Cyborg Commerce, Pervasive Computing, Cyber-Physical Digitization and the Deep Web:

RiskTech Applications of Tertiary Data and Implications for Navigating Emergent Risk within Workers’ Compensation Exposures

David K. A. Mordecai
Risk Economics®, Inc.
RiskEcon® Lab for Decision Metrics @ NYU Courant
Numerati™ Partners LLC

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A “Perfect Storm”: The Confluence of Metabolic Frailty with Occupational Injury
Another (Behavioral & Metabolic) Source of Risk From Cognitive Impairment

Past month heavy alcohol use among adults aged 18 to 64 employed full time, by industry category: combined 2008 to 2012

Source: SAMHSA, Center for Behavioral Health Statistics and Quality, National Surveys on Drug Use and Health
... And Yet Another (Behavioral & Metabolic) Source of Risk From Cognitive Impairment

Illicit Drug Use among Full-time Workers by Occupation (by percentage)**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Percent Using Illicit Drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Preparation and Serving Related</td>
<td>17.4</td>
</tr>
<tr>
<td>Construction and Extraction</td>
<td>15.1</td>
</tr>
<tr>
<td>Sales and Related Occupations</td>
<td>9.6</td>
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<tr>
<td>Installation, Maintenance and Repair</td>
<td>9.5</td>
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<tr>
<td>Transportation and Material Moving</td>
<td>8.4</td>
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<tr>
<td>Building and Grounds Cleaning, Maintenance</td>
<td>8.2</td>
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<tr>
<td>Office and Administrative Support</td>
<td>7.5</td>
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<tr>
<td>Management</td>
<td>6.1</td>
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<tr>
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<td>6.1</td>
</tr>
<tr>
<td>Protective Service</td>
<td>3.4</td>
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</tbody>
</table>

Heavy Alcohol Use among Full-time Workers by Occupation (by percentage)**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Percent Heavy Alcohol Use in Past Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and Extraction</td>
<td>17.8</td>
</tr>
<tr>
<td>Installation, Maintenance and Repair</td>
<td>14.7</td>
</tr>
<tr>
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</tbody>
</table>

“Peer Effects” as **Social Risk Propagators**

[Graphs and charts illustrating the relationship between BMI and mortality, as well as the impact of alcohol consumption on mortality.]

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Worksite Accidents <=> Avoidable Behavioral Occupational Incidents?

The hours between 1pm and 5pm accounted for 18.2% of all accidents and 29.4% of fatalities (fatigue, routine, time constraints).
Worksite Accidents <=> Avoidable Behavioral Occupational Incidents?

Metabolic Syndrome
suppressed immunity

Biomechanical Impairment

Stress

Accidents

Safety Impacts of Too Little Sleep

Drowsy driving is a RED ALERT!

- Chronic stress response
- Depression
- Fatigue
- Sleep disruption

Being awake for 18 hours is similar to being legally drunk
**COMMON WORK-RELATED INJURIES**

**MOST COMMON INJURIES**

- **42%** Sprains and strains
- **13.7%** Musculoskeletal fractures
- **8.8%** Fractures
- **5.8%** Mental disorders
- **4.1%** Deafness
- **2.4%** Other disease
- **1.6%** Dislocation
- **7.5%** Open wound
- **5.6%** Contusion with intact skin surface
- **4.4%** Other injuries
- **2.3%** Hernia
- **1.5%** Burns

**HOW THE INJURIES OCCURRED**

- **40%** Body stressing
- **21.4%** Falls, trips and slips
- **13.8%** Being hit by moving objects
- **6.7%** Hitting objects
- **5.4%** Mental stress
- **4.3%** Sound and pressure
- **3.5%** Other mechanisms of injury
- **2.4%** Vehicle incident
- **1.5%** Heat, radiation and electricity
- **1%** Chemicals and other substances

