Swiss Re Institute

Machine intelligence's influence on risk measurement, management, and markets

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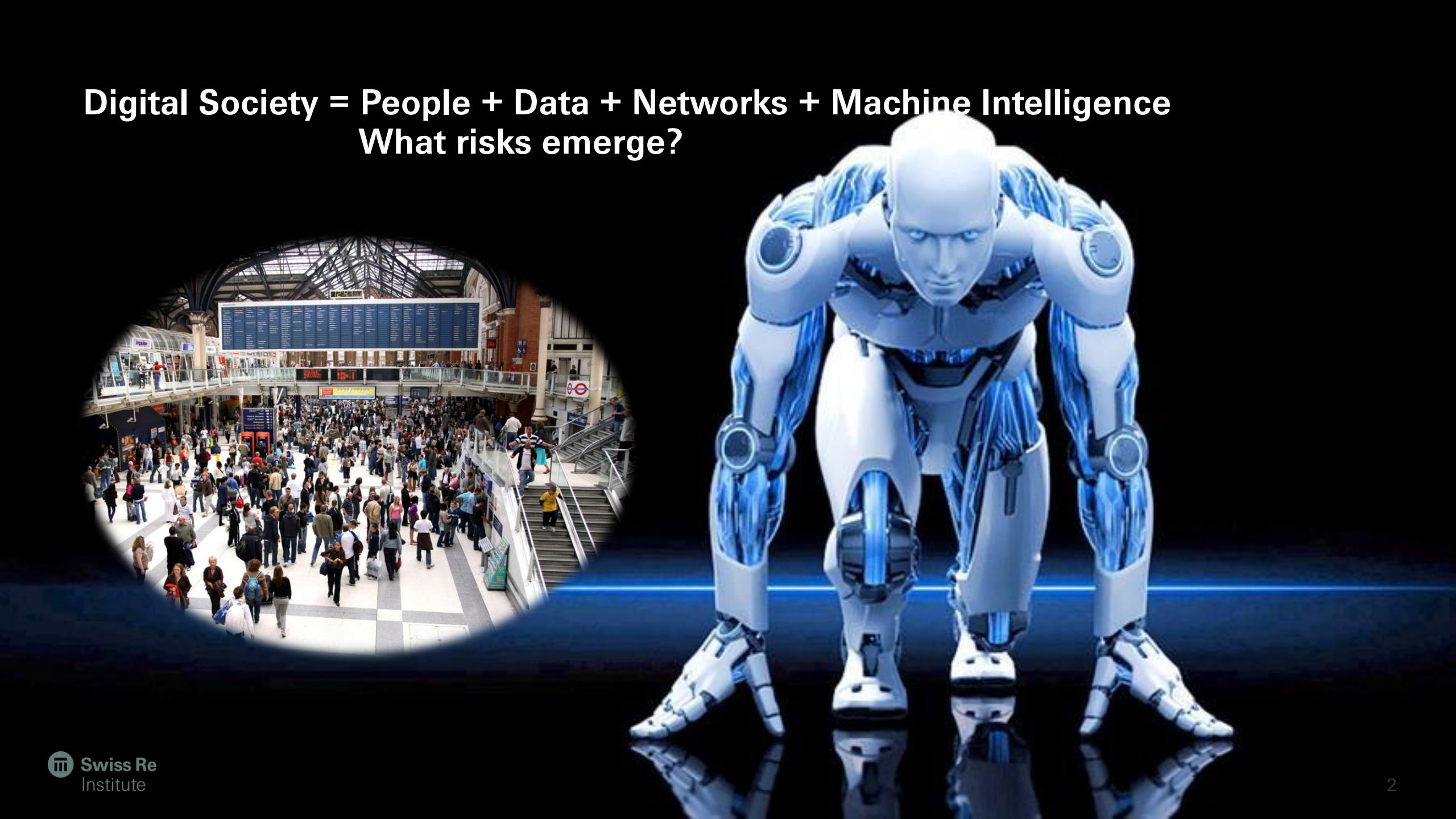
Digital Society = People + Data + Networks + Machine Intelligence
What risks emerge?



