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# Exponential Technologies and Society: Challenges, Opportunities and Risks

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**Atlantic Council**

**IRAHSS 2013**
**International Risk Assessment and Horizon Scanning Symposium**
**Singapore, July 16-17, 2013**

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# Can We Imagine the Future?

"*I'm always struck that Facebook, Twitter, 4G, iPhones, iPads, high-speed broadband, ubiquitous wireless and Web-enabled cell phones, the cloud, Big Data, cell phone apps and Skype did not exist or were in their infancy a decade ago when I wrote a book called* ***The World Is Flat***." Thomas Friedman

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# Increasingly Interdependent, Integrated Ecosystems

- Nature's ecosystem services sustaining life
  - ✓ Air, water, land, sea, natural resources increasingly facing "denial of services attacks" from the other ecosystems
- Technology-powered globalization ecosystem underpinning economic prosperity and security
  - ✓ Technology has driven globalization and has been driven by globalization, social development
- Technology-Innovation ecosystem
  - ✓ New technology increasingly at the edges where different technologies come together or in the combination of technologies enabling each other

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# Technology & Global Trends

- Technology both cause and solution to environmental degradation, climate change
- Technology key to rise of global middle class
- Technology critical to meeting demand for food, water
- Technology key to urban future
- Technology empowering individuals and governments

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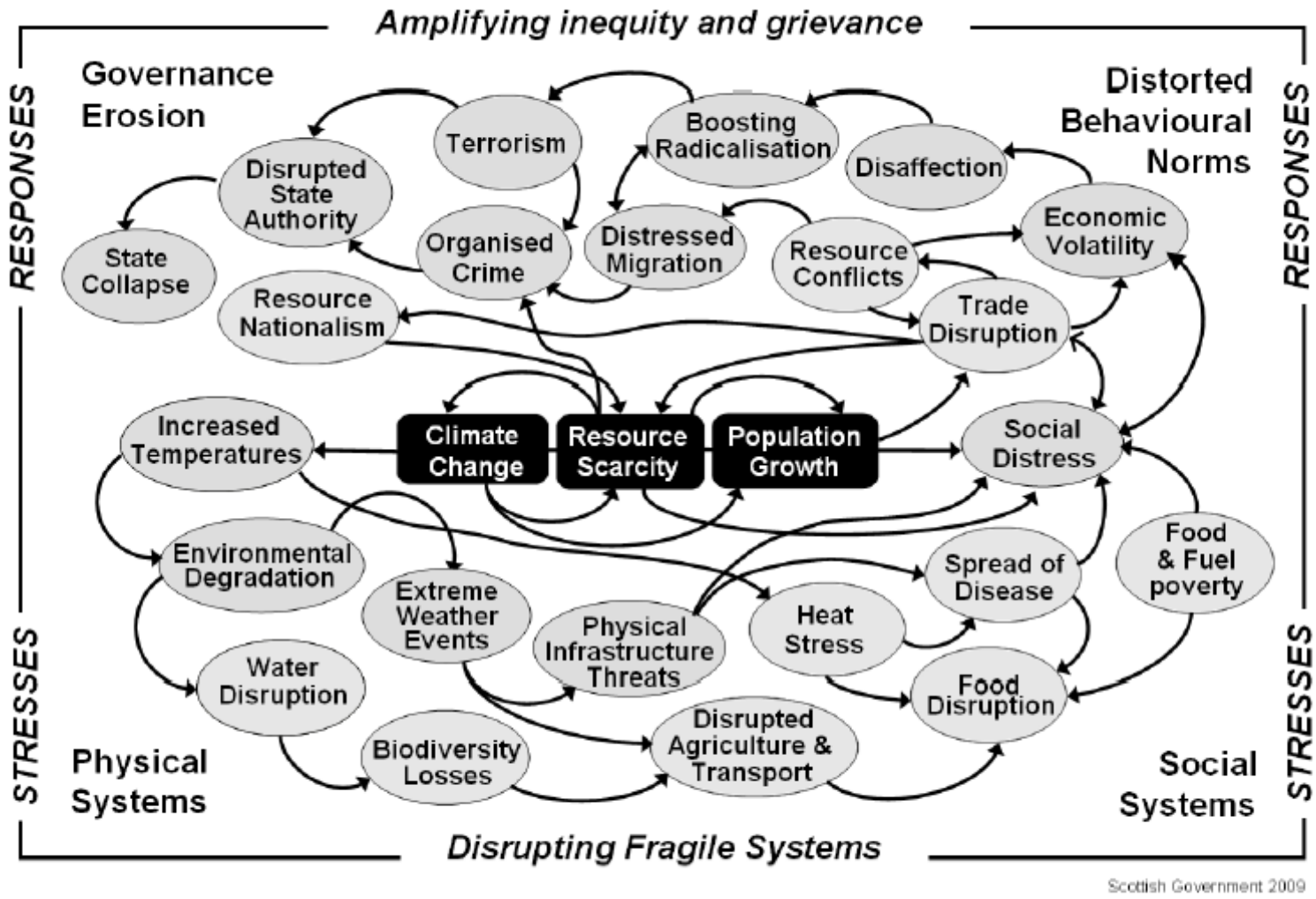
# Complex Interactions of Nature's and Globalization's Ecosystems