**INJURY CLAIMS BY INDUSTRY 2010-2011**

- **9,625** Agriculture, Forestry and Fishing
- **8,300** Mining
- **7,420** Retail Trade
- **7,675** Manufacturing
- **5,885** Wholesale Trade
- **5,380** Accommodation & Food Services
- **4,765** Health Care and Social Assistance
- **2,520** Construction
- **1,630** Transport, Storage and Communications
- **1,400** Professional, Scientific & Technical Services
- **1,115** Captial Goods Manufacture
- **1,065** Financial and Insurance Activities
- **925** Education
- **785** Electricity, Gas, Water and Waste Services
- **6,020** Public Administration and Safety Activities
- **5,320** Real Estate, Rental and Business Activities

**SOURCES**

- [Source 1](https://www.imo.com/exposedresilience/)
- [Source 2](https://www.imo.com/exposedresilience/)
- [Source 3](https://www.imo.com/exposedresilience/)
- [Source 4](https://www.imo.com/exposedresilience/)
Pervasive Computing and Embedded Sensors
Example: Autos

Car ECUs control a growing list of vehicle functions
Each ECU is a miniature computer with a specific set of tasks and vulnerabilities: More ECUs ==> more risk
Connectivity can be exploited (e.g. via Bluetooth, entertainment system, etc.) to access critical onboard systems (engine, brakes, ...)

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Cybersecurity and Corporate Espionage (More Broadly Defined)

Commercial Demography and Tacit Collusion
Network Externalities and Coalitions

An example of dynamic "network fragility"

Another example of a complex interconnected network (in this case a hashtag community)
Wearable Tech On The Worksite
Sensors Coupled with Computing Devices are Proliferating
Employing ‘Tertiary Data’, Embedded Sensors and Pervasive Computing

- ‘Tertiary data’ generated by pervasive, embedded and wearable tech
  - data generated as a by-product of sensored commercial activity
- Forensic surveillance, monitoring and analytics applications
  - to actively navigate and manage i.e. avoid, and/or otherwise
    mitigate ex ante risk and ex post losses
- Behavioral monitoring & intervention ==> preparedness, early
  warning, rapid response and recovery as well loss validation/dispute
  resolution
  - Incentives-based behavioral engagement/intervention to mitigate
    risk exposure
    - Reduce inherent physical frailty and cognitive impairment
      due to metabolic co-morbidities, chronic inflammation, stress
      response and fatigue
  - Accident avoidance via activity recognition applications to fleet
    and inventory logistics management
  - Mitigating and rehabilitating chronic biomechanical and structural
    impairment of repetitive stress injuries
Navigating Emergent Risks in Real-Time with Scalable Data Analytics

- Harnessing massive and dynamic datasets for underwriting, pricing, loss mitigation and claims management
- The need to navigate the *Deep Web* in order to respond to the evolving risk landscape
- New **data forensics** i.e. metrics/analytics to explore deep structure and collective behavior, and hence reflect future dynamics
- Spatio-temporal Mapping of Metadata
  - In 2012, 2.5 exabytes (2.5 billion gigabytes) created daily; that number doubles every month
  - In 2013, mobile data traffic = 1.4 million terabytes per month (Source: iGR); forecasted for 2014 is 2.6 million terabytes/m
  - 2018 Projections: 15.9 million terabytes per month
    - Mostly *unstructured data* (i.e. text, audio, video, usage) which requires special tools (e.g. *machine learning*)
Agent-Based Modeling

Realistic “bottom-up” models of real-world strategic interactions, structural shifts, and complex evolving dynamics to inform underwriting for more intelligent risk management and loss mitigation

Source: CI Chicago

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Does “God” Play With Fuzzy Dice?

A stochastic game is a dynamic game played by one or more players with probabilistic transitions, such that at each stage the probability distribution for that new random state depends on the previous state and the actions chosen by the players.

Representation of a finite-state machine (example): an FSM that determines whether a binary number has an odd or even number of 0’s. FSM can be non-deterministic (i.e. stochastic). Also state machines can be infinite (i.e. continuous).

Probabilistic parameters of a Hidden Markov model (example of the simplest dynamic Bayesian framework):
- \( x \) states, \( y \) possible observations;
- \( a \) state transition probabilities, \( b \) output probabilities.