Outline for presentation

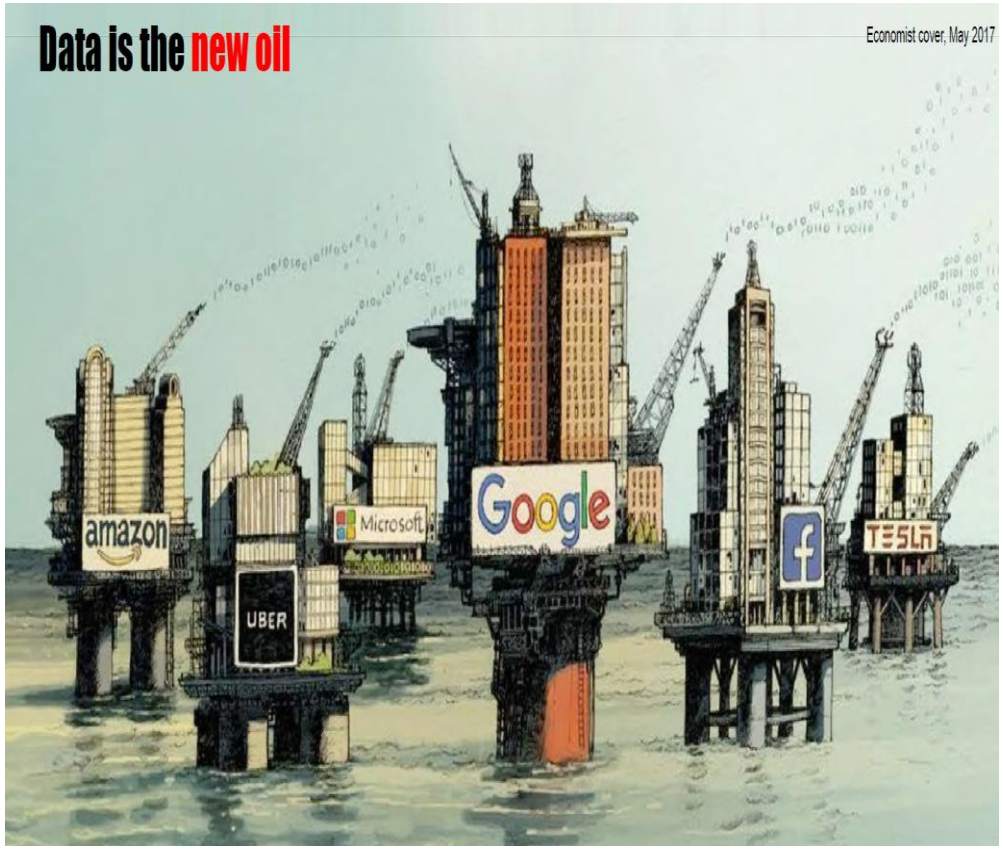
- Tools in a digital society
- Changing risk landscapes
- Evolution of risk modeling
- Re/insurance
- Final remarks

