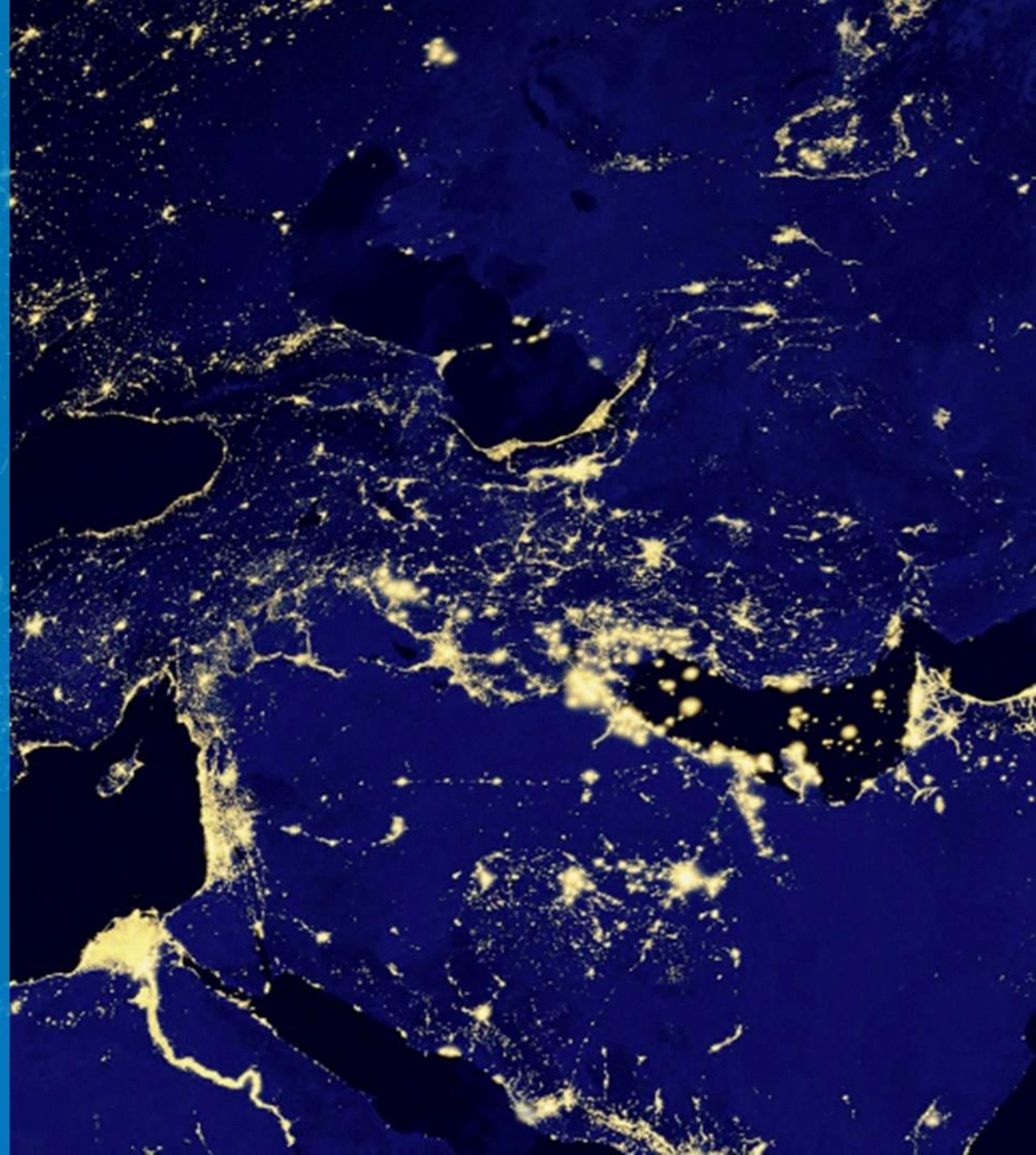Swiss Re Institute

Black Swans, Grey Swans, Grey Rhinos, & Perfect Storms: Managing risk to ensure resilience in the face of the next crisis

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June, 2020

Summary Points

- Metaphors, framing, & mental models impact the way we make decisions and how we respond to downside risk events:
  - Preparation (e.g., "We have enough capital for foreseeable events)
  - Accountability (e.g., "Business strategies that don't anticipate foreseeable events should lead to mgt changes)
  - Scenario development
- Causal inference & counterfactual thinking
  - Search out causal drivers, confounders, and contingent effects in the scenario analyses
  - Avoid false dichotomies− scenarios are not either/or, but a spectrum of possibilities; thresholds & gradients matter
- Animal guidance to scenario analyses
- Reverse stress testing
  - Link scenarios not only to institutional failure, but also to material changes to management strategy
  - Delve into secondary, tertiary, & cascade effects
- Lessons learned and way forward