Model underlying the Kalman filter. Squares represent matrices. Ellipses represent multivariate normal distributions (with the mean and covariance matrix enclosed). Unenclosed values are vectors. In the simple case, the various matrices are constant with time, and thus the subscripts are dropped, but the Kalman filter allows any of them to change each time step.
Bayesian Graphical Models

A Bayesian network is a probabilistic graphical model that represents a set of random variables and their conditional dependencies via a directed acyclic graph (DAG).

Bayesian networks that model sequences of variables are called dynamic Bayesian networks. Generalized Bayesian networks that can represent and solve decision problems under uncertainty by combining probabilistic inference and utility maximization are called decision networks, relevance diagrams, or influence diagrams. Efficient algorithms exist that perform inference and learning in Bayesian networks.

A Markov random field ("MRF"), Markov network or undirected graphical model: is a graphical model in which a set of Markov random variables are described by an undirected graph, and is similar to a Bayesian network in its representation of dependencies. An MRF can represent certain dependencies that a Bayesian network cannot (such as cyclic dependencies), but cannot represent certain dependencies that a Bayesian network can (e.g. induced dependencies). The classic MRF is the Ising model, a statistical model of ferromagnetism $P(S) \propto e^{-\mathcal{E}}$.

$$P(X = x) = \frac{1}{Z} \exp \left( \sum_{\ell \in \mathcal{E}} w_{\ell} \cdot f_{\ell}(x_{\ell}) \right) = \frac{1}{Z} \exp \left( \sum_{\ell \in \mathcal{E}} \sum_{i=1}^{N_{\ell}} w_{\ell,i} \cdot f_{\ell,i}(x_{\ell,i}) \right)$$

$$Z = \sum_{x \in \mathcal{X}} \exp \left( \sum_{\ell \in \mathcal{E}} w_{\ell} \cdot f_{\ell}(x_{\ell}) \right)$$

A log-linear model is a Markov random field with feature functions $f_\ell$ such that the full-joint distribution can be written as shown with partition function $Z$, and where $X$ is the set of possible assignments of values to all the network's random variables.
These analytic methods are applicable to many risks: Energy and power and natural resource markets; Social systems and integrated modeling of interactions between natural and social processes; national security topics, e.g. distributed adaptive network control and terrorist networks; supply chain dynamics; biological systems, including pandemics; industrial and macroeconomic structures (trade and capital flows); other geopolitical, socioeconomic, legislative, regulatory, commercial, financial market and policy issues.
Demographics, Sociometrics and Psychometrics matter

Actively monitoring consumer behavior, lifestyle choices, and aggregated preferences (e.g. food consumption) at the right level of granularity can be predictive of both short- and long-tailed loss development.
Can Marketing Data Predict Life Spans?

Deloitte Consulting uses a hypothetical ‘Sarah’ and ‘Beth’ to promote technology for life insurers that promises to help size up people’s health risk using offline and online dossiers rather than blood tests.

**Some data collected**
- Sarah: Second child born last year, high investment risk tolerance, lived in home - two years, owns home, commuting distance - one mile, reads design and travel magazines, urban single cluster, premium bank card, good financial indicators, active lifestyle: run, bike, tennis, aerobics, healthy food choices, little to no television consumption.
- Beth: Current residence - four years, lived in same hometown - 15 years, currently renting, commuting distance - 45 miles, works as administrative assistant, divorced with no children, foreclosure/bankruptcy indicators, avid book reader, fast-food purchaser, purchases diet, weight loss equipment, walks for health, high television consumption, low regional economic growth.

**Some risk-assessment factors**
- Good financial indicators
- Strong ties to community/location
- High activity indicators
- Foreign traveler
- Healthy food choices
- Avid outdoor enthusiast
- Avid golfer
- Little television consumption
- Occasional tobacco user
- Average commute
- Poor financial indicators
- Purchases tied to obesity
- High television consumption
- Lack of exercise
- Long commute

**Potential actions by insurers**
- Sarah: Actively pursue for new business and retention efforts, quickly issue a preferred policy and avoid further medical tests.
- Beth: Do not send offers, do not pursue aggressive retention efforts, collect more information; send to senior staff for review.