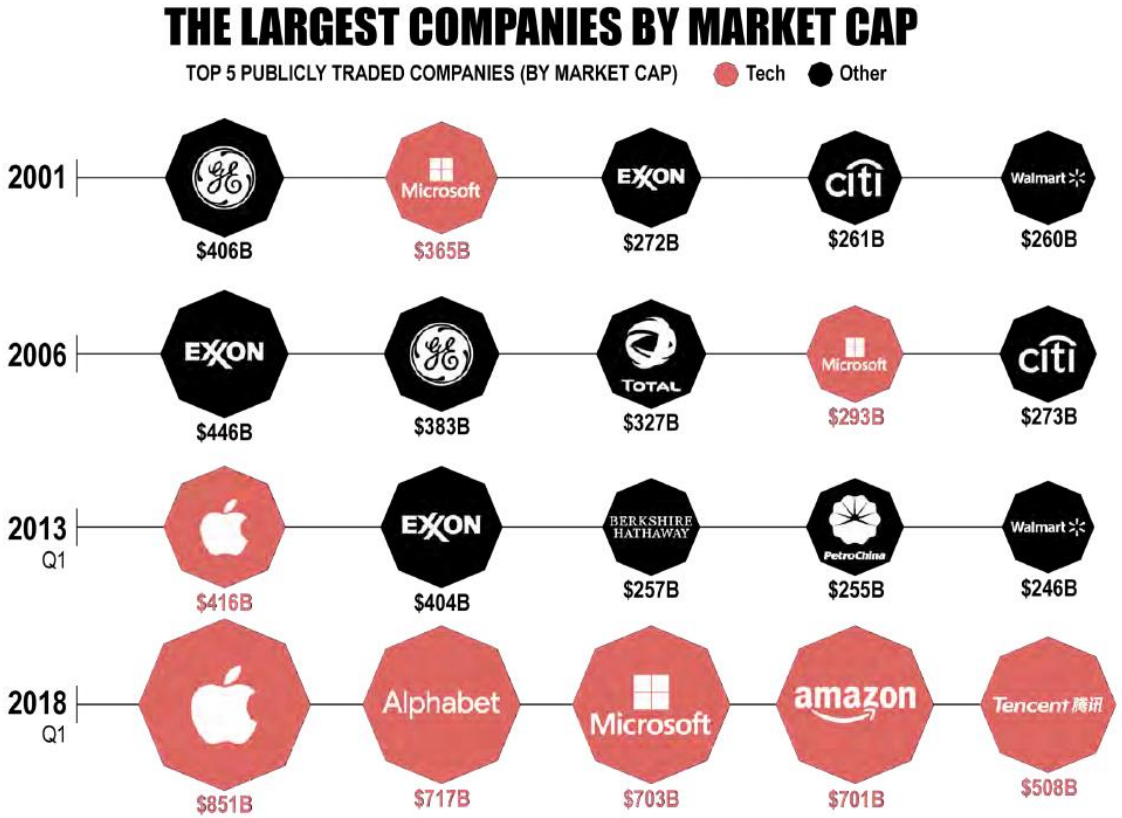
Tools in a digital society

Machine intelligence taxonomy

- **Artificial intelligence:** Mimic human intelligence and possibly go beyond
- **Artificial general intelligence:** Possibly self-aware intelligence
- **Machine learning:** Data-dependent calibration
- **Deep learning:** Model-free, data-dependent calibration
- **Meta-learning:** Learning how to learn
- **Cognitive computing:** Simulate human-brain processes
- **Augmented intelligence:** Human assistants
- **Expert systems:** Advice systems using knowledge databases
- **Robotic process automation:** Roboticized systems that replicate repetitive processes
- **Intelligent automation**: Hybridized processes that use automation to better leverage human productivity

Companies that use data to drive their decisions and understand their customers are successful

