share of firms that are highly exposed to multiple hazards and have weak preparedness, by economy

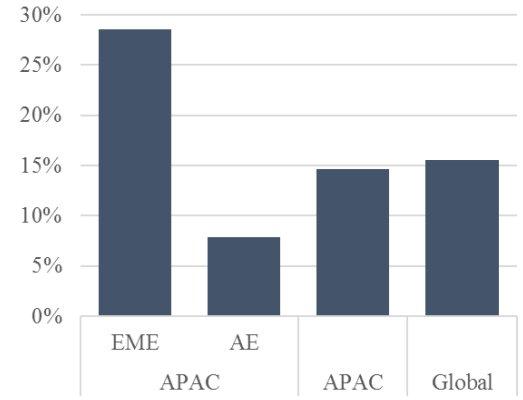
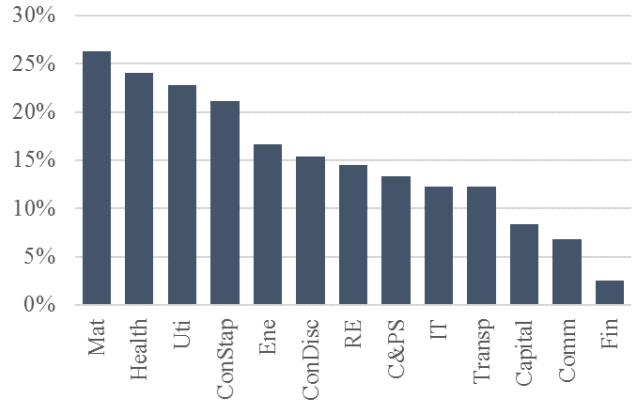


Chart 8: Share of firms that are highly exposed to multiple hazards and have weak preparedness by sector



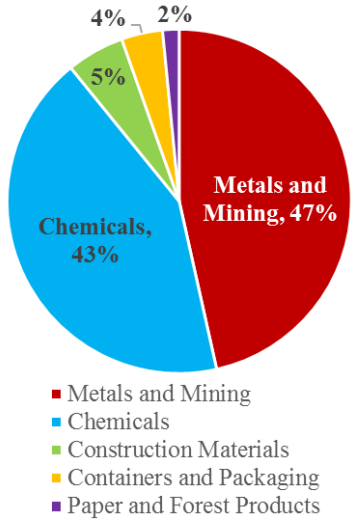
Note: A firm is deemed highly exposed to a hazard if its physical risk exposure score for that hazard is in the top quintile of a global sample of listed firms. Weak preparedness is defined as having ESG subcomponent scores of 10 or below for climate risk management and physical risk adaptation and 15 or below for scenario analysis.
Sources: S&P Global and HKMA staff calculations.

High-risk firms are more common in several sectors, including the materials, health care, utilities and consumer staples sectors (Chart 8). To illustrate the implications of physical risk for supply chains, we take a closer examination of the materials sector, given its crucial role in the green transition and the digital transformation of the global economy. About a quarter of the sample firms in the materials sector are found to be subject to high physical risk. Most of these firms are engaged in metals and mining, or chemicals manufacturing activities (**Chart 9, Panel A**), including extracting and refining the materials (e.g. nickel, lithium and copper) that are critical to the production of electric vehicles (EVs) and other electronic and electrical products. Although these high-risk materials firms tend to be smaller or similar in size and serve fewer customers than non-high-risk materials firms (**Chart 9, Panels B and C**),[20] disclosed information on customer relationships reveals that some of these high-risk materials firms serve key players in the automobile (including EVs) and electrical equipment industries.[21] Accordingly, improving the climate risk preparedness of materials firms would be conducive to strengthening the resilience of the supply chain supporting the green and digital transformation of the global economy.