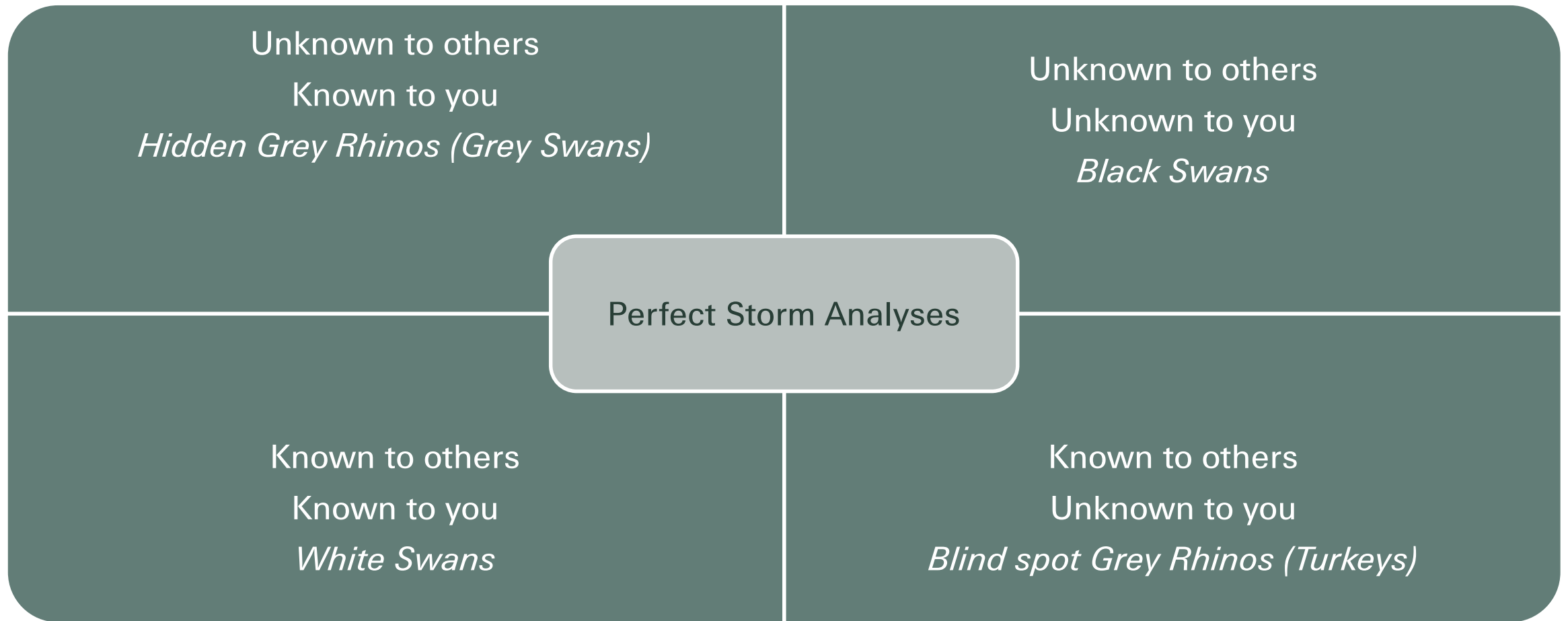Swiss Re
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Metaphors & framing

Framing

(Swiss Re Institute, SONAR Report)

- Societal environment

- Political environment

- Technological & natural environmnet

- Business & competitive environment

(Composite view from various publications)

- Deflation (Japanification)

- (Wealth) redistribution (Economic output share to labor at multi-decade low)

- Deglobalization (Nationalism)

- Demographics (Some countries older & some younger)

- Digitization

- Disruption (Coronavirus)

Adapted Johari window (Luft & Ingham, 1955)

Unknown to others
Known to you
Hidden Grey Rhinos (Grey Swans)

Unknown to others
Unknown to you
Black Swans

Perfect Storm Analyses

Known to others
Known to you
White Swans

Known to others
Unknown to you
Blind spot Grey Rhinos (Turkeys)

Black swans, gray rhinos, and perfect storms from new *General Purpose Technologies*