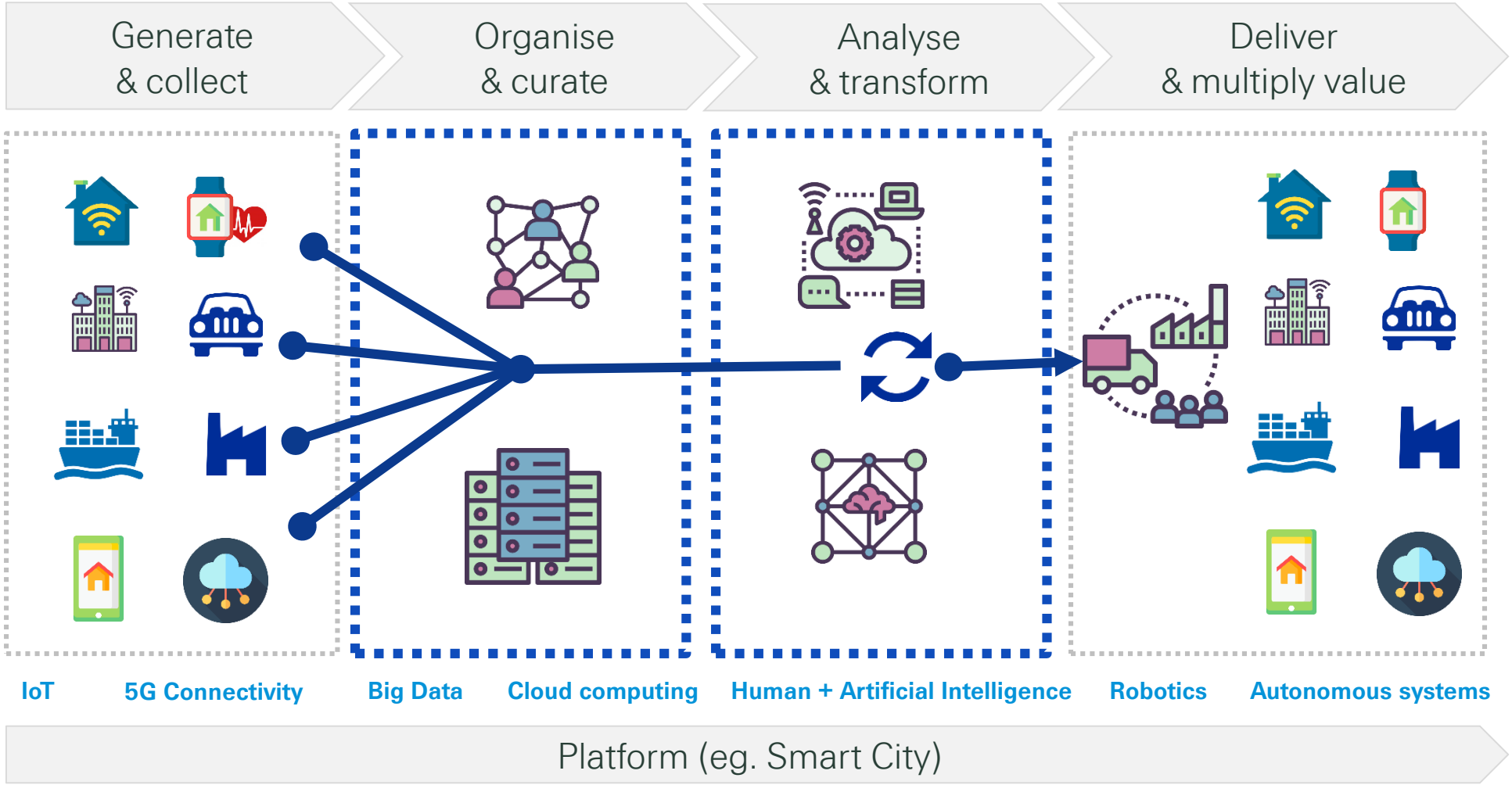




Source: Economist

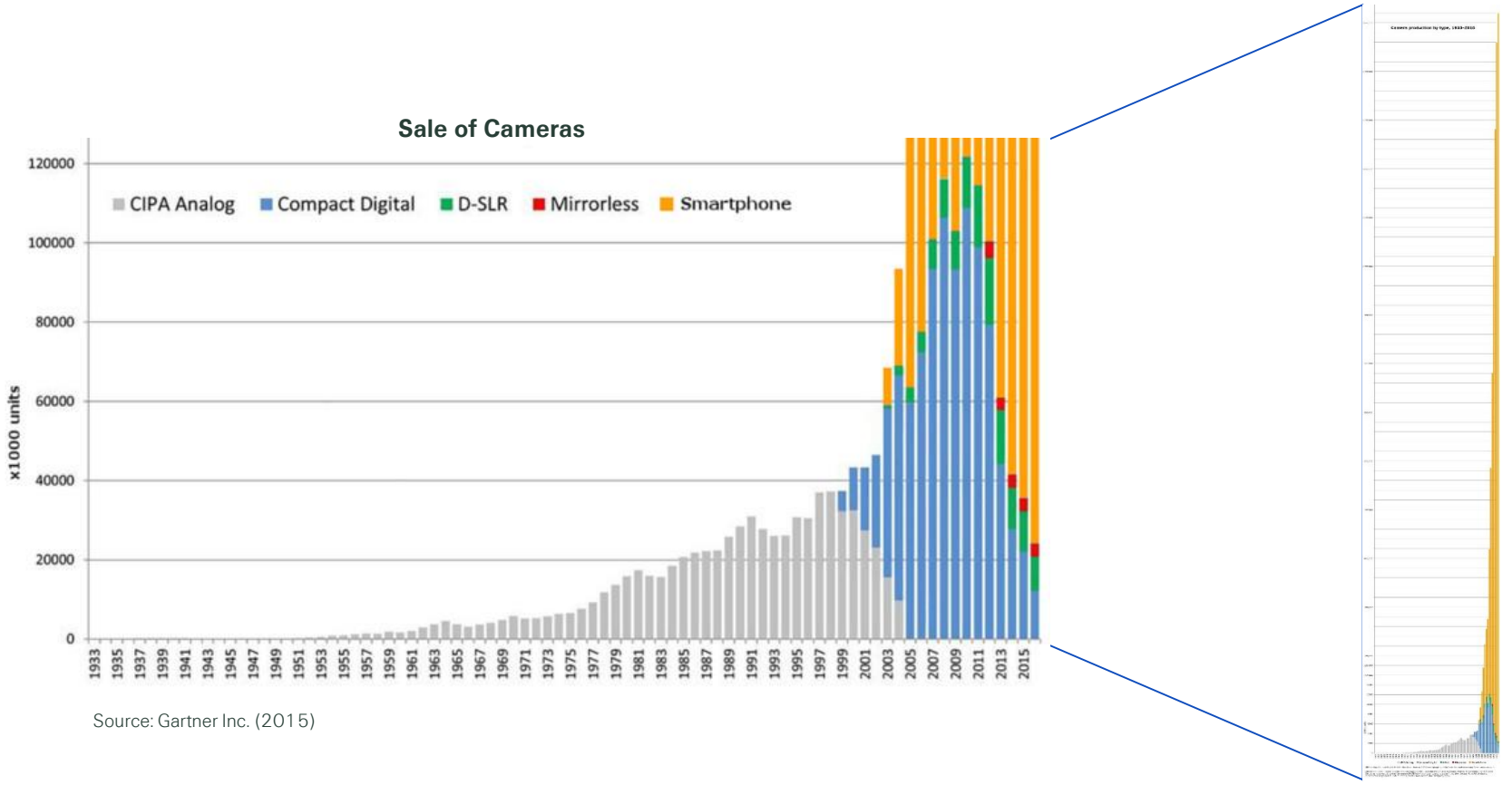
Source: https://www.visualcapitalist.com/chart-largest-companies-market-cap-15-years/

Data is the new oil: Crude product multiplies in value after refinement



Changing risk landscapes

Lessons from technological change in a different industry



Source: Gartner Inc. (2015)