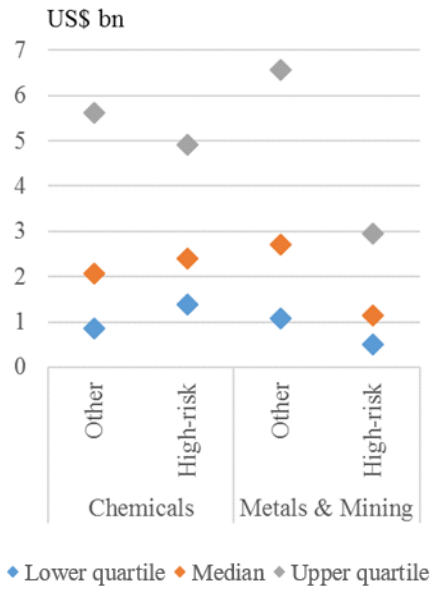
[20] Data on supplier-customer relationships (disclosed within the last two years) are sourced from S&P Global. Customers of a firm's subsidiaries are included in our analysis.
[21] More generally, the immediate customers of these high-risk materials firms account for 10%-15% of the total assets of all listed firms globally in the automobile and components and electrical equipment industries.

Chart 9: Materials firms that are subject to high physical risk

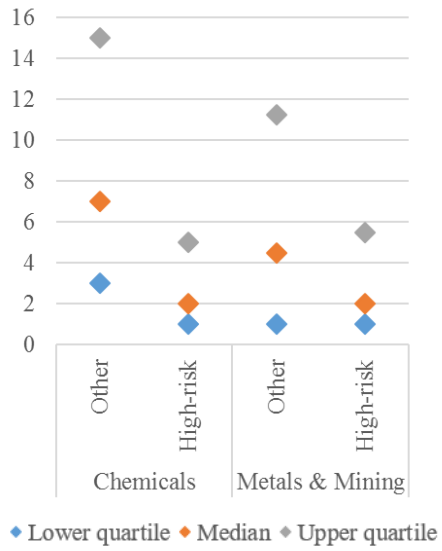
Panel A: High-risk materials firms by industry



Panel B: Asset size of materials firms



Panel C: Number of immediate customers served by materials firms



Note: Panel C only includes firms that have disclosed at least one customer.
Sources: S&P Global and HKMA staff estimates.

5. WHAT FACTORS DRIVE THE IMPROVEMENT OF CORPORATES' PREPAREDNESS FOR CLIMATE PHYSICAL RISK?

Given the importance of climate physical risk preparedness in strengthening the resilience of corporates to climate hazards, we explore the factors that drive improvements to their preparedness, with the aid of regression analysis.

Specifically, we explore whether climate-related disclosure requirements drive improvements to corporates' climate risk preparedness. Intuitively, requirements to disclose comprehensive information on climate-related performance should incentivise corporates to enhance their climate risk management and adaptation, because disclosure would expose poor performance to investor and public scrutiny. For instance, under the Task Force on Climate-Related Financial Disclosures (TCFD) framework, a firm needs to describe its processes for identifying, assessing and managing climate-related risks, and the resilience of its strategy, taking into consideration different climate-related scenarios.[22]

[22] The TCFD was created by the FSB in 2015 to improve and increase the reporting of climate-related financial information. The core elements of the TCFD's recommended climate-related financial disclosures include disclosures on governance, strategy, risk management, and metrics and targets. TCFD disbanded in 2023, with its recommendations fully incorporated into the International Financial Reporting Standards (IFRS)

As a proxy for the quality of climate-related disclosure at the economy level, we average the *S&P ESG assessment question-level scores for 'TCFD Disclosure'* of the listed firms in an economy.[23] The S&P score evaluates the extent to which a firm applies the TCFD framework to the management of climate-related risks and opportunities. While not directly measuring the stringency of disclosure requirements, the average score provides an indication of the strength of regulatory initiatives and peer pressures that enhance climate-related disclosures.

We also examine whether physical risk exposure shapes a firm's preparedness.[24] In this regard, we consider two levels of the physical risk environment. The first one is the broader, economy-level vulnerability to physical risk, as measured by the *ND-GAIN vulnerability score*. Firms operating in economies that are more vulnerable to physical risk may have greater awareness of physical risk and be better prepared for it.[25] The second one is firm-specific physical risk exposure, i.e. the *S&P physical risk exposure score* explored in Section 3. While analyses in the previous sections imply that firms' exposure to physical risk may not be strongly correlated with their preparedness, we examine this relationship more formally using a regression analysis.

