Concept Note

Emerging risks

Sources, drivers and governance issues

(Revised edition, March 2010)

Phase 1 of the IRGC project on:

Developing guidance for people and organisations to improve their own detection of emerging risks, mainly by looking at how and why risks emerge.

This paper draws on discussions at a roundtable on 8-9 June 2009 and a workshop on 16-17 December 2009

Abbreviations used in the text:

AIDS	Acquired Immune Deficiency Syndrome
CFC	Chlorofluorocarbon
CO2	Carbon Dioxide
EFSA	European Food Safety Authority
ENISA	European Network and Information Security Agency
EPA	Environmental Protection Agency (US)
EU	European Union
GAO	Government Accountability Office (US)
HIV	Human Immunodeficiency Virus
IRGC	International Risk Governance Council
ISO	International Organization for Standardization
MRSA	Methicillin-Resistant *Staphylococcus Aureus*
NGO	Non-Governmental Organisation
NRC	National Research Council (US)
OECD	Organisation for Economic Co-operation and Development
SARS	Severe Acute Respiratory Syndrome
SONAR	Systematic Observations of Notions Associated with Risk
UK	United Kingdom of Great Britain and Northern Ireland
US	United States of America

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Preface

The International Risk Governance Council (IRGC) aims to support governments, business and other organisations and to foster public confidence in risk governance and in related decision-making by

- reflecting different views and practices and providing independent, authoritative information;
- improving the understanding and assessment of important risks issues and any ambiguities involved;
- designing innovative, efficient and balanced governance strategies.

IRGC's mission includes developing concepts of risk governance, anticipating major risk issues, and providing risk governance recommendations for key decision-makers.

At the core of IRGC's work is the concept and practice of risk governance, and central to this is the IRGC risk governance framework. The framework was developed precisely to provide a structure for combining the conventional practices of risk assessment, management and communication with the principles of good governance. The framework includes several innovations described fully in IRGC's White Paper No1 "Risk Governance – Towards an Integrative Approach", published in 2005.

More recently, IRGC has endeavoured to identify commonly recurring "deficits" in risk governance. IRGC's report on Risk Governance Deficits is designed to foster better understanding of their causes and how they can be prevented or mitigated through improved assessment and management. The IRGC project on risk governance deficits is an entry point to the current IRGC project on emerging risks.

With this note, IRGC intends to help improve the understanding and governance of emerging global risks that have impacts on human health and safety, the environment, the economy and society at large. In general, IRGC is concerned that important opportunities for social and economic development may be foregone through inadequate risk governance of emerging issues.

As with all IRGC concept notes, this document has the purpose of providing a brief summary of some of the issues that will be addressed in the course of future project. Comments are welcome on how this IRGC project can make a constructive contribution.

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Introduction

This concept note is the first output of IRGC's project on emerging risks. The project's objective is not to develop a list of emerging risks but, instead, to focus on their origins. In this concept note IRGC proposes and describes a preliminary list of elements – sources, drivers and governance issues – related to how risks emerge.

The sources, drivers and governance issues described in this paper draw on discussions at an IRGC roundtable held on 8 and 9 June 2009, hosted by the Swiss Re Centre for Global Dialogue. The roundtable brought together 30 experts from different countries and sectors, including participants from academia, policymaking, industry, and the non-profit sector. Participants concluded that these elements have been important to the development of past risk issues in their emerging phase and remain relevant to many currently emerging risks.

Once these elements and how they are structured are validated, revised or refined through more in-depth case studies and deliberation, IRGC plans to produce a policy brief that will explain in more detail than in this concept note the perspective it will develop on emerging risks. This perspective will also form the basis for IRGC's development of practical guidelines for practitioners in business and the public sector, helping them improve their own capabilities to understand, anticipate, and respond to emerging risks. Work on these practical guidelines will be done in a second phase of this project and may take the form of developing an *emerging risk framework.*

It should be stressed that the elements being introduced in this document refer specifically to emerging risks (or to risks re-emerging in a new form or context). Many of these elements are also relevant to the extent and pervasiveness of the many risks with which society deals on an everyday basis. IRGC[1] uses the term "uncertain" to characterise risks and for which there is incomplete or inadequate knowledge. Thus, most emerging risks can be defined as uncertain. In the following pages we do not identify uncertainty as itself a specific driver of risk, but we shed some light on aspects of the uncertainty of new risks, and the associated challenges for risk governance.