Implementing machine intelligence can lead to system fragility & vulnerability

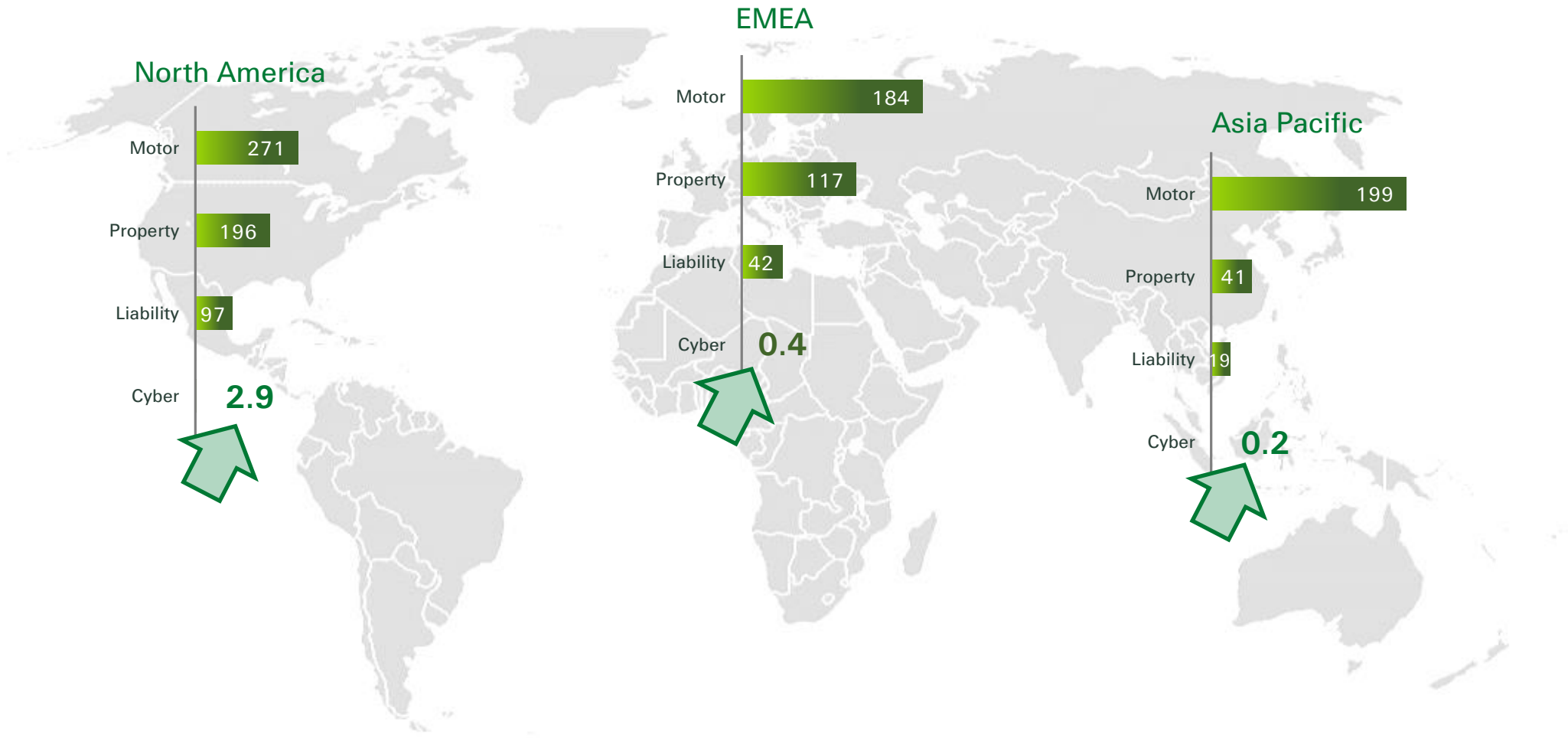
As society becomes more dependent on networks, systems, software, and data, system-wide fragility & vulnerability become critical risk drivers

Sources of fragility & vulnerability

- Overlaying new systems on existing systems that are not likely to be seamlessly interoperable
- Mismatching systems/algorithms with particular use cases
- Interaction of humans and machines
- Poorly designed system architectures
- Poorly designed algorithms buried in a system architecture– ***algorithmic malpractice***
- Overall exposure to cyber attacks

The global cyber insurance market is still small...

Insurance premium in 2017 per LoB, in USD bn



Source: Swiss Re Institute

How severe is emerging cyber risk?

1.9B records stolen in first 3 quarters of 2017 compared to 600M in entire 2016

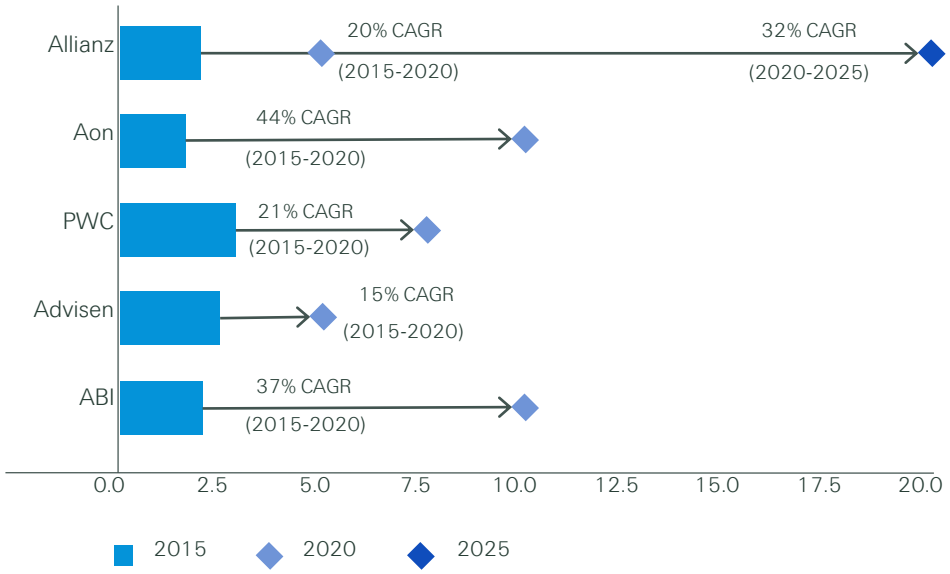
500M forms of malware (400k created everyday)