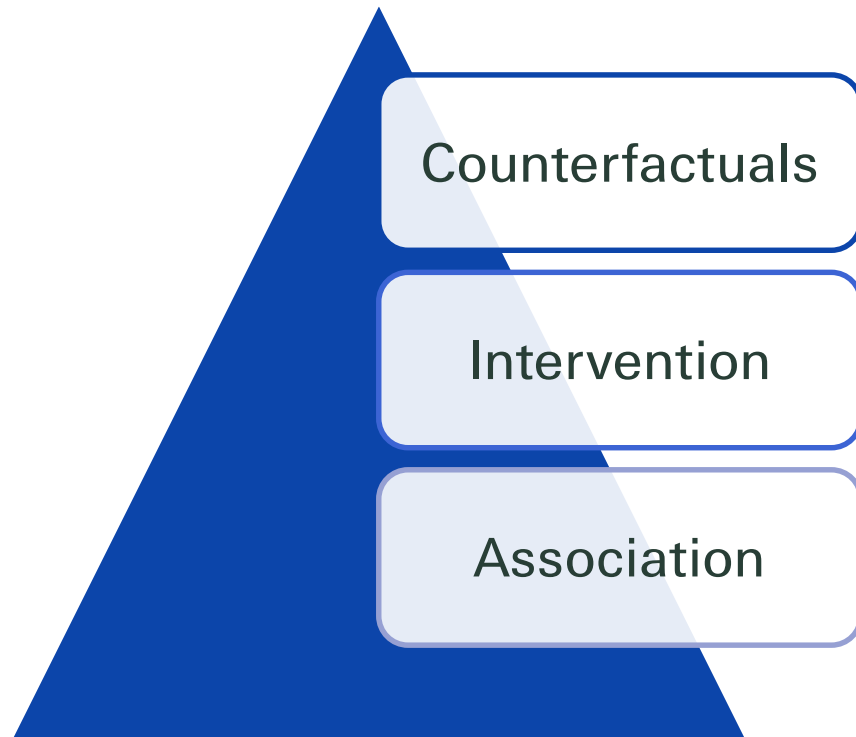| General purpose technologies change the risk landscape	Extreme-downside scenario categories are not created equal	Mitigation
• Lead to new risks & alter incentives • Create coordination & organizational challenges related to adoption and diffusion	• Black swans (Nassim Taleb): Unknowable given current information & virtually impossible to predict • Grey swans: Low probability & describable & analyzable • Gray rhinos (Michele Wucker): Moderate probability & straightforwardly predictable given current information, but neglected • Perfect storms (Operational research): Low probability & not straightforwardly predictable given the outcome results from interaction of infrequent events, but can be identified via scenario analysis & counterfactual analyses	• Focus on scenario-based analyses in addition to forecasts • Undertake deeper analyses of underlying assumptions, relationships, and data • Spend more time and resources on process management • Renew efforts to enforce *preproducibility, reproducibility,* and *out-of-sample testing*

Causal inference & counterfactual thinking

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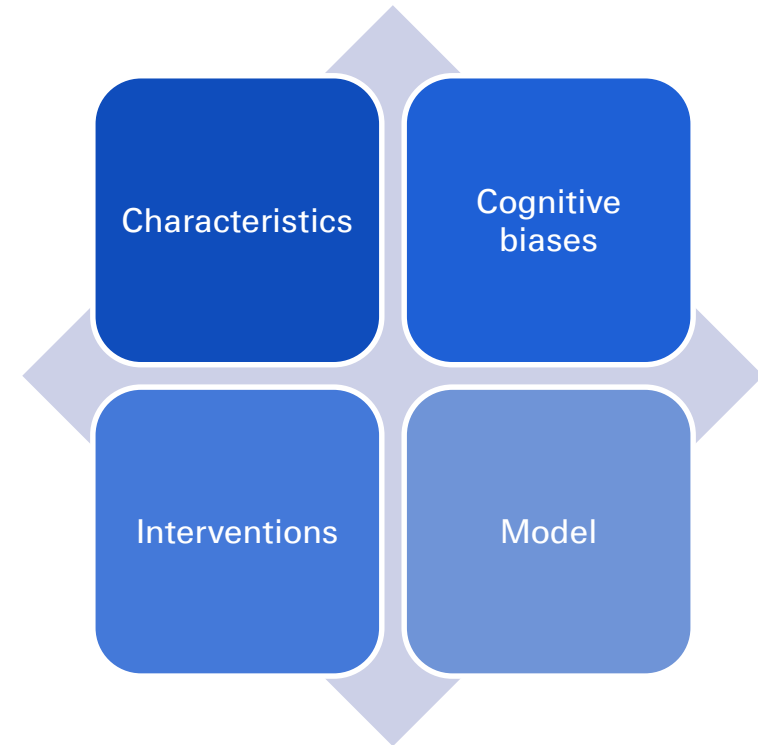# Probability as a subjective assessment (Bayesian perspective)

- Extreme events are not amenable to frequentist assessment

- Stress testing & scenario analyses suffer from incomplete & sparse data, often with bias

- Integrate theories (in a scientific sense), data-driven models, & subject-matter expertise

- Bayesian approach can be more useful

Are we collectively making the most of the many "big" repositories of data?

