2024 FM GLOBAL RESILIENCE INDEX
METHODOLOGY

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SECTION 1

THE FACTORS OF RESILIENCE

The risk of disruption to a company's operations is a complex exposure, subject to many different influences. The process of identifying for an index a set of core drivers with significant impact on enterprise resilience to disruptive events is partly heuristic, partly statistical, and partly practical.

Research into the causes of operational disruption and subsequent recovery highlight some common themes. Conflict and political unrest, energy dependency, natural disasters including climate-related events, rapid urbanization, maturity and investment in risk management, infrastructure and the supply chain all appear regularly. Increasingly, cyber risk, pandemic risk, and water stress loom large.

To meet statistical criteria, the factors in the index must have an impact on resilience; represent faithfully the intended property; have sufficient sensitivity to detect changes in resilience, but not so much volatility as to disrupt the index; exhibit minimal correlation across factors; and be calculated consistently over time.

Practical considerations require that the data are available, quantitative (or quantifiable), global, annual and from credible sources.

The FM Global Resilience Index is a composite measure of countries' relative enterprise resilience to disruptive events.

Eighteen factors of resilience combine to form the FM Global Resilience Index. These include six physical factors and 12 macro factors.

1. **Physical** – A unique attribute of the FM Global Resilience Index is its ability to draw upon the wealth of experience and data gathered over many years by FM Global's team of property risk engineers who visit and assess more than 100,000 locations annually across the world. The metrics have the advantage of being applied consistently across all industry sectors and regions. Five physical factors are sourced from FM Global: climate risk exposure, climate change exposure, climate risk quality, seismic risk exposure, and fire risk quality. A sixth physical factor is included to capture a country's commitment to cybersecurity.
2. **Macro** – Twelve macro factors embrace political, economic, and social resilience. Each macro data series is sourced from an authoritative agency. The macro factors include productivity, health expenditure, education, inflation, political risk, control of corruption, logistics, internet usage, urbanization rate, water stress, greenhouse gas (GHG) emissions, and energy intensity.

To verify the FM Global Resilience Index, FM Global leveraged its proprietary data on insured engineered locations worldwide. Expected business interruption (BI) losses were scaled by the corresponding insured property value and analyzed. Locations in countries ranking higher in the index were shown, on average, to have shorter expected downtime associated with their worst deficiencies. The results serve to validate the index, where countries with greater business resilience appear higher in the ranking.

Locations in countries ranked in the top 50 of the FM Global Resilience Index recover over 30% faster from property losses, on average, than locations in other countries.

SECTION 2

INDEX CONSTRUCTION

The FM Global Resilience Index combines equally the 18 identified factors of resilience, and provides ranked scores for 130 countries and territories around the world. The largest countries (by gross domestic product) with the most complete set of data across the most recent five years are identified.

The index enables business executives to identify the sources of strength and vulnerability in a country's resilience, in terms both of physical and macro risks. Such analysis offers opportunities to managers seeking to improve their company's resilience to disruptive events.

Described below are the key procedures applied to construct the FM Global Resilience Index.

1. Annual data, for the most recent five years, are collected for the maximum number of countries for each of the 18 factors.
2. A common set of countries with data availability across the 18 factors is identified and aligned into a consistent data set.
3. Each data series is standardized through the calculation of z-scores to enable comparison and combination of factors with different units. Where necessary, z-scores are inverted for consistency across variables.
4. The z-scores are converted into scores on a scale of 0-100 for presentation purposes.
5. The scores of the 18 factors then are combined with equal weighting to form the index.

The index comprises the rankings for the top 130 countries and territories for which data are available. Each of Canada, China, India, and the United States is divided into three regions because their geographical spread includes disparate exposures to natural hazards such as wind, flood, and earthquake.

Based on data availability, new entrants to, and exits from, the index may emerge. To maintain consistency in the interpretation of results, the index is restricted to the top 130 countries and territories in any given year.

Many simulations were carried out to determine the most appropriate weighting scheme. Ultimately, very little difference emerged in rankings from the adoption of various weighting schemes so, rather than impose a subjective system of aggregation without due cause, it is appropriate to remain with equal weights across the 18 factors of resilience.

The composite index is, by design, a simplified, summary measure of resilience. The FM Global Resilience Index provides an indication of countries' relative enterprise resilience to disruptive events.

In combination with additional information, the index provides business executives with a national context to assist in the risk evaluations of supply chains, the siting of new facilities and in acquisition/divestment due diligence.

SECTION 3

SOURCES AND DEFINITIONS

Provided in this section is the technical definition of each index driver and its data source.