Source: Deloitte Consulting
For example, there are currently unexploited techniques for analyzing statistical relationships between changing unemployment insurance claims relative to workers compensation and disability claims.

Source: NBER, ETA and Risk Economics® calculations
Disability versus Earnings

Relative earnings of permanent partial disability claimants as a proportion of earnings of comparison workers in five states

What this graph does not tell you is that disability claims increase during periods of high unemployment, i.e. poor business conditions. In other words, disability and workers compensation may be serving as a substitutes or supplements to unemployment insurance.

Question: what specific industry and occupational interactions may be predictive of (food-related) frailty?

SOURCE: Workers’ Compensation Permanent Partial Disability and Return to Work, (Santa Monica, CA)
Economics of Tort Escalation: 3% of Fortune 500 Annual Net Profits
Tort Cost Economic Drivers: Common underlying risk factors for WC

Plaintiff Success Rate By Trial Type -- 2005

Source: U.S. Department of Justice, Bureau of Justice Statistics


Source: Tillinghast-Towers Perrin

2005 Median Damages Awarded To Successful Plaintiff By Trial Type

Source: U.S. Department of Justice, Bureau of Justice Statistics

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Data Mining has Economic Forensic Implications for Tort, Litigation, and Claims Settlement for a wide range of Workers’ Compensation Exposures
Networked Worksites: Drones, Droids and Wearable Tech
DAVID K.A. MORDECAI

David K.A. Mordecai is President and co-founder of Risk Economics, Inc., a New York City based advisory firm. Risk Economics® specializes in the application of computational economics to the proprietary development and scalable implementation of robust modeling and data analytic frameworks for valuation, strategic and systemic risk analysis, and dynamic asset-liability management.

As lead for the RiskEcon® litigation, regulation and arbitration expert advisory practice, David Mordecai serves as an expert on loss causation and economic damages related to market structure, financial institutions governance, and complex issues related to finance, economics and market standards and practices within securities, derivatives, reinsurance, and commodities markets, as well as market structure within a broad range of non-financial industry sectors. His expertise includes financial engineering, the valuation of fixed income securities and structured products, including over-the-counter derivatives (in particular fixed income and credit derivatives), complex insurance and reinsurance liabilities, as well as asset liability and risk management models and practices. He has advised and provided technical oversight for internal regulatory investigations, as well as stress-testing for global financial institutions. Having testified extensively at deposition, trial, arbitration and international arbitration, he has been admitted as an expert in federal, state and county courts, and cited favorably in court decisions.

Dr. Mordecai advised the Uniform Credit Committee in the bankruptcy resolution of Lehman Brothers, and provided technical oversight for the valuation team, assigned to validate the fair market value of the exotic structured notes portfolio with a notional value in excess of 15 billion dollars. He has testified in Federal Claims Court regarding market evidence and commercial reasonability surrounding the Government rescue of AIG, and advised on a merger-related intellectual property dispute involving Samsung and Microsoft.

During his thirty year tenure in the financial services industry, David has served as a Managing Director at Swiss Re, where he led Relative-Value Market Strategies, a quantitative economics and financial engineering function with the global mandate to develop firm-wide and industry standards, benchmarks and frameworks for the valuation and trading of exposures underlying long-dated life, health, medical and pension liabilities as well as geopolitical risk. Prior to this, he served as Senior Advisor to the Head of Swiss Re Financial Services. Previously, at a multi-strategy hedge fund with $10 Billion of assets under management, he was Managing Director of Structured Products, responsible for $5 billion of CDO assets. Prior to his role as a hedge fund manager, he was Vice President of Financial Engineering/Principal Finance at AIG, and a Director at the rating agency Fitch. During the first decade of his career, he specialized in credit analysis and the origination, structuring, and trading of leveraged loans for non-recourse project finance and highly leveraged transactions involving corporations and financial institutions.

He holds a Ph.D. with concentrations in Econometrics/Statistics and Economics/Industrial Organization from the University of Chicago and an M.B.A. in Finance from the NYU Stern School of Business. His doctoral research focused on the limits of arbitrage, and how market shocks trigger contagion via the financing of highly leveraged financial institutions during periods of extreme market volatility.