Understand causation

Understand context

Counterfactuals

Intervention

Association

Characteristics

Cognitive biases

Interventions

Model

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U = Type of hackable point (Savvy users, Naïve users, IoT)

X = Online Dependence

Z = More vulnerabilities

Y = Cyber hacks
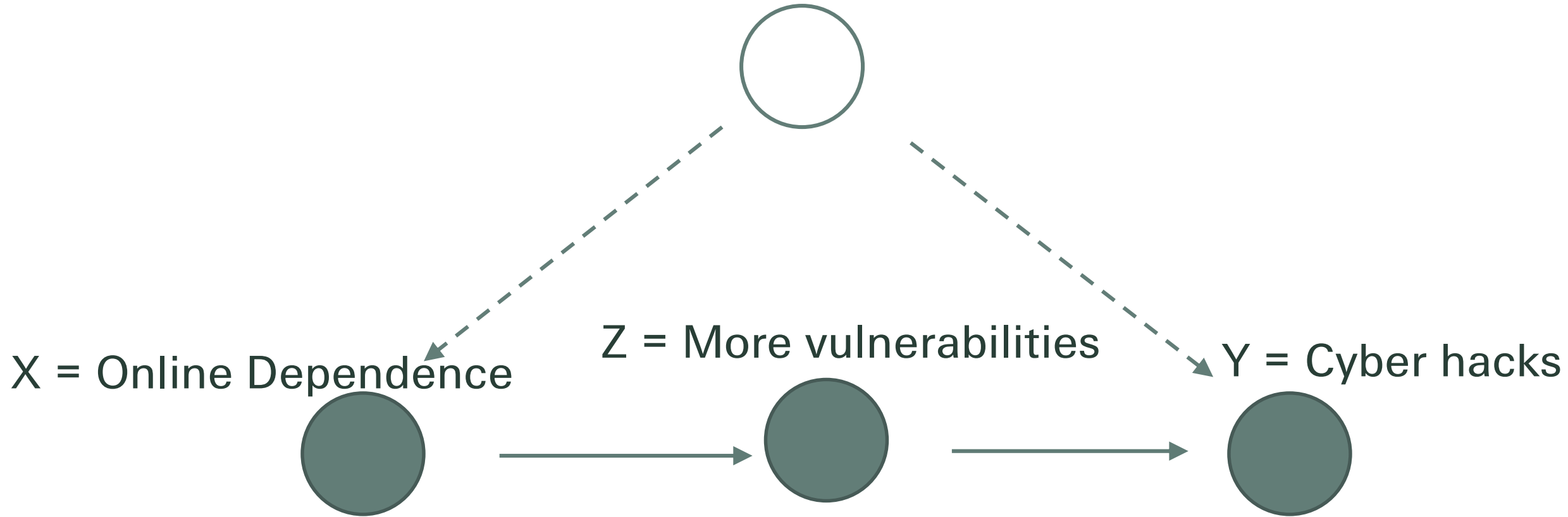
Data work can sometimes fall prey to Simpson's Paradox

- Definably distinct groups (e.g., hackable point types, age cohorts, occupations, etc.)

- Different groups have different sensitivities to causal drivers

- Different growth rates across groups with most sensitive group growing the fastest

- Result is that aggregate trend is in one direction

- Individual group trends are in the opposite direction

Causal inference & Counterfactual thinking

- Mediation analysis: Identify confounders

- Look for Simpson's paradox

- Assess **natural direct effects & natural indirect effects**

- Use backcasting
  - Work backwards to achieve a desirable future outcome/objective
  - Deliberately normative

- Identify hinge events to develop counterfactual analyses to inform scenario development

- **Confounder: Treatment and outcome is affected (Simpson's paradox− Overall effect reversed when segmented by confounder)**

- **Collider: Risk factor and outcome is affected (Berkson's paradox− No effect or negative effect is shown to have a positive effect when data restricted to the collider)**

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Animal guidance to scenario analyses

- Preparedness & accountability
- Trading off short-term cost & long-term sustainability

Black Swans (Taleb, 2007) Historical perspective for benchmarking

- World War I

- Advent of the personal computer

- Rise of the internet

- Fukushima nuclear disaster

Perfect Storms: Systems, Narratives, and Heuristics

- "Dynamically changing" normal: Inter-related crises...
  - Health
  - Economic
  - Political
  - Technology
  - Environment