The audience of this concept note is both risk practitioners and members of the scientific community whose work is concerned with risk assessment and management of emerging issues. Later publications will be addressed to managers in government and industry responsible for the identification and early management of risk.

[1] In its approach to risk governance, fully described in the IRGC White paper No1 "Risk governance – towards an Integrative Approach" [IRGC, 2005], IRGC advises that the knowledge about a risk can be characterised as being predominantly simple, complex, uncertain or ambiguous.

1. Framing the project

Consider the current H1N1 flu epidemic, the recent financial meltdown, global climate change, the disruptions in Europe when Russia cut off gas supplies to Ukraine, the damages from hurricane Katrina, the tragic events of 9/11 and subsequent terrorist attacks in Madrid and London, the AIDS epidemic in Africa, and the rise of obesity in the developed world. Are each of these problems a distinct phenomenon, or are they all "emerging risks" that can be understood within a common intellectual perspective? In this concept note, IRGC explains how seemingly disparate risks can each be understood within a common perspective that covers sources, drivers, and governance. Before advancing, we define some of the key terms used in this document.

1.1 Definitions

Systemic risks

IRGC focuses on risks that have a capacity to become global (or at least span several countries and sectors), thus requiring collective action. The systemic dimension of most important risks is a key focus of IRGC's work. Dealing with interconnections between elements of social, technological, environmental and economic systems is a particular challenge for today's risk governance.

Emerging risks

IRGC defines as "emerging" a risk that is new, or a familiar risk in new or unfamiliar conditions (e.g., the re-emergence of the polio virus). Emerging risks are issues that are perceived to be potentially significant but which may not be fully understood and assessed, thus not allowing risk management options to be developed with confidence. Some emerging risks do not prove to be as significant as originally feared but others may prove to be worse than expected, with a high potential for major losses. Typically, the future consequences of emerging risks cannot be defined in monetary terms, at least not to any satisfactory degree of precision. Thus, conventional approaches to projecting loss size, relative frequencies or probability distributions over time or severity of consequences are ineffective. Indeed, it is often difficult to establish causality between the source of the emerging risk and its consequences using conventional technical or scientific data. As scientific understanding of emerging risks may be changing – sometimes quite rapidly – the challenge for risk managers in government and industry can be serious, and it is easy to criticise managers after a risk has emerged, regardless of how competent their ex ante decisions may have been, given the information available.

1.2 Sources, drivers and governance issues

IRGC aims to shed light on emerging risks with a perspective that has three elements: sources of risk, drivers of risk, and governance issues.

- *Sources* of risk are defined by the ISO as elements which alone or in combination have "the intrinsic potential to give rise to risk" [ISO, 2009];
- *Drivers* of risks act as *amplifiers* or *attenuators* of a risk by, for example, increasing its frequency or scale;
- *Governance issues* related to emerging risks reflect how individuals and organisations deal with the emerging risks, and so also attenuate or amplify their potential consequences. The governance issues

proposed in this paper have been identified in the course of previous IRGC project work on governance deficits.