1M identities breached per breach

Probability of breach in a year is close to 100%

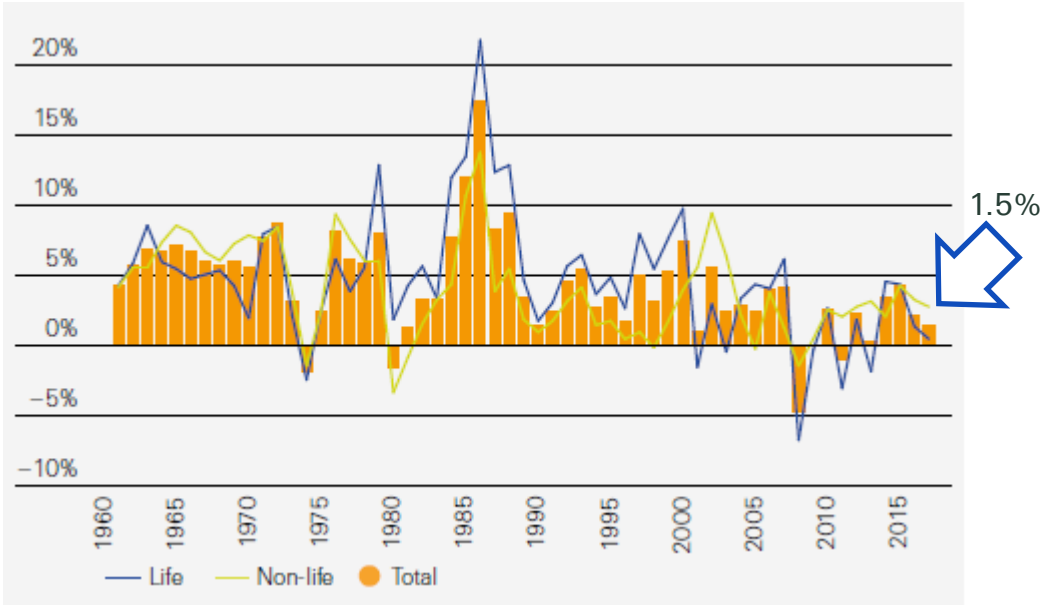
...but expected to grow rapidly

Expected global cyber insurance premium volume (2015 – 2025), in USD bn



Source: Swiss Re Sigma No 1/2017, Cyber: getting to grips with a complex risk

Global insurance premium growth (1960 – 2017)



Source: Swiss Re Sigma No 3/2018, World insurance in 2017

Cyber-insurance market is expected to grow more rapidly than other lines of business. Currently, market focus is on the SME segment. However, first cyber insurance solutions for individuals are also entering the market.

Digital society and new risk landscapes

- New networks overlayed on legacy networks create gaps and vulnerabilities
- Vulnerabilities arise from IoT-enabled devices with outdated security features
- Mismatching digital tools with a given use case leads to poor implementations & vulnerabilities
- Insufficient investment in data collection & curation systems
- Digital “exhaust” and “hygiene”
- Differing value/regulatory systems underlying society’s digitization create disconnects
- Over-dependence on automated/machine-intelligence-enabled systems leads to blind spots and unnecessary risk