- Covid-19 cascade still littered with unknowns...
  - Health
  - Economic
  - Infrastructural
  - Political

Grey Swans

Event Description

- Mental health epidemic– particularly among younger generations

- Deglobalization leads to uncoordinated technical standards & regulations

- Kindleberger or Thucydides trap: Rising power challenges established power

- Digitization pace (accelerated by Covid-19):
  - Legacy hardware & software (buried in enterprise software software systems)-- system fragility
  - **Cyber-risk**
  - Algorithmic risk & malpractice

- Digitization (un)preparedness:
  - Enterprise system fragility
  - Unproductive enterprise machine intelligence
  - Adversarial machine learning
  - Inadequate frameworks to ensure *digital trust*

Perfect Storm Assessment

- Widespread social & economic impact plus the ongoing health-care cost

- Disrupted supply chain & reduced economic growth arising from deglobalization

- China-US war (Thucydides) and/or China does not provide "global public goods" (e.g., rule of law)

- Digital contagion can depend on points of vulnerability (e.g., IoT); cyber war becomes elusive

- Linkages across technology, algorithmic development, system complexity & regulation

- Industry verticals & specific infrastructure (in)adequacies should be assessed collectively

- Speed of adopting MI & digital verification with other industry & geopolitical changes creates different contexts; regions on different tracks

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Greyer Swans (relatively lower probability, but possibly high impact)

- Quantum computing (Quantum-inspired algorithms, Quantum-vulnerable cryptography)

- Nanotechnology

- Unmanned aerial mobility (UAM); Electric, vertical-takeoff landing vehicles (eVTOLs)

- Artificially intelligent self-writing software

- Integrated autonomous mobility (air, land, sea)

- Algorithmic malpractice arising from excessive dependence on available sub-components

- Adversarial machine learning

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Grey Rhinos (Wucker, 2016)
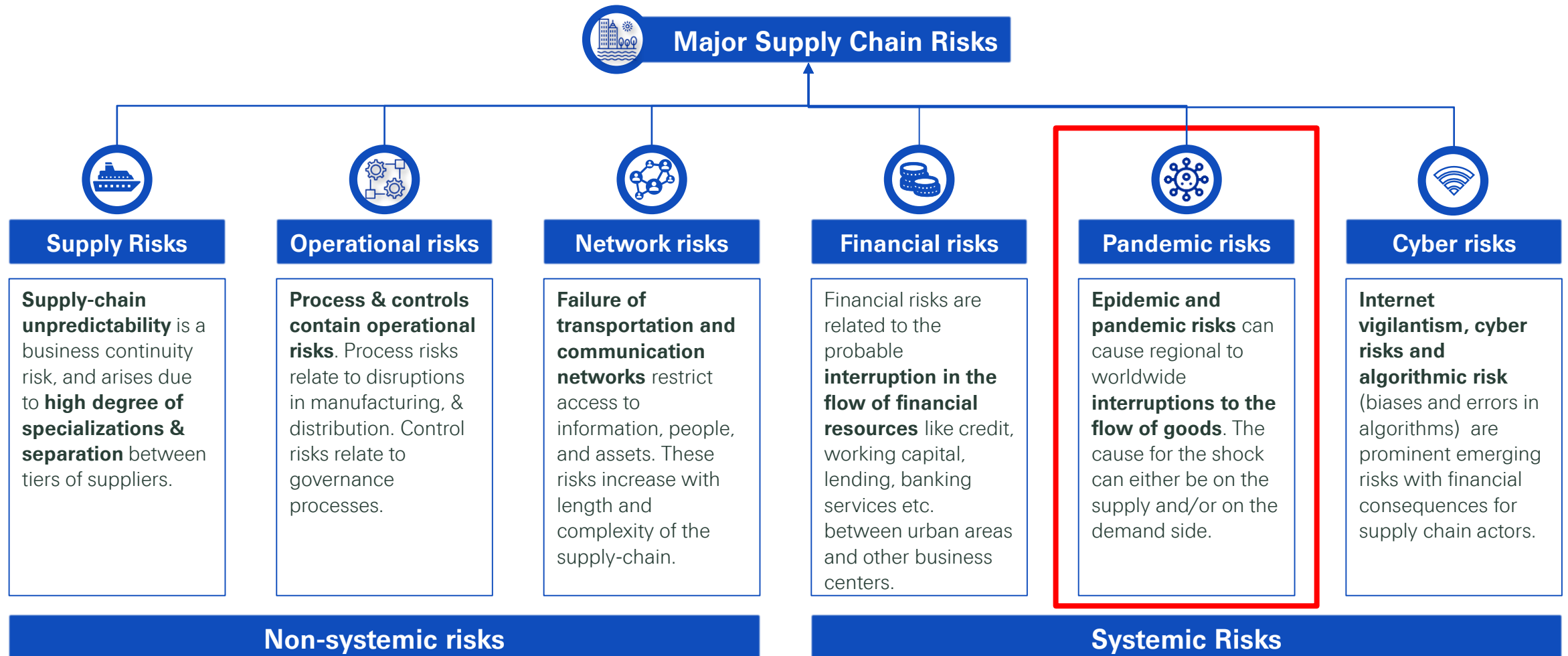
Event Description