1.3 Relationships between elements

In this document IRGC assumes that there is an analytical difference between *sources*, *drivers* and *governance issues*: the source is the origin of the risk, and there cannot be a risk if there is no source of risk. But a source of risk may not generate risk unless it interacts with other elements. If these elements are emergent properties of driving trends in society, they are called *drivers*, as they are the trends that fundamentally drive the development of a risk. If they are related to how people and organisations deal with either the source itself or the trends that drive the development of the risk, they are called *governance issues*. By *development* we mean *change*, not necessarily increase or *amplification*, but also decrease or *attenuation.*

It should also be noted that there is no hierarchy between these elements, meaning that no one is more important than another. Note also that the relationship between these elements is not linear or unidirectional, but can be in the form of a feedback loop (positive or negative); the sources, drivers and the governance issues may impact upon each other.

Over the next year, IRGC will re-assess each of these elements in light of:

- Whether they have been observed in the emerging phase of previous risks; and whether they are robust and relevant as possible components of guidelines for anticipating emerging risks; and
- Their capacity to be anticipative and therefore their usefulness: Do they actually help people and organisations to anticipate the risks they may face in the future, and to improve the efficacy of “horizon scanning” and other early warning systems?

Summary Table

Sources of risks	
1. Natural sources	Deriving from the natural environment, even if conditioned by humans and human activity
2. Human sources	
a. Unintended risks	Harm may result from: • Self-hazardous behaviour • Co-generated risks • External risks
b. Intended risks	Intentional harm inflicted by one actor upon another
3. Causal interactions between different sources	The complexity of the phenomena involved means that it is not always possible to designate a risk's cause as due to *either* natural *or* human sources. For many systemic risks, the cause is a combination of both. Examples of such risks include risks related to: • technical failure • international trade It is also difficult to differentiate between intentional and unintentional risks

Drivers of risks	*Background characteristics, or trends, in the environment, science and society that act to either amplify or attenuate the scale, frequency or probability of risks arising from various sources*
1. Knowledge of emerging risk *Scientific knowledge about a risk and understanding of its perception are required for adequately assessing and managing a risk. In the case of emerging risks, this is most often incomplete.*	• When there is no knowledge about an emerging risk, it may be ignored or overlooked. • Uncertainty is a particular problem (tractable uncertainties vs. "deep unknowns"). • It is difficult to appreciate the gravity of a new possible risk.
2. System complexity *Some emerging risks are driven, positively or negatively, by the complexity of systems.*	• Systemic risks require collective, global action. • The increasing scale and connectivity of systems can be a driver of risk, acting either as a risk attenuator (increasing fitness) or amplifier (creating robust, yet increasingly fragile, systems).
3. Social and cultural dynamics *Change in society is not itself risky, but such change can play a role in amplifying or attenuating risks.*	Amongst the dimensions to which attention should be given are trends in: • Technological innovation; • Population dynamics; • Cultural, social and economic globalisation.
4. Degree of development, poverty and inequality *The exposed population's degree of development, wealth and inequality may influence whether the risk is amplified or attenuated.*	• Variables such as wealth, literacy and education influence risk culture. • An organisation's or population's "risk culture" will determine its tolerance or aversion for a new risk, thus determining how this risk is prioritised.
5. Natural resources and the environment *The emergence of risk can be linked to a variety of stresses placed on the environment.*	• Overexploitation of natural resources is a recurring factor in the emergence of risks. • Ecosystems may fail to adapt to economic, social or environmental change.
6. Competing interests, ideologies, values and	• Values and cultures have an influence on risk

religions *Cultural diversity builds resilience into society and so may attenuate the breadth or severity of harm, but conflicts over different futures may exacerbate it.*	taking. • But attitudes and opinions may also have geopolitical origin or be grounded in material interests.
7. Variability in susceptibility to risk *Risk does not affect all individuals and groups in an equal manner.*	• Geographic location, genetic make-up and prior experience all affect susceptibility to risk.