Table 1: Definitions and data sources

PHYSICAL FACTORS		
CLIMATE RISK EXPOSURE	The percentage of a country's area devoted to economic activities that is exposed to wind or flood	FM Global
CLIMATE CHANGE EXPOSURE	The percentage of a country's area devoted to economic activities that is exposed to climate change impacts (estimated 2050) from wind or flood	FM Global
CLIMATE RISK QUALITY	The quality and enforcement of a country's building code with respect to wind-resistant design (80%), combined with the level of wind and flood risk improvement achieved, given the inherent wind and flood risks in a country (20%)	FM Global
SEISMIC RISK EXPOSURE	The percentage of a country's area devoted to economic activities that is exposed to earthquake risk	FM Global
FIRE RISK QUALITY	The quality and enforcement of a country's building code with respect to fire-based design (80%), combined with the level of fire risk improvement achieved, given the inherent fire risks in a country (20%)	FM Global
CYBERSECURITY	A country's commitment to cybersecurity; includes legal measures, technical measures, organizational measures, capacity development and cooperation	United Nations Global Cybersecurity Index (GCI)
MACRO FACTORS		
PRODUCTIVITY	Gross Domestic Product (GDP) per capita, based on Purchasing Power Parity (PPP)	International Monetary Fund World Economic Outlook (WEO) database
HEALTH EXPENDITURE	Average expenditure on health per person, based on PPP; includes public and private financing	World Health Organization Global Health Expenditure Database (GHED)

EDUCATION	Equally weighted average of Expected Years of Schooling and Mean Years of Schooling	United Nations Human Development Index (HDI)
INFLATION	Annual percentage change in average consumer prices	International Monetary Fund WEO
POLITICAL RISK	The perceived likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism	World Bank Worldwide Governance Indicators (WGI)
CONTROL OF CORRUPTION	The perceived extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as capture of the state by elites and private interests	World Bank WGI
LOGISTICS	A survey-based assessment of how easy it is to export to a target country in terms of the quality of infrastructure, the quality and availability of logistics activities, and public sector bottlenecks	World Bank Logistics Performance Index (LPI)
INTERNET USAGE	Individuals using the internet as a percentage of the population	United Nations International Telecommunications Union (ITU)
URBANIZATION RATE	The average annual rate of change in the extent to which a country's population is living in an urban area	United Nations World Urbanization Prospects (WUP)
WATER STRESS	Freshwater withdrawal as a proportion of available freshwater resources	World Bank
GHG EMISSIONS	Greenhouse gas (GHG) emissions divided by GDP, based on PPP; measures the GHGs emitted per unit of productivity	International Energy Agency (IEA) Emissions Database for Global Atmospheric Research (EDGAR)
ENERGY INTENSITY	Total energy consumption divided by GDP, based on PPP; measures the dependency on energy per unit of productivity	U.S. Energy Information Administration (EIA)

Further detail on FM Global's data that underpins the physical factors of resilience is provided below.

1. **Climate risk exposure, climate change exposure and seismic risk exposure** – FM Global property risk engineers use wind, riverine flood, and earthquake maps to determine whether industrial locations they visit are exposed to any natural hazard. Satellite-based night lights are used as a proxy to indicate economic/industrial activities.

   For each country, the percentage captures how great an area of economic/industrial activities is exposed either to wind or riverine flood perils, now or in the future, in the case of climate risk exposure and climate change exposure, or earthquake risk, in the case of seismic risk exposure. For climate risk exposure, exposed areas are determined based on potential losses from 100-year wind gusts not less than 100mph (161 kph) or water flowing from rivers in 100-year flood zones.

   To estimate the 2050 impact of climate change on populated areas exposed to wind or flood, the change in mean wind speeds and the change in maximum 1-day precipitation are used, both produced by the Coupled Model Intercomparison Project (CMIP6) global climate model ensemble. The RCP4.5 climate change scenario is chosen as an intermediate scenario for the trajectory of future greenhouse gas emissions and the adoption of green technologies globally, and the 2041-2060 time horizon to represent the year 2050 as the midpoint.

   For seismic risk exposure, exposed areas are determined based on potential losses more frequent than 500-year earthquake motions that can cause damage to weak buildings.