Model set-up

We use a panel regression model to explore the factors that affect physical climate risk preparedness:

$$prepare_{i,t} = \alpha + \boldsymbol{\beta_1 disclosure_{j,t-1}} + \boldsymbol{\beta_2 vuln_{j,t-1}} + \boldsymbol{\beta_3 exposure_i} + \gamma_1 control_{j,t-1} + \gamma_2 controls_{i,t-1} + FE_s + FE_t + \varepsilon_{i,t} \quad (1)$$

where $prepare_{i,t}$ is the preparedness score of firm i in year t. A firm's physical risk preparedness is measured by its preparedness score, which is calculated as the weighted average of the three S&P ESG question-level scores introduced in Section 4, i.e. climate risk management, climate-related scenario analysis and physical climate risk

Sustainability Disclosure Standards, issued by the International Sustainability Standards Board (ISSB). See TCFD (2017) and the IFRS Foundation (2023) for further details.

[23] Ideally, a quantitative measure of the stringency of climate-related disclosure requirements should be used. However, no such measure is readily available, although a number of studies have provided qualitative assessments (e.g. MSCI 2023).

[24] For example, using a global sample of public companies, Li (2025) finds that increased (firm-level) physical climate exposure heightens the perceived impact of climate change, and leads to a higher level of adaptation.

[25] The ND-GAIN vulnerability score measures an economy's (i) exposure to climate hazards, (ii) sensitivity to hazards, and (iii) ability to adapt to the negative impact of climate change. For details, please refer to ND-GAIN (2024). We follow S&P's geographical classification, which uses the location of a firm's headquarters.

adaptation. We apply S&P's ESG question-level weights to each question.[26] The preparedness score ranges from 0 to 100, with a higher score indicating better preparedness.

For the explanatory variables, $disclosure_{j,t-1}$ is the average TCFD Disclosure score of firms in economy j; it ranges from 0 to 100, with a higher score indicating higher disclosure quality. $vuln_{j,t-1}$ is the ND-GAIN vulnerability score of economy j, and it ranges from 0 to 100, with a higher score indicating greater vulnerability to climate change.[27] $exposure_i$ is the exposure of firm i to physical risk, defined as either (i) a dummy variable that equals 1 if a firm's assets are highly exposed to multiple hazards, and zero otherwise; or (ii) the number of hazards to which a firm's assets are highly exposed, which ranges from 0 to 9.[28] It is a point-in-time measure as of 2023.

$control_{j,t-1}$ denotes the economy-level control variable, i.e. GDP per capita (in logarithmic form), which captures the level of economic development, as this may affect preparedness as well as disclosure quality. $controls_{i,t-1}$ is a set of firm-level control variables, such as firm size and leverage.[29] We include sector and year fixed effects (FE_s and FE_t) to capture unobserved time-invariant and firm-invariant characteristics, respectively, that could affect a firm's preparedness. To prevent the problem of reverse causality, time-varying explanatory and control variables are lagged by one year. The regression sample consists of 2,165 firms from nine APAC economies, and covers the period from 2021 to 2024.[30]

Findings

The regression analysis finds that the quality of climate-related disclosure in an economy has a positive impact on firms' preparedness for physical risk. An increase in the average TCFD Disclosure score in an economy by 1 unit is estimated to improve the preparedness score of its firms by over 1 unit (**Table 1**). Although the regression analysis does not directly examine the impact of disclosure requirements, the results imply that regulatory initiatives or peer pressure on disclosure may incentivise firms to better prepare for and adapt to physical risk. This finding is consistent with the case in

[26] S&P's ESG question-level weights vary by industry and across time.

[27] The original ND-GAIN vulnerability scores range from 0 to 1. For ease of interpreting the estimated impact of changes in the ND-GAIN vulnerability score on the average preparedness score, we multiply each economy's ND-GAIN vulnerability score by 100, such that it ranges from 0 to 100.

[28] As discussed in Section 3, a firm's assets are deemed highly exposed to a hazard if its S&P physical risk exposure score for the hazard belongs to the top quintile of a global sample of listed firms.

[29] Following the literature (e.g. Duan et al. 2025 and Leung and Wan 2023), our firm-level control variables include firm size (the logarithm of total assets), leverage (the ratio of total debt to total assets), profitability (return on assets), fixed assets (the ratio of property, plant and equipment assets to total assets), capital expenditure (relative to total assets) and liquidity (cash and short-term investments relative to total assets). Firm-level control variables are winsorised at the 1% and 99% levels to mitigate the effect of outliers.