- Climate-change induced natural disasters & impact on food, water, shelter, & air

- Multi-faceted threat to supply chain & its resilience

- Continued deflation & low (negative) interest rates

- A trillionaire & 25% unemployment (wealth inequality)

- Intergenerational imbalances & conflict (retirement/pension funds crises)

- Next Great Kanto Earthquake (Tokyo metropolitan area)

- Continuing pandemic & new pandemics

Perfect Storm Assessment

- Catastrophes; Food chain disruption; Ocean acidification; Invasive species; Social & political

- Lack of redundancy & resiliency in the global supply chain

- Reduces macroeconomic resilience & creates difficult environments for financial services

- Political systems compromised; monetary & fiscal policy less effective

- Financial & real estate markets impacted; social & political unrest

- Supply chain disruption & financial market impact− particularly liquidity provision

- Lower economic growth trajectory; mass industrial disruption

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Grey Rhino Case Study: Supply chain disruption

Covid-19 pandemic risk highlights new nature of systemic risks: Data-driven risk monitoring facilitates tracking of systemic & non-systemic supply-chain risks.

Major Supply Chain Risks

Supply Risks

Supply-chain unpredictability is a business continuity risk, and arises due to **high degree of specializations & separation** between tiers of suppliers.

Operational risks

Process & controls contain operational risks. Process risks relate to disruptions in manufacturing, & distribution. Control risks relate to governance processes.

Network risks

Failure of transportation and communication networks restrict access to information, people, and assets. These risks increase with length and complexity of the supply-chain.

Financial risks

Financial risks are related to the probable **interruption in the flow of financial resources** like credit, working capital, lending, banking services etc. between urban areas and other business centers.

Pandemic risks

Epidemic and pandemic risks can cause regional to worldwide **interruptions to the flow of goods**. The cause for the shock can either be on the supply and/or on the demand side.

Cyber risks

Internet vigilantism, cyber risks and algorithmic risk (biases and errors in algorithms) are prominent emerging risks with financial consequences for supply chain actors.

Non-systemic risks

Systemic Risks

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Covid-19 brought unprecedented challenges across verticals redefining Next Gen Supply Chain resilience

Maritime Supply Chain:
Cargo at Rest and at Risk

Cargo has been steadily **building up in warehouses, port terminals, and inland depots** during the lockdown as factories have shut down production.

Airfreight Supply Chain:
Spiking demand

As countries run out of **critical medical supplies the demand for airfreight spiked.** Year over year airfreight prices out of China are up 253%.

Agri-Business Supply Chain:
Food demand-supply mismatch

U.S. has two distinct food supply chains: one for grocery stores and one for the food service industry. Covid-19 forced the latter to close. Farmers are forced to dump milk and let fresh vegetables rot even as more Americans face food insecurity.

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Increasing global segmentation creates more challenges where technology may be best suited to address

1 Countries have different policy measures in pandemic containment, which creates divergence in economic & social results between advanced & emerging markets, and the East & West.

2 Prior to the pandemic, there were already signs that globalization had peaked due to the developing US-China trade war, rising global nationalism & populism

3 US-China trade war has no end in sight and is escalating. While decoupling the two countries is difficult, partial retreat from global value chains is a negative-sum game

4 Pandemic will accelerate parallel supply chains; more industries will relocate out of China, decreasing global cooperation and increasing regional cooperation

5 Strategic (high-tech) and national security productions (health and medical related production) will become more domestically concentrated