   Canada, China, India, and the United States are each divided into three regions to capture the significantly different exposures to natural hazards within these countries. Regions in China are based on provinces, municipalities and autonomous regions, and regions in the United States are based on states. The composition of regions for China and the United States is presented in Section 5. For Canada and India, Region 1 covers the eastern, coastal area of each country where wind and flood are the dominant natural hazard perils. Earthquake exposure is the dominant natural hazard in Region 2 (though wind and flood remain significant), which includes the western coastal provinces and territories in Canada and, for India, the northern part of the country plus a chain of Islands in the Bay of Bengal. For each of Canada and India, Region 3 has lower exposure to wind, flood, or earthquake.

2. **Climate risk quality** – To capture the quality of a country's management of climate-related risks, two components are combined. Dominant (and weighted 80%) is a measure of the quality and enforcement of a country's building code with respect to wind-resistant design. A full exposition of the building code rating methodology is provided in Section 4. The remaining component (weighted 20%) reflects the risk quality of actual facilities and is obtained from FM Global's proprietary RiskMark® algorithm available to FM Global clients.

   RiskMark is a mathematical benchmarking model that calculates the relative risk quality of FM Global's insured locations. It uses a 100-point scale, where 100 represents the best-managed, highest-quality risk.

The RiskMark score of a location includes a measure of both inherent risks and risks where there are recommendations for improvement. The potential RiskMark score represents the highest possible score achievable by that location, given those inherent risks. The percentage potential RiskMark score provides a way to measure risk improvement opportunities given the inherent risks. It is calculated by dividing the actual RiskMark score by the potential RiskMark score.

For climate risk quality, the weighted average (by total insured value) percentage potential RiskMark score for wind and riverine flood is provided for each country or region for which there is a statistically valid sample of locations. Those countries with few locations are rated solely by the quality and enforcement of the country's building code with respect to wind-resistant design.

3. **Fire risk quality** – For fire risk quality, the same logic as for climate risk quality applies. The quality of a country's management of fire risk combines two components: a measure of the quality and enforcement of a country's building code with respect to fire-based design (weighted 80%), and a measure of the fire risk quality of actual facilities visited by FM Global's property risk engineers.

   For this metric, the weighted average (by total insured value) percentage potential RiskMark score for fire and equipment hazards is provided for each country or region for which there is a statistically valid sample of locations. Again, those countries with few locations are rated solely by the quality and enforcement of the country's building code with respect to fire-based design.

The index compiles data from sources such as the United Nations, World Bank, and the International Monetary Fund, and combines them with data gathered over many years by FM Global's team of property risk engineers who visit and assess more than 100,000 locations annually across the world.

SECTION 4

BUILDING CODE RATINGS

Described in this section is the method by which FM Global property risk engineers estimated the quality of building codes around the world with respect to natural hazard and fire risks. Evaluation of the outcome of building codes and regulations entails a method that is based not only on the requirements of the code but also on the level of its enforcement. The approach adopted combines an understanding of the requirements with actual observations by FM Global property risk engineers in the field.

NATURAL HAZARD ELEMENTS	SCORE
Is there a regularly used and updated building code that includes mandatory requirements for natural hazard-resistant designs published?	0, 1, 2
Are these requirements regularly enforced?	0, 1, 2
Are there current, nationally recognized flood maps available?	0, 1
FIRE ELEMENTS	**SCORE**
Is there a regularly used and updated building code that includes mandatory requirements for fire-based design published in the country?	0, 1, 2
Are these requirements regularly enforced?	0, 1, 2
Based on a 5,000-m2 building, would the code require automatic sprinklers to be installed in any office/warehouse/factory buildings?	0, 1

CODE RATING METHODOLOGY

1. National building codes and their implementation were reviewed first to define the key questions for a survey that would yield the most, and most relevant, responses.
2. Based on this review, and following a pilot study, the following filter questions were established to address natural hazard and fire risk, respectively:
    a. Is there a regularly used and updated building code that includes mandatory requirements for natural hazard-resistant designs published in the country?
    b. Is there a regularly used and updated building code that includes mandatory requirements for fire-based design published in the country?
3. To ensure that requirements are fully understood, they need to be adopted fully and within the mainstream of building practice in a country. A revised code or draft code would not meet these criteria. A code quality score of 2 was assigned for observed full code covering natural hazard/fire elements, 1 for limited code covering these elements, and 0 where these elements are absent.
    a. In the case of natural hazards, matching design requirements for seismic, wind, snow, etc., were considered.
    b. In the case of fire risk, requirements covering fire-rated compartmentation, fire protection, combustibility requirements for materials, etc., were considered.