Dr. Mordecai is principal scientist and lead investigator at the RiskEcon® Lab for Decision Metrics established in 2011, and a Visiting Scholar at the Courant Institute for Mathematical Sciences at New York University (NYU). As of 2012, he holds a joint appointment as Senior Research Scholar for Computational Economics of Commerce, Law and Geo-Politics at NYU Stern Graduate School of Business. In 2010, he was invited to become a Fellow, as well as a member of the Advisory Board of the Mathematical Finance Program at Courant, having served as a guest lecturer for the program since 2006. He has served as an adjunct instructor of applied mathematics at Courant, as well as being an Adjunct Professor and an active member of the working group for NYU Center for Data Science (NYUCDS). In March 2014, he was appointed the Course Director to lead the NYUCDS Capstone graduate applied research program in its inaugural year (Fall 2014).
DAVID K.A. MORDECAI (Continued)

Since November 2013, he has been appointed the first Scientist-in-Residence at FinTech Innovation Lab, an accelerator platform for early and growth stage technology firms, organized by The Partnership Fund for New York City in conjunction with Accenture and a consortium of venture capital firms and global financial institutions.

David has served as an advisor on systemic risk issues to the Federal Reserve, the International Monetary Fund (IMF), the US Treasury, and the Commodities and Futures Trading Commission (CFTC), and as an advisor on hedge fund valuation issues to the International Organization of Securities Commissions (IOSCO). He has also been a member of the Investment Advisory Committee of the New York Mercantile Exchange (NYMEX). He is the founding Co-Chair of the International Association of Financial Engineers’ (IAFE) Liquidity Risk Committee, and has actively served on the Steering Committee of the IAFE’s Investor Risk Working Group on hedge fund and CTA disclosure issues, as well as the Advisory Board.

David K.A. Mordecai was the founding Editor-in-Chief of the Journal of Risk Finance (JRF ca.1999), a quarterly peer-reviewed research periodical, which addresses topics in financial risk intermediation. He remains a senior member of JRF’s Advisory Board subsequent to its sale by the original publishers Institutional Investor/Euromoney to Emerald Publications. He has published numerous articles on topics including hedge fund strategies, structured credit, and weather and insurance derivatives. He has also served on the advisory committee for Chartered Alternative Investment Analysts (CAIA) Association, and on the editorial board of the Journal of Alternative Investments. In addition, he has been a guest lecturer at Columbia University, at the Graduate Business School, the Engineering/Operations Research Division, as well as the School for International and Public Affairs.

David currently serves as a member of the board of directors for two not-for-profit organizations: Scenic Hudson, one of the nation’s three largest conservation organizations for which he co-chairs their Science Committee, as well as Hudson Highlands Land Trust. He is also a member of the leadership council of Black Rock Forest Consortium, a 4,000-acre natural living laboratory for field-based scientific research and education, operated by a consortium of twenty-three colleges and universities, public and independent schools, and scientific and cultural institutions.

SAMANTHA KAPPAGODA

Samantha Kappagoda is Chief Economist and co-founder of Risk Economics, Inc. (www.riskecon.com), a New York City based advisory firm. She provides advisory services as well as research and development (R&D) of rigorous analytics with applications to large-scale, real-world modeling and surveillance of global macroeconomic trends, socioeconomic and demographic conditions and geopolitical events.

As lead for the RiskEcon® macroeconomic and portfolio strategy advisory practice, Samantha’s areas of expertise include currency, fixed income, commodity and capital markets activity, as well as business cycle dynamics, econometric time-series and longitudinal analyses of consumer behavior, labor markets, wealth and income distribution, housing, population and immigration, political risk and international trade, resource allocation, environment, health, aging and retirement.

Samantha is also co-lead investigator at RiskEcon® Lab for Decision Metrics, established in 2011 at NYU Courant Institute for Mathematical Sciences, in order to apply a range of computational methods to analyze commercial, consumer and population-related societal trends. She is also Visiting Scholar at Courant Institute, and associated with the Social Media and Political Participation Lab (SMaPP) at NYU, an interdisciplinary collaboration that investigates the relationships between social media and political behavior.