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Reverse stress testing

Data-driven insight does not necessarily lead to evidence-based decision making

- Most CEOs value data-driven insight, but still do not rely on this evidence for key decisions i.e., Overlook data-driven insights to follow intuition (KPMG, 2018)
    - US: 78%
    - UK: 68%
    - Germany: 61%
- Despite an explosion in data and published research, much of this research is not reproducible
    - Data science/statistics often wrong
    - Bias toward publishing statistically significant results
    - Survivorship/selection bias
    - Confirmation bias
    - p- hacking
- ***SRI contributes to a global effort to apply data science tools properly to support superior decision making***
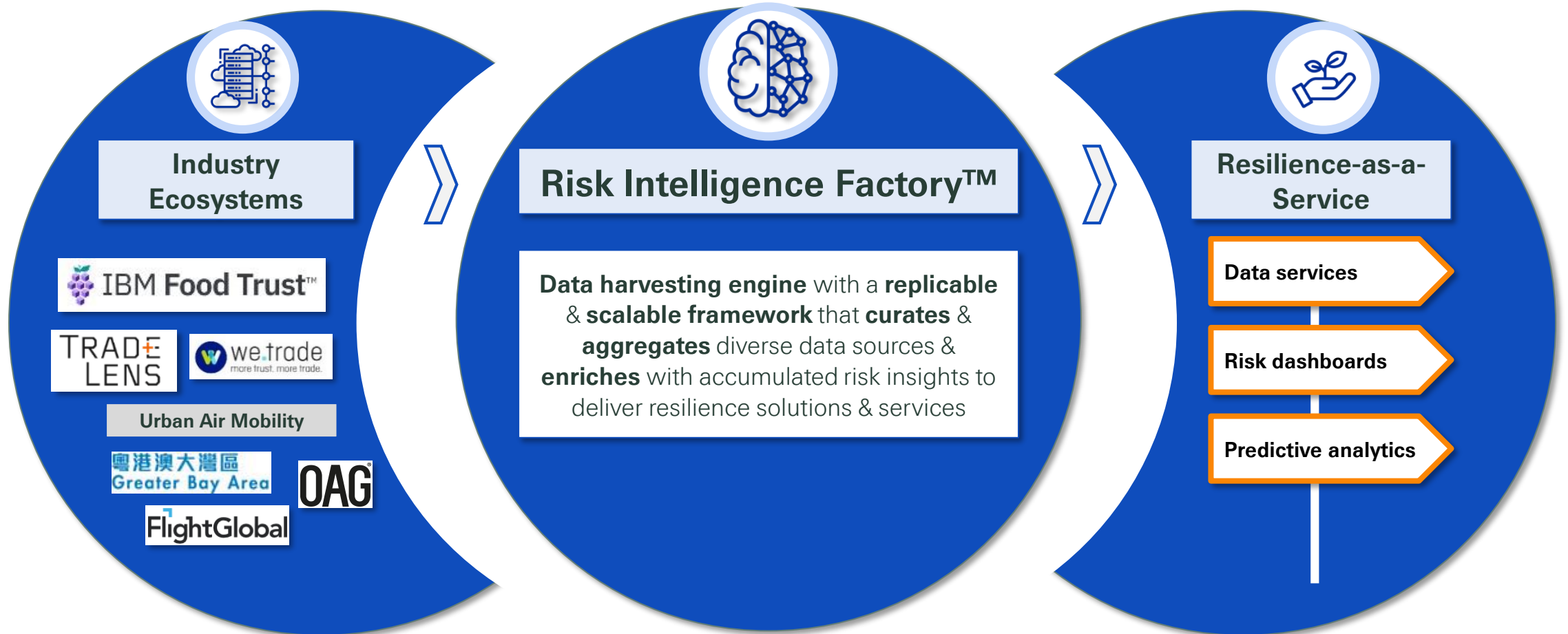
Thoughts on reverse testing

- Focus on what causes business strategy to change & what causes management to change
    - Employ counterfactual reasoning
    - Identify consequences cascade
    - Segment business lines, asset classes, liability classes, etc.
- Distinguish P&L events from capital events
- Incorporate both structured & unstructured data
- Dive into trade-off analyses– when do we reduce short-term profitability to improve long-term sustainable profitability?