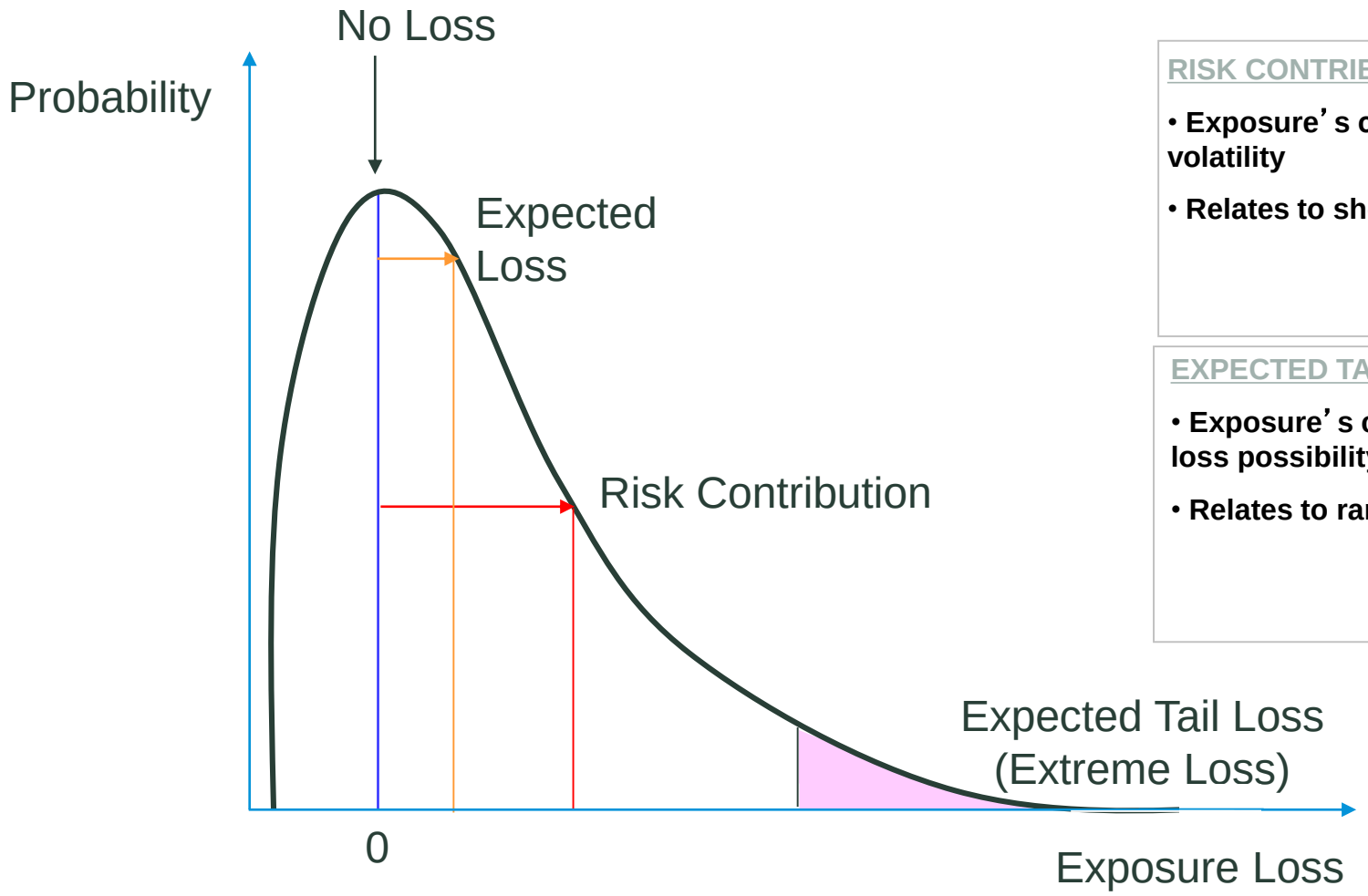
Cyber risk and ***algorithmic malpractice*** increasingly becoming most important risk categories

Evolution of risk modeling

“Risk” definitions matter

- Symmetric return/loss distributions with parameterizable distributions based on existing data– “known unknowns”
  - Volatility measures may be sufficient
  - “Beta” risk should be the focus i.e., allocation more important than individual exposure selection
- Asymmetric return/loss distributions with changing distribution parameters with sparse data– “partially known unknowns”
  - Focus shifts to tail risk/expected tail loss
  - Diversification opportunities continue even as portfolio becomes quite large
  - Active management may be better compensated given huge savings to avoiding tail events
- Emerging risk means data availability may be so sparse as to make any parameter estimation infeasible– “unknown unknowns”
  - Ambiguity creates risk that cannot be managed using traditional approaches
  - “Structural” model based on subject matter experts can provide some guidance, which cast some light on unknown

RISK CONTRIBUTION (RC) & EXPECTED-TAIL-LOSS CONTRIBUTION (TLC)



RISK CONTRIBUTION

- **Exposure's contribution to portfolio's volatility**
- **Relates to shorter-term risk**

EXPECTED TAIL-LOSSCONTRIBUTION

- **Exposure's contribution to extreme loss possibility (i.e. the "tail")**
- **Relates to rare, but severe losses**

Simple

* Volatility Multiple
* Analytical solutions

Simulated

* Flexible
* ETL contribution

Stratified

* Dynamic
* Individual exposure differentiation

Black swans, gray rhinos, and perfect storms

- Defining extreme-downside, scenario categories:
  - Black swans: Unknowable given current information set and virtually impossible to predict
  - Gray rhinos: Highly probable and straightforwardly predictable given current information set, but neglected
  - Perfect storms: Low probability and not straightforwardly predictable given the outcome results from interaction of infrequent events
- Scenario-based analyses vs. forecasts
- Deeper analyses of underlying assumptions, relationships, and data
- More focus on tools/processes to manage multiple sets of scenarios and analyses across time
- Renewed efforts to enforce *preproducibility, reproducibility,* and *out-of-sample testing*
- Process management systems with robust audit logs are more important than ever