[30] The nine economies are Australia, Chinese Mainland, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore and Thailand. The sample is constrained by the availability of ND-GAIN vulnerability score data. We use robust standard errors clustered at the firm level. See Annex 3 Tables A3 and A4, respectively, for summary statistics and details about the variables used.

Europe, where more stringent environmental regulations and climate risk disclosure requirements appear to drive increased awareness of the potential financial impacts of hazards, which in turn prompts companies' actions on adaptation (S&P Global 2024).

In addition, we find that a firm's level of physical risk preparedness is influenced by the overall physical risk vulnerability of the economy in which it is based, but not by the physical risk exposure of its own assets. An increase in the ND-GAIN vulnerability score of an economy by 1 unit is estimated to improve the preparedness score of firms in that economy by nearly 2 units. However, firm-level risk exposure is not estimated to have a statistically significant impact on preparedness. Taken together, these results suggest that while APAC corporates are generally aware of their economy's climate physical risk, they may not have sufficiently considered their own specific risk exposure. This may reflect the lack of requisite data and capacity to conduct climate risk assessments at a granular level and to form context-specific adaptation plans.[31]

Table 1: **Regression results**

Dependent variable	$\boldsymbol{prepare_{i.t}}$	
Definition of $exposure_i$	(I)	(II)
$\boldsymbol{disclosure_{j,t-1}}$	**1.18*** **	**1.18*** **
$\boldsymbol{vuln_{j,t-1}}$	**1.94*** **	**1.92*** **
$\boldsymbol{exposure_i}$	**1.09**	**-0.32**
$gdp\ per\ capita_{j,t-1}$	6.45***	6.16***
$size_{i,t-1}$	10.12***	10.12***
$leverage_{i,t-1}$	-0.16***	-0.16***
$profitability_{i,t-1}$	-0.16	-0.16*
$fixed_{i,t-1}$	-0.014	0.0043
$capex_{i,t-1}$	0.18	0.19
$liquidity_{i.t-1}$	-0.051	-0.053
Sector fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
No. of firms	2,165	2,165
Observations	6,495	6,495

Note: Columns (I) and (II) differ in the definition of $exposure_i$, with column (I) using a dummy variable that equals 1 if a firm's assets are highly exposed to multiple hazards, and column (II) using number of hazards to which a firm's assets are highly exposed. ***, ** and * denote 1%, 5% and 10% level of statistical significance
Source: HKMA staff estimates.

[31] For example, in a survey by the World Economic Forum (2023), insufficient human resources and a lack of technical expertise were cited by 34% and 31% of the surveyed businesses, respectively, as barriers to business action on climate resilience. There are also limitations of climate data, e.g. it is difficult to estimate with certainty the frequency and severity of climate events, and the spatial variability of these events.

The control variables also offer some insights. Larger and less leveraged firms tend to be better prepared for physical risk. One possible reason is that smaller firms may lack the technical skills to make their adaptation projects financially viable, as noted by NGFS (2024a). Lastly, firms located in wealthier economies, as measured by GDP per capita, are better prepared.

6. POLICY IMPLICATIONS

Overall, this study underscores the importance of strengthening the resilience of corporates to climate hazards, especially for EME corporates, with a view to mitigating the macro-financial impacts of intensifying climate physical risks. The findings of this study have some policy implications.

First, strengthening climate-related disclosure requirements could incentivise corporates to improve their climate physical risk preparedness. The regression analysis shows that firms in economies with higher disclosure quality demonstrate better preparedness for climate risk, supporting the notion that more stringent disclosure requirements could incentivise firms to improve their physical risk preparedness and step up their adaptation measures. In this sense, the active steps being taken by a number of jurisdictions in the APAC region to adopt the ISSB standards or other sustainability disclosure requirements could be instrumental in strengthening physical risk preparedness.[32] When information becomes more transparent, firms with poor climate risk management practices would be exposed to the general public and subject to scrutiny by investors and the banks providing financing.

Second, it is imperative to enhance corporates' capacity to assess climate physical risk at a more granular level and step up their adaptation planning, especially firms in EMEs and smaller firms. The ongoing efforts by the public and private sectors in the region and globally to make granular physical risk data more accessible could help narrow the data gap.[33] At the same time, training and qualification programmes to expand the talent pool for climate risk assessments and adaptation planning would benefit corporates, whether the climate-related functions are conducted in-house or assisted by external consultants. Building on rapid advances in the field, climate technology solutions

[32] According to the IFRS Foundation, several Asian economies have finalised approach to adopting the ISSB standards (e.g. Australia, Malaysia and Hong Kong SAR); for some others, regulatory status of sustainability disclosure requirement is in progress (as of June 2025).