Governance issues	*How organisations and individuals deal with emerging risks will determine how severe their consequences will be.*
1. Tackling complexity *The approach used to manage complexity and to tackle risks emerging from complex systems can influence (amplify or attenuate) the scale of the consequences.*	• Governance of complex systems needs to account for the many linkages within and between systems. • Systems thinking vs. silo mentality.
2. Dealing with tractable and deep uncertainty	Assessing and managing uncertainty and ignorance when characteristics and potential consequences of risks are unknowns
3. Governance of change and adapting institutions *How apt an organisation is at dealing with change will determine how it is impacted by emerging risks.*	Of particular importance are: • The need for early-warning systems; • Adapting to change; • The science-society relationship; • Assessment of innovative technologies; • Regulation.
4. Organisation and authority	Organisational capacity and resource allocation
5. Better agenda-setting *With emerging risks, societies engage in a process of risk selection. Some risks are selected for priority attention while others are ignored or deferred.*	• The selection process is often influenced by specific interests expressed by powerful stakeholders. • Processes such as hyper-democracy can give too much influence to public views.
6. Resolving conflicts *Conflict resolution is a mechanism to attenuate risks that evolve into conflicts, but emerging risks led by competing interests, values or ideologies may be particularly difficult to handle.*	• It is often difficult to manage trade-offs when dealing with emerging risks. • Short-term orientation of reward systems may discourage prevention of long-term emerging risks. • When early signs of risk appear, preventive or mitigation measures are often opposed by concentrated economic interests.

2. Sources of risk

At the most basic level, the sources of risks in life are natural phenomena, human activity, or a combination of the two. Outcomes from natural phenomena become risks only when they impact on the well-being of humans or on what is important to humanity (e.g., ecosystems). Risks that arise from human activity may be the unintended consequences of activities undertaken (or decisions made) for other purposes (e.g., the safety risks of driving a car for commuting or leisure purposes) or they may derive from intentional harm such as fraud or terrorism. In many countries, this difference is reflected in a legal distinction between civil liability (under the principle of the duty of care) and criminal law.

We begin with a consideration of natural sources of risk and then explore why risks arise from human activity. We then describe how systemic risks often have sources that arise from human/natural interactions.

2.1 Natural sources

The most common sources of natural risks are bacteria, viruses, parasites, genetic variation, earthquakes (and the tsunamis they trigger), extreme weather conditions (including drought, extreme heat and cold), floods, storms and hurricanes, landslides, fires and volcanic eruptions.

Bacteria are ubiquitous on Earth. A handful of soil contains millions of bacteria, which are essential to breaking down organic matter. Most are entirely harmless to man – indeed, many are essential to critical processes within the body, such as digestion. Some, however, are pathogenic, such as salmonella or MRSA (a “superbug” implicated in many hospital-associated infections). Pathogenic bacteria cause many widespread diseases such as tuberculosis, tetanus, pneumonia, typhoid fever, diphtheria and cholera.

Viruses are agents of nature (we ignore here the possibility of an engineered virus released from the laboratory) that cause many diseases to humans. They vary in their transmissibility and virulence. The Ebola virus, for example, causes a type of viral haemorrhagic fever that is largely untreatable and can be particularly lethal, depending on the strain. Zoonosis refers to the process whereby a virus crosses the species barrier, infecting humans through transfer from infected animals. Ebola, SARS and HIV, for example, are believed to have zoonotic origins.

Malaria is a deadly disease caused by a natural parasite carried and transmitted by mosquitoes. In tropical regions of the world where conditions are suitable for mosquitoes, the risk of malaria is heightened. Today there are approximately 250 million cases of acute malaria each year, from which some one million people die [WHO, 2009a]. One of the concerns about climate change – whether induced by nature or human activity – is that it may create new environments where malaria and other diseases can thrive.

There are many risks linked to weather conditions: electrocution from lightning, flooding during hurricanes, deaths from extremely hot and cold weather, and damage from extreme winds and tornadoes. The European heatwave of 2003 is estimated to have caused the deaths of 52,000 people [Larson, 2006]. An ice storm in the US in January 2009 killed 55 people and left 2 million without electricity [Biesk, 2009].