General modeling challenges

- Variable data availability & quality
- Changing underlying data generation processes
- Markets'/economies' participants' interactions (Game theory)
- Behavioral economics (Changing product design, marketing, distribution, strategy can change opportunities within a given segment)
- Digitizing society impact

- **Moving up the ladder of causation (Pearl, 2018, p. 28)**
  - **Level 1: Association (Seeing, observing)– often suffers from selection bias & confounders**
  - **Level 2: Intervention (Doing, intervening)– difficult to implement, can sort out confounders**
  - **Level 3: Counterfactuals (Imagining, retrospection, understanding)– algorithmize, supports scenario analysis**

Challenges more specific to financial market and insurance risk modeling

- Sources of non-stationarity/ non-ergodicity
  - Structural changes in the real economy
    1. Digital ecosystems
    2. Increased concentration within sectors
    3. Information & communications technology
  - Structural changes in the financial economy
    1. Near-zero interest rates
    2. Inflation
    3. Globalization of capital markets

- Ergodic systems
  - Closed
  - Low dimensional
  - Not evolving, but can be cyclical
- Non-ergodic systems
  - Open
  - Generate new information all the time
  - Learn and adapt over time (e.g., Darwinian evolution)
  - Past data mostly not useful
  - Purely inductive models are mostly ineffective

It is far better to have absolutely no idea of where one is— and to know— than to believe confidently that one is where one is not.
-- Jean-Dominque Cassini, astronomer, 1770

Match techniques to objectives

- Use cases:
  - Identify trends (first moment estimation e.g., expected return)
  - Identify short-term risk (second moment estimation e.g., volatility estimation)
  - Identify long-term "risk" (higher moments, e.g., expected tail loss or expected shortfall from a skewed, non-normal [likely non-ergodic] distribution)
  - Accommodate regime changes
  - Facilitate scenario analyses
  - Curate data
    - Address missing data
    - Find data impossibilities
    - Evaluate data & relational implausibilities
- Old school
  - OLS/Factor modeling (Explicit & implicit)
  - Better regression techniques: Random forests, lasso regression
  - ARIMA/GARCH/Vector Auto Regression (VAR)
- New school
  - Recursive Neural Networks (RNNs)
  - Gaussian dynamic Boltzmann machines
  - Gradient boosting
  - Generative adversarial networks (GANs)
  - Reinforcement learning
  - Incorporate unstructured data

Re/insurance

Reinsurance is a catalyst for economic growth.

	Activity	Benefits
Risk transfer function	Diversify risks on a global basis	Make insurance more broadly available and less expensive
Capital market function	Invest premium income according to expected pay-out	Provide long-term capital to the economy on a continuous basis
Information function and knowledge	Price risks	Set incentives for risk adequate behavior

Reinsurers absorb shocks, support risk prevention and provide capital for the real economy

Forward-looking modeling is key to improving a reinsurer's performance

- Capital allocation: Choose/avoid outperforming/underperforming insurance portfolio segments (IPS)
- Risk selection: Select risks within each IPS
- Strategic asset allocation: Choose/avoid outperforming/underperforming asset classes

More examples where machine intelligence changes insurance

- Forward-looking modeling of risk pools
- Incorporating unstructured data into business and capital steering
- Tracking natural catastrophe damage in real time
- Assessing damage
- Automated underwriting
- Improving customer targeting
- Parametric insurance contract implementation
- Intelligent automation & robotic process automation (RPA) for underwriting and claims processing
- Chatbots for customer support
- Natural language processing applied to contract review

Final remarks

Defining a research agenda at the intersection of machine intelligence and digitizing societies

- Focus more on…
  - Addressing the challenge of data curation
  - Communicating actionable insight
  - Testing algorithms on real, useful data at scale
  - Discussing how machine intelligence should integrate into a digitizing society (define algorithmic malpractice; shape regulatory environment regarding data & machine intelligence)
- Focus less on…
  - Developing more sophisticated algorithms without a specific applied use case
  - Testing algorithms on toy datasets

Challenges

- Collecting & curating suitable & sufficient data
- Matching the type of machine intelligence with an objective or use case
- Making algorithms interpretable and diagnosable
- Defining what constitutes *algorithmic malpractice* in the machine intelligence arena
- Dealing with data sparsity and non-stationary data-generating processes
- Architecting and complying with data privacy regulations
- Addressing conflicts arising from human notions of law, fairness, and justice and machine-intelligence capabilities that can circumvent protections
- Addressing system fragility as interconnected and complex networks are infused with machine intelligence
- Addressing growing cyber-risk in digital ecosystems infused with machine intelligence

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