[33] For example, authorities in Hong Kong have launched the green and sustainable finance data portal, which contains various climate-related data, such as district-level flooding and typhoon impact data; globally, the World Bank's Climate Change Knowledge Portal offers granular data related to climate physical risk.

could also be encouraged, e.g. real-time flood warning systems and digital twins (Boston Consulting Group 2024).[34]

For the financial sector, improved corporate climate-related disclosure would not only facilitate the assessment of the climate physical risk of firms in their portfolios, but would also help scale up financing for climate adaptation and resilience. Improved transparency on climate risk exposure and preparedness, together with better data availability, could enable investors to make more informed decisions and price climate-related financial products, thus driving capital towards adaptation and climate-resilience investment (NGFS 2025; OECD 2025). Furthermore, enhanced disclosure and management of climate risk and adaptation measures may improve the affordability and availability of (re-)insurance against NatCat (Möhr et al 2025; NGFS 2025), thus strengthening the financial resilience of corporates to climate hazards.

7. CONCLUSION

Climate hazards could disrupt business activities and damage corporate assets. This could have economic and financial stability implications, including supply chain disruptions and increased credit risk. In view of this, this study assesses both the exposure and resilience of APAC corporates to climate physical risk. The firm-level physical risk exposure scores reveal that nearly half of the APAC firms in the sample are highly exposed to multiple climate hazards, which is a higher proportion than the corresponding share in the global sample. With respect to resilience, while the majority of APAC firms have some form of climate risk management process in place, practices in the more granular aspects of climate scenario analysis and physical risk adaptation are rather rudimentary.

Considering both the exposure and resilience dimensions, this study finds that about 15% of the APAC firms in the sample are subject to high physical risk, as they are highly exposed to multiple climate hazards and have low preparedness across all three aspects of climate strategy considered in the analyses. In particular, EMEs have a higher proportion of high-risk firms, which should warrant our attention as Asian EMEs are integral to the global manufacturing supply chain and generally have low insurance protection against NatCat. By sector, there are more high-risk firms in the materials sector. Improving the resilience of materials firms would be conducive to the green transition and digitalisation of the economy.

The regression analysis in this study shows that firms in economies with higher quality climate-related disclosure demonstrate better preparedness for physical risk, implying that disclosure-related regulatory initiatives and peer pressure may incentivise

[34] A digital twin is a virtual representation of a physical object or system designed to accurately reflect a physical object.

firms to better prepare for and adapt to physical risks. However, firms may not have adequately accounted for its own assets' physical risk exposure, even though they may be aware of the overall physical risk vulnerability of the economy in which they are based. Smaller firms also appear to be less prepared for climate hazards.

In addition to contributing micro-level evidence to the literature on climate physical risk, the findings of this study have implications for policymakers seeking to enhance corporate resilience to physical risk. First, strengthening climate-related disclosure requirements could incentivise corporates to improve climate risk management and step up their adaptation, as disclosure exposes poor practices and opens them to scrutiny by banks, investors and the public. Improved transparency on corporate climate risk exposure and resilience could also help scale up financing for climate adaptation and resilience. Second, it is imperative to enhance the capacity of corporates to assess climate physical risk at a more granular level and step up their adaptation planning, for example, by making granular physical risk data more accessible, providing training and qualification programmes and encouraging technological solutions.

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Annex 1: Scenarios used in the S&P physical risk exposure scores

Table A1: Scenarios used in the S&P physical risk exposure scores

Climate Change Scenario	Emissions mitigation	Global average temperature
Low (SSP1-2.6)	**Aggressive**: Net zero by 2050	Rise by 1.3-2.4°C by 2100 (align with Paris Agreement)
Medium (SSP2-4.5)	**Strong**: GHG emissions stabilise at current levels until 2050 and then decline to 2100	Rise by 2.1-3.5°C by 2100
Medium-High (SSP3-7.0)	**Limited**: GHG emissions double by 2100	Rise by 2.8-4.6°C by 2100
High Climate (SSP5-8.5)	**Low**: GHG emissions triple by 2075	Rise by 3.3-5.7°C by 2100

Annex 2: S&P ESG assessment – the subcomponents related to climate physical risk preparedness used in this study

Key issues assessed under each subcomponent are extracted below. For details, see S&P Global (2025).