Extreme weather conditions should not be confused with climate change, but the climate is changing and some of the potential effects of climate change are that patterns of extreme weather will change. There may be more frequent and more intense hurricanes and they may affect different parts of the world than they do now. Monsoons may become more intense. Globally, temperatures will slowly rise, as will sea level. Changes to the climate will also influence ecosystems; the Millennium Ecosystem Assessment has concluded that 15 out of 24 ecosystem services are already in decline or under threat [MEA, 2005].

The risks of earthquakes, tsunamis, and volcanic eruptions share geological origins. These events vary in predictability and severity but generate large amounts of premature death and property damage around the world. The December 2004 Asian tsunami is estimated to have killed 230,000 people in 11 countries [Synolakis et al., 2005]. The 2008 Great Sichuan earthquake in China killed 69,000 people, injured 374,000 and left over 4 million homeless [USGS, 2008].

Solar radiation is the source of most of the world's energy and gives us light and heat, but can also be a cause of cancer. Experts are currently concerned that a solar storm and other severe space weather events could cause serious and long-term damage to electricity grids and, as a consequence, to the functioning of all appliances and services dependent on electricity. It is also possible that a meteor travelling at extreme speed, possibly a very large one, could strike the earth and create massive immediate harm as well as climate change.

Natural sources of risk are often familiar rather than emerging, in the sense that the term is used in this document. However, viruses and bacteria have the capability to evolve and re-emerge (sometimes as a more deadly strain). They may mutate enough to bypass any immunity that has previously been developed or develop resistance to common pharmacologic treatments. Thus, viruses such as influenza re-emerge periodically. Even well-known natural sources of risk such as floods and earthquakes may be considered emerging due to population movements that multiply the number of people, businesses, and communities at risk – this increases the potential severity of the risk. Frequently, natural and man-made sources of risk interact to foster or exacerbate emerging risks, making them sources of systemic risks.

2.2 Human sources

Risks emerge from human activities and behaviours, but the resulting harm may be unintended or intended by the individuals who generate the risk. In the analysis that follows, we also distinguish the person(s) or group(s) who generate the risk from those who bear the risk, since they may not be the same individual(s) or group(s).

(a) Unintended risks

Self-hazardous behaviour refers to situations where the same person who generates a risk also bears the risk. We shall assume the adverse outcome of the risk is not intended to occur. (If the adverse outcome is intended, such as suicide, it is a form of intentional risk generation, which is addressed below). Self-hazardous behaviour is a major concern among public health and medical professionals, governments, as well as private sector players (such as insurance companies) around the world.

Rational forms of self-hazardous behaviour occur when a presumably informed individual incurs risk in exchange for other perceived benefits. For example, drivers accelerate their vehicle in order to reduce travel time to a destination even though they know that the probability and severity of crashes rise with travel speed, at least under many circumstances. Consumers treat themselves to calorie-rich desserts even though they know that obesity is an increasing problem in many societies. The thrill of extreme skiing or sky diving is pursued despite the danger. Anyone volunteering for military service does so in full knowledge of the risk of capture, injury, torture and/or death.

Not all forms of self-hazardous behaviour are rational. Mental illness can lead to alcoholism or other risky personal behaviours. Addictions – physical or psychological – are known to contribute to smoking, alcohol abuse, excessive gambling and food disorders, some of the leading behavioural causes of harm from self-hazardous behaviour.

Co-generated risks arise when two or more agents, usually related by informal or formal contracts, engage in decision-making that generates risk that is incurred by at least one of them.

Employers and employees co-generate risk. An employer may offer a job with tasks known to be hazardous but compensate the worker with formal hazard pay. When workers are represented by unions, bargaining covers not just wages but also the extent of workplace hazards and safety measures, including who should bear the healthcare costs and foregone earnings associated with injuries and deaths incurred on the job.