- Embrace fuzzy & heuristic analyses: Don't let the elegant be the enemy of the useful
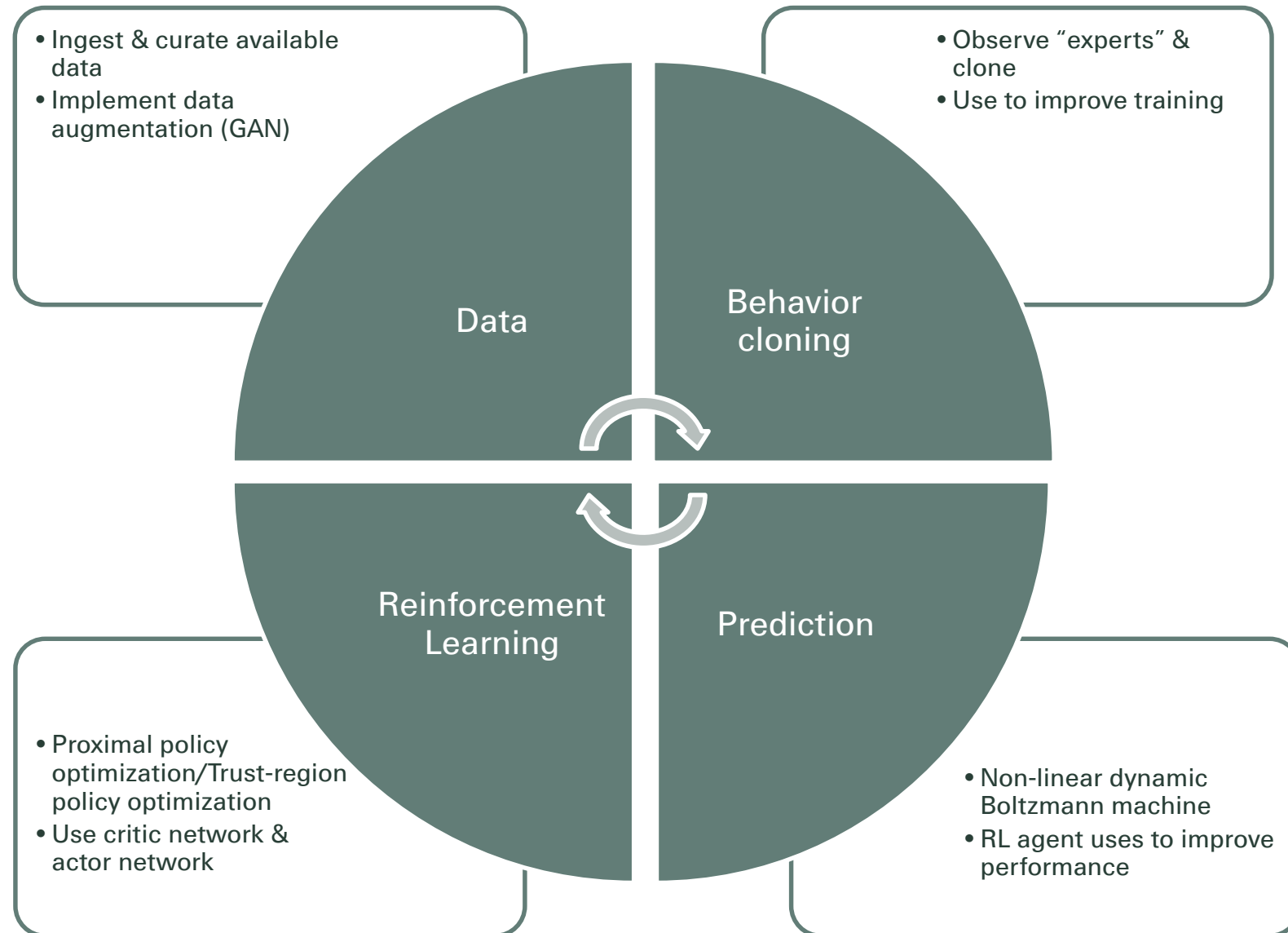
Lessons learned and way forward

Delivering Resilience-as-a-Service solutions powered by Swiss Re Institute's Risk Intelligence Factory™

Enriching curated data with risk knowledge to deliver next-generation resilience solutions

Industry Ecosystems

IBM Food Trust™

TRADE LENS

we.trade — more trust. more trade.

Urban Air Mobility

粵港澳大灣區 Greater Bay Area

OAG

FlightGlobal

Risk Intelligence Factory™

Data harvesting engine with a **replicable** & **scalable framework** that **curates** & **aggregates** diverse data sources & **enriches** with accumulated risk insights to deliver resilience solutions & services

Resilience-as-a-Service

Data services

Risk dashboards

Predictive analytics

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Integrate data, subject-matter-expertise, & new machine intelligence to facilitate better prediction & portfolio optimization

- Ingest & curate available data
- Implement data augmentation (GAN)

- Observe "experts" & clone
- Use to improve training

Data

Behavior cloning

Reinforcement Learning

Prediction

- Proximal policy optimization/Trust-region policy optimization
- Use critic network & actor network

- Non-linear dynamic Boltzmann machine
- RL agent uses to improve performance

Lessons learned

- Involve business unit heads in more discussions with research & risk management

- Perfect-storm analyses of scenarios are essential to productive stress testing
  - Pandemic was unsurprising, some geo-political & economic consequences were
  - Interconnected nature of trends (e.g., climate change, digitization, de-globalization, demographics) need more analyses

- Detail decision responses to downside events

- Blend narrative & science-based (not just evidence- or data-based) analyses

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