Scottish Government 2009

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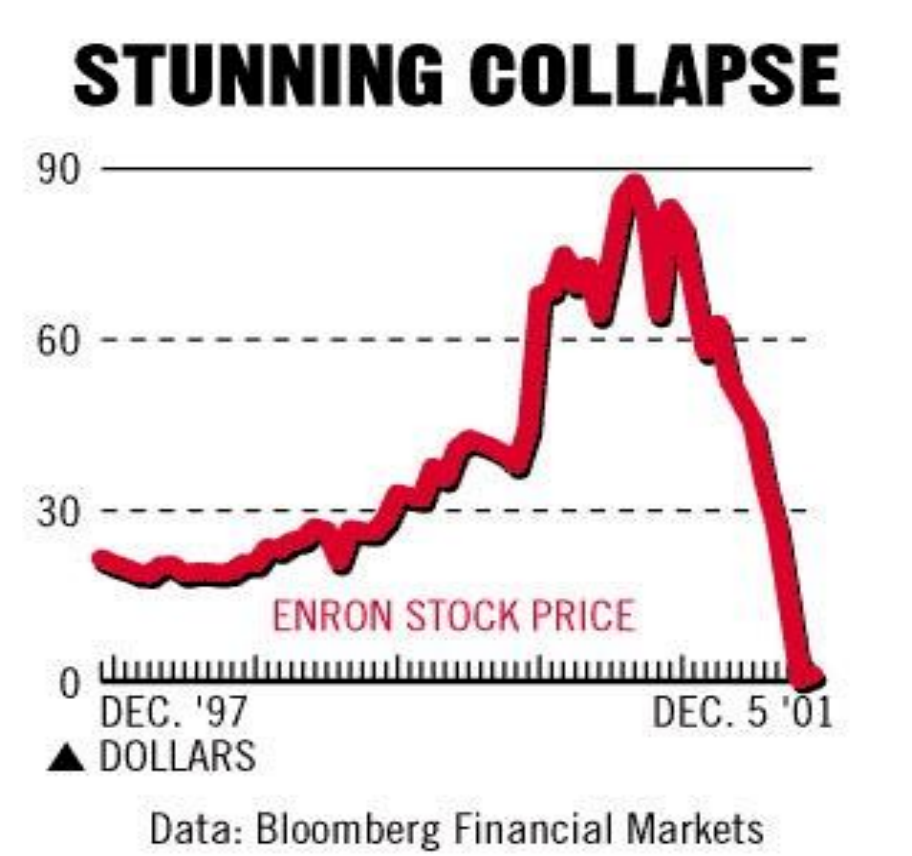
# Perils of Linear Thinking



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# Technological Change Accelerating

- Change often exponential not linear: Moore's Law and 30 steps
- Technology only meaningful in context of society – second, third order implications
- Transforming way we live, communicate, work, produce goods and service – and fight wars
- Disrupting industries, business models, societies, globalization, nature
- Creating new opportunities, risks, uncertainties
- Further stressing nature's ecological services?