When bargaining in the labour market is considered an inadequate response to workplace hazards, regulations may also be issued. Workplace health and safety is heavily regulated in many countries, precisely to reduce or transfer many of the risks of carrying out one's job. Globally, the International Labour Organization reports over 270 million occupational accidents annually and that they result in about two million deaths among workers [ILO, 2005]. The global rate of occupational accidents has been increasing in recent decades, although not as rapidly as the rate of growth in economic activity.

Consumers and producers (including suppliers of producers) make decisions that co-generate risks that may be incurred when the product is produced, transported, stored or consumed. In ideal markets, risks throughout the supply chain are well known, the parties are equally well-informed, and no parties have undue market power (e.g., in the form of monopoly or monopsony). The contract between producer and consumer typically states that a product, when used or consumed properly, will do what it should do and will not cause undue harm to the consumer; where the producer is aware of potential harm, this is communicated to the consumer (normally in the form of product labelling as in warnings about allergens or carcinogens).

In the case of many co-generated risks, one or more parties has the option of declining to accept the risk, by not accepting a job, not purchasing a product, choosing a different supplier, or choosing to travel by a different means. Globally, 1.2 million road users die annually in road accidents; the WHO estimates that figure will rise to 2.4 million by the year 2030 [WHO, 2009b]. Concern about co-generated risks rises when choices are highly constrained (i.e., there are no substitute jobs, products or means of transport available, or when substitution is difficult or costly).

Even seemingly well-functioning supply chains give rise to risks of concern to the public. During the recent financial meltdown, for example, bundles of risky mortgages were resold to investors around the world through instruments called derivatives, yet the real risks of the bundles were not disclosed. In fact, the derivatives (and the companies who marketed them) were often assigned the highest ratings with regard to investment risk.

Co-generated risks from international trade are coming under increasing scrutiny by the World Trade Organization. Due to highly publicised risks from consumption of products produced in China and sold in the United States and Europe, China is under increasing pressure to strengthen its health, safety and environmental regulations. Yet the World Trade Organization has also found that some regulations of imported products are a de facto form of protectionism (designed to protect local markets from global competitors) rather than a well-designed effort to protect human health, safety and the environment.

Thus, co-generated risks are not always simple issues involving a single worker and his or her employer. In our globalised economy, co-generated risks give rise to complex regulatory, trade and foreign policy issues.

External risks – called “externalities” if they have not been priced in a market system – arise when the party who bears the risk is different from the party who generates the risk. As a result, the risk generator has no formal relationship with the risk bearer (even though they may be residents and taxpayers in the same community). External risks can be either common pool risks (such as climate change) or third party risks where an identifiable number of people are affected and could organise themselves (such as in a community suffering from polluted drinking water).

An external risk may arise from production or consumption of a product. For example, the process of manufacturing a car may create pollution at plants throughout the supply chain, pollution that creates risks for third parties who were not involved in the market for cars. When the car is used, pollution may occur at the tailpipe of the vehicle, the precise amount of pollution depending on how much the car is used and how well the engine is maintained.

Industrial facilities are well-known sources of external risks. For example, pollution-induced diseases have occurred due to chemical exposures from a factory that has polluted well-water in a nearby community. The catastrophic chemical release in Bhopal, India, in 1984 killed several thousand people within 72 hours [Sharma, 2005].

Transboundary external risks occur when risk generators and risk bearers are in different countries. In other words, parties in one country may incur an unintentional risk that is generated by activities in another country. For example, the radiation fallout from the Chernobyl nuclear accident extended over much of Europe and even reached eastern North America. Energy-security risks have a more complex dynamic. As more and more crude oil passes through the Malacca Straits, much of it bound from the Middle East to China, the people and natural environments of Singapore, Malaysia and Indonesia are exposed to the potential risks of an oil spill such as those caused by the Torrey Canyon (affecting coasts and wildlife in the UK and France) and Exxon Valdez (Alaska, US).