Table A2: ESG subcomponents related to climate physical risk preparedness

Subcomponent	Key issues assessed
Climate risk management	• Does the company have a climate risk management process? Is it available publicly? • Integrated into the centralized enterprise risk management program or a specific climate risk management process? • Types of climate-related risk included (e.g. acute physical risk, chronic physical risk, regulation, technology, legal, reputational, etc) • Value chain stages covered; time horizons covered (short-term, medium-term, long-term).
Climate-related scenario analysis	• Does the company conduct climate-related scenario analysis? Is this information available publicly? • Qualitative, quantitative or both qualitative and quantitative? • Scenarios used – physical scenarios (various RCP scenarios), transition scenarios (various IEA and NGFS scenarios, etc) or others.
Physical climate risk adaptation	• Any plan to adapt to the identified physical climate risks? Is the supporting evidence available in the public domain? • Context-specific plan or overall plan? • Coverage of physical climate risk assessment and adaptation plan (x% of total revenues; x% of new operations) • Target timeline to implement the adaptation measures.

Source: S&P Global

Annex 3: Additional information on the regression analysis

Table A3: Summary statistics of the variables used in the regression

Variables	Obs	Mean	Median	St. Dev.
Firm-level variables				
prepare	6,495	36.7	32.0	34.6
exposure (0/1)	6,495	0.44	0.00	0.50
exposure (number of hazards)	6,495	1.4	1.0	1.3
size (US$m)	6,495	23,218	3,258	70,716
leverage (%)	6,495	22.4	19.6	17.4
profitability (%)	6,495	3.6	3.1	4.7
fixed (%)	6,495	25.9	22.3	21.1
capex (%)	6,495	3.6	2.6	3.7
liquidity (%)	6,495	19.6	15.2	15.4
Economy-level variables				
vuln	6,495	36.5	36.0	2.7
disclosure	6,495	25	22	16
gdp per capita (PPP$)	6,495	42,293	44,657	20,805

Table A4: Details on data items and sources

Variable	Description	Source
Firm-level variables		
prepare	Weighted average of S&P's ESG question-level scores for climate risk management, physical climate risk adaptation, and climate-related scenario analysis. S&P's question-level weights are used. Ranges from 0 to 100.	S&P Global
exposure	Firm-level exposure to climate physical risk measured in two ways: (i) a dummy variable that equals 1 if a firm's assets are highly exposed to multiple hazards, or zero otherwise; and (ii) the number of hazards to which a firm's assets highly exposed (0 to 9). A firm is deemed highly exposed to a hazard if its S&P physical risk exposure score for the hazard belongs to the top quintile of a global sample of listed firms. This is a point-in-time measure as of 2023. The S&P physical risk exposure scores are only available from 2023.	S&P Global
size	Natural logarithm of total assets, winsorised.	S&P Global
leverage	The ratio of total debt to total assets, in percentage terms, winsorised.	S&P Global
profitability	Return on assets, in percentage terms, winsorised	S&P Global
fixed	The ratio of property, plant and equipment assets to total assets, in percentage terms, winsorised	S&P Global
capex	The ratio of capital expenditure to total assets, in percentage terms, winsorised.	S&P Global
liquidity	The ratio of cash, cash equivalents and short-term investments to total assets, in percentage terms, winsorised.	S&P Global
Economy-level variables		
vuln	ND-GAIN vulnerability score. Ranges from 0 to 100.	ND-GAIN [35]
disclosure	The average S&P ESG question-level scores on 'TCFD Disclosure' of listed firms in an economy. Ranges from 0 to 100.	S&P Global
gdp per capita	Natural logarithm of GDP per capita (current prices) in PPP dollars.	IMF

[35] Data for 2021 and 2022 are retrieved from ND-GAIN's website: https://gain.nd.edu/. Data for 2023 are retrieved from the European Commission's composite Indicators & Scoreboards Explorer: https://composite-indicators.jrc.ec.europa.eu/explorer/indices/nd-gain-ci/notre-dame-global-adaptation-initiative-country-index.