# Cross-cutting Technologies

- Sets of technologies enabling each other and creating whole greater than sum of parts
- Convergence of ICT, AI, robotics, big data, algorithms, cloud computing, synthetic biology, genomics, nanotechnology
- Ubiquitous and cheap Internet and mobile computing platforms
- Exponential increase in power/decrease in cost of computation and storage

# Three Key Technologies

- Algorithms have been with us for Millennia
  - ✓Taking over more and more of our world
- Robots have been with us for decades
  - ✓Moving out of the factory to ubiquity
- Quantum Computing will be with us in coming decades
  - ✓Not just faster but doing things now impossible

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# A World Run on Algorithms

- Algorithms are just rule sets, but put on steroids by computers
- Without algorithms, no modern transportation system, no digital TVs, no smartphones, no modern defense systems
- Algorithms give power to big data – from analyzing what to keep, what to throw away, what action to take
- Mining data about us to recommend movies on Netflix, books on Amazon, and "perfect matches" on dating sites
- Enabling energy efficiency smart grid, smart homes, smart cities
- Replacing lawyers for discovery, writing news stories instantly as data available, parsing data for the NSA
- Running the IoT or IoE that is wiring up the planet, society, people, and machines – 15 billion today, 50 billion in 2020, 1 trillion in 2050?

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# Algorithms Create New Risks

- Hacking the Internet of Things
- Privacy, Propensity and (Mis)Use of algorithms and big data
- Financial system vulnerability (70% trading by algorithms)
- Taking humans out of the decision-making loop
  - ✓ Algorithms on Wall Street, Amazon bidding war
  - ✓ Self-driving cars
  - ✓ Robotic warfare, from drones to robot armies making autonomous decisions
  - ✓ Autonomous kinetic cyber weapons (Stuxnet)
- Can we understand and manage these systems of systems?
  - ✓ Humans have not had a brain upgrade in 50,000 years

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# Rise of the Robots

- Currently, 70% of industrial robots assembling autos and electronics
- Inflection point in robotics: convergence of ICT, AI, sensing technology, cloud computing, advanced algorithms
- Empowered by cheap technology like smartphones, Kinect, and GPS
- Robots Uncaged: Baxter coming out of the factory to work with people – and replace them
- Performing surgery, making diagnoses powered by Watson, helping care for the elderly
- Drones transforming surveillance, warfare
- Robotic vehicles will transform transportation, cities
- Robots co-evolving with humans?

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# Quantum Computing Will Change the World

- All the above accelerated exponentially
- Quantum computing sooner than you think
- Bits to Qubits: binary to infinite
- End of encryption as we know it
- Solving the unsolvable: climate change, materials, engineering, pharmaceuticals, photosynthesis
- New materials by design, no trial and error
- Artificial photosynthesis, room temperature superconductor
- Big data, algorithms, AI, image recognition, search on hyperdrive
- Quantum computer arms race?
- Quantum world, hard to envision, risks and opportunities: are we ready for it?

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# Implication I: Third Industrial Revolution

- Convergence of technologies transforming where, how, and what we make
- Robotics, 3D printing empowered by algorithms, big data, cloud computing, the Internet of Things, new materials, unconventional gas
- Bringing it all back home with more and more customized production at the point of consumption
- DIY - democratization of technology as prices drop as capabilities increase, ICT connects
- Quantum computing will bring "quantum leap"

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# Implication II: Job Shock

- The Second Economy: Jobs lost not just to outsourcing but to algorithms and robots
- Amazon, Apple, Facebook, Twitter, Google: Market cap: $1 trillion; jobs: 150,000
- Techno-pessimists: we are in a race against the machine
- Techno-optimists: technology will create new jobs that we cannot even envision now
- Will technology create more jobs than are lost?
- New models of work and pay in 21st Century?

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# Implications III: Technology and Global Challenges

- Technology has fueled - and been fueled by – globalization, powered by natural resources
- Globalization, rise of middle class, urbanization have damaged and threatened natural ecosystsms
- These worlds are increasingly being wired up providing more information on our impact
- New technology, including quantum computing, could help address global challenges
- How do we inject strategic foresight about the risks and opportunities of these technologies and interacting ecosystems into strategic thinking, planning and policymaking?

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# Thank You!


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