4. As noted, the presence of strong enforcement will ensure that the outcome of a code is delivered. Therefore, for each natural hazard and fire risk, the following contingency question was asked: Are these requirements regularly enforced?
5. The focus is placed on what is observed in a country rather than what is intended, and responses to the question of enforcement concentrate on the skill, education and training available to implement the requirements regularly. A code enforcement score of 2 was assigned for observed strong and consistent enforcement, 1 for limited enforcement, and 0 for negligible or poor enforcement. The code enforcement score is applied as a multiplier to the code quality score, reflecting the practical power of effective code enforcement.
6. A final modifier was added to the resultant score (quality x enforcement) to introduce the observed availability of flood maps into the natural hazard elements and the requirements for automatic sprinkler protection into the fire elements.
    a. There are limited elements within building codes with respect to flood hazard. Usually, it is considered in the wider elements of building laws relating to development and land use that determine where a building can be sited. However, this requires a scheme of flood maps to assess the risk. A score of 1 is added if nationally recognized flood maps are present and available in the country.
    b. FM Global's experience shows that a key driver in minimizing fire damage is the presence of automatic sprinkler protection. In the industrial arena, the typical target occupancies are offices, warehouses, and factories; in particular, buildings of moderate size at 5,000 square meters. Such buildings represent a reasonable scale of investment where fire protection makes economic sense, based on value alone in most territories. A score of 1 is added if there is a requirement for the installation of automatic sprinklers within this size of building in any of the specified occupancies.
7. The questions were distributed to FM Global property risk engineers who were surveyed and interviewed for their expert assessment of building code quality and enforcement, based on their actual observations in the field.
8. For those countries where limited observations were available, secondary research in the form of a literature review of the available code was used to supplement the primary field research.
9. Finally, the ratings were reviewed iteratively by the engineering and standards community to ensure consistency in grading, and to reach consensus on the relative ratings.

The FM Global engineering team operates across the world, visiting industrial and commercial clients to undertake property risk evaluations. The engineers apply their training and assess the current conditions to the applicable FM Global standards to determine if there are opportunities to enhance the protection of a facility against natural hazard and fire risks. Through this work, FM Global engineers enjoy unique access to observe the practice and application of building codes and regulations across different countries.

The index provides business executives with a national context to assist in the risk evaluations of supply chains, the siting of new facilities and in acquisition/divestment due diligence.

SECTION 5

COUNTRY REGIONS BY DOMINANT NATURAL HAZARD

CHINA 1	CHINA 2	CHINA 3	UNITED STATES 1	UNITED STATES 2	UNITED STATES 3
Wind	**Earthquake**	**Miscella-neous**	**Wind**	**Earthquake**	**Miscellaneous**
Fujian	Hebei	Anhui	Alabama	Alaska	Arizona
Guangdong	Jiangsu	Beijing	Connecticut	California	Arkansas
Hainan	Neimenggu	Chongqing	Delaware	Hawaii	Colorado
Jilin	Ningxia	Gansu	Florida	Nevada	District of Columbia
Liaoning	Sichuan	Guangxi	Georgia	Oregon	Idaho
Shandong	Tianjin	Guizhou	Louisiana	Puerto Rico	Illinois
Shanghai	Yunnan	Heilongjiang	Maine	Utah	Indiana
Zhejiang		Henan	Maryland	Washington	Iowa
		Hubei	Massachusetts		Kansas
		Hunan	Mississippi		Kentucky
		Jiangxi	New Hamp-shire		Michigan
		Qinghai	New Jersey		Minnesota
		Shaanxi (Shanxi)	New York		Missouri
		Xinjiang	North Carolina		Montana
			Rhode Island		Nebraska
			South Carolina		New Mexico
			Texas		North Dakota
			Virgin Islands		Ohio
			Virginia		Oklahoma
					Pennsylvania
					South Dakota
					Tennessee
					Vermont
					West Virginia
					Wisconsin
					Wyoming

SECTION 6

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ABOUT FM GLOBAL

Established nearly two centuries ago, FM Global is a mutual insurance company whose capital, scientific research capability and engineering expertise are solely dedicated to property risk management and the resilience of its client-owners. These owners, who share the belief that the majority of property loss is preventable, represent many of the world's largest organizations, including one of every four Fortune 500 companies. They work with FM Global to better understand the hazards that can impact their business continuity in order to make cost-effective risk management decisions, combining property loss prevention with insurance protection.
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ABOUT PENTLAND ANALYTICS

Pentland Analytics provides advanced analytics and advisory services to the executive management of the world's leading companies. The firm converts complex business issues into mathematical models that yield fresh insights and direction. The results inform strategic decisions and help to build clients' resilience, reputation, and long-term owner value.
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