Previously, she was Senior Economist at Caxton Associates LP, a hedge fund established in 1983, investing in global fixed income, currencies, commodities and equities. She was a key member of Caxton Global, the firm’s flagship global macro fund, which, at its peak, had approximately $12 billion of assets under management. Her macroeconomic and demographic analytics and development of proprietary econometric models of financial markets, the global economy, central bank and related policy actions guided the firm’s senior decision makers during her thirteen year tenure there.

Prior to working in the financial markets, Samantha was an Economist in the Operations Evaluation Department of The World Bank in Washington D.C., working on the evaluation of structural adjustment lending programs and dynamic stochastic general equilibrium (DSGE) modeling, with a primary focus on the outcome, impact and sustainability of these programs in emerging market economies.

Samantha pursues her broader research interests by serving as a senior editorial advisory board member of The Journal of Risk Finance (JRF), an Emerald Publications journal which provides a rigorous forum for the publication, both by academics and practitioners, of theoretical and empirical research related to the financing of risk, with a long-standing focus on issues of market convergence. She was originally the founding Managing Editor of JRF in 1999, initially published by Institutional Investor Journals/Euromoney, before its successful sale to its current publisher. She has also served as Special Editor for Risk Management, for The Journal of Alternative Investments, another Institutional Investor journal.

Samantha received an M.B.A. in Analytic Finance and Statistics from the University of Chicago Graduate School of Business. She also holds an M.A. in Economics from the University of Toronto, and graduated with a B.Sc. (Honors) in Mathematics from Imperial College, London. Her biography has been published in the Marquis’ Who’s Who in America, Who’s Who in Finance and Business (formerly Finance and Industry), Who’s Who of Emerging Leaders, Who’s Who of American Women, and Canadian Who’s Who (University of Toronto Press). In 2013, she was honored by the Girl Scouts of Greater New York as a Woman of Distinction, for her activities in Science, Technology, Engineering and Mathematics (STEM).

Samantha currently serves as a member of the board of directors of three not-for-profit organizations: Council for Economic Education, an organization that delivers economic education and financial literacy to K-12 students by educating the educators; Glynwood, which focuses on sustainable agriculture and regional food systems; and subsequent to being honored by the Girl Scouts of Greater New York, she has joined their board. Samantha is also a member of the leadership council of Black Rock Forest Consortium, a 4,000-acre natural living laboratory for field-based scientific research and education, operated by a consortium of twenty-three colleges and universities, public and independent schools, and scientific and cultural institutions.

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• Risk Economics, Inc. (RiskEcon®) provides advisory services at the intersection of commercial business-process engineering and risk engineering with a particular focus on coupling commercial reinsurance and financial technology, through the rigorous application of agent-based, demographic, and statistical methodologies to microeconomic and macroeconomic analytics.

• RiskEcon®’s computational economics activities focus on the proprietary development and scalable implementation of robust modeling and data analytic frameworks, including the application of computational tools and methods derived from machine learning, data-mining, and text-mining to systemic real world issues.

• The Risk Economics® Lab for Decision Metrics (RiskEcon® Lab) at NYU Courant Institute of Mathematical Sciences is applying algorithmic data analytics and decision metrics to identify patterns within large datasets that influence long-tailed insurance risk.

• Numerati™: Numerati is a private-sector based platform, affiliated with Risk Economics, established to sponsor and promote coordinated incubation and acceleration of computational, digital and statistical forensic applications to fintech, risktech and littech (financial, risk and litigation technology) and allied risk analytics ventures (e.g. within wholesale commercial specialty, supplemental and surplus financial lines and casualty insurance) via syndicated consortium investments.

• RiskEcon®’s client roster and affiliations are diverse and include global insurance and reinsurance firms, leading law firms, technology firms, global banking institutions, asset management firms, multinational corporations with interests in natural resources, commodities and energy, as well as multilateral institutions and government agencies.
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Samantha Kappagoda

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