Another illustration of transboundary risks is related to resource depletion. The unsustainable exploitation of natural resources such as water supplies, forests or fisheries create externalities. Even if all parties generating the risk prefer that the risk not be generated (i.e., to assure long-term access to the resource), a "tragedy of the commons" may occur when no agent will act to prevent the risk unless all agents act in unison. This has been the case with the depletion of many fisheries in the world's seas and oceans. As demands for finite supplies of natural resources continue to increase without any effective collective mechanism to address the commons problem, transboundary external risks tend to be shifted to the future, with serious consequences for future generations.

(b) Intended risks (intentional harm inflicted by one actor upon another)

People can be exposed to risks that are deliberately generated by others (individuals, groups, nations or groups of nations) in order to meet certain objectives or satisfy psychological impulses. Examples of intentional harm include theft, cyber attacks, murder, terrorism and acts of war. In contrast to the harm of pollution, which is typically an unintended side-effect of production or consumption activity, the harm from an intentional risk is typically the outcome that is desired by the agent generating the risk.

Inside the family, examples of intentional risks include child and spouse abuse. Within a community, examples include rape, assault, burglary, robbery and murder. The risk generators may be individuals or they may be groups, such as the violent gangs that operate in some cities around the world. Within a nation state, intentional risks also encompass the violence generated by isolated terrorist incidents, organised terrorist campaigns and even civil war. And nation states, through organised military action (e.g., covert or declared war) have imposed intentional risks on other states for a wide range of reasons (e.g., access to valued natural resources, attempted resolution of border disputes, and religious or ideological conflict).

In business, individual corporations face intentional risks such as employee theft and sabotage. Within the business world at large, intentional risks include cases of corporate fraud such as the bogus accounting schemes that led to the Enron scandal in the US and the recent Ponzi scheme run by Bernard Madoff.

2.3 Causal interactions between different sources

Many systemic risks arise because of complex causal interactions between different natural and/or human sources. More often than not, human and natural systems cannot be usefully disentangled, and technological systems reside at the complex interface between these systems. All three types of system co-evolve; in other words, they each form a key part of the environment influencing the other two. Take the potential risks that could arise from synthetic biology as an example: the source of these risks would be related to how natural biological components interact with 'engineered' components in a technological system that is neither entirely natural, nor entirely human-made. Both biological evolution (natural) and technological advancement (human) will affect how the system develops and the sort of potential risks that could emerge.

Other examples of such risks include risks related to technical failures or to international trade:

Technology is “man-made” and thus sources of technological risks are most often “human”. However, technical failures are most often not caused by human action alone, and are illustrative of this third category of risk sources, where a technological system straddles the human-natural divide. For example, a natural event, such as a storm, could damage electricity infrastructure, causing various risks to emerge. Human behaviour (such as error in design or management of the technical system) interacts with natural forces to bring about the risk.

Similarly, the origin of risks related to international trade can be a combination of natural factors (e.g., parasites or biological food contaminants present in one region of the world, but not in others) and human factors (modern transport systems, geopolitics and international trade regulations which can determine whether and how widely this contaminated food is spread to other countries)

For systemic risks of this kind it may also be difficult to distinguish between intended and unintended risks. The example of the melamine-contaminated infant formula discovered in China in 2008 provides a good example: in this case, it is clear that the addition of melamine to milk was intentional (it was designed to make the milk appear to have higher protein content, allowing it to meet nutritional standards), but it is also clear that manufacturers were unaware of melamine’s toxic effect on infants. Making infants seriously ill (causing kidney stones and renal failure) was not at all a sought outcome, and in this sense it was unintentional. However, it is also possible to argue that manufacturers knew that the infant formula would be harmful to health, simply due to its lack of adequate nutrition, and thus they were intentionally creating a health risk.

In conclusion, whether a source of risk is natural, human, intentional or unintentional is thus not always clear-cut and can involve some degree of subjectivity. Nevertheless the above categories of sources can be useful in guiding thinking about the processes by which risks emerge.

3. Drivers of risk

What we call “drivers” are background characteristics (or trends) in the environment, science and society that act to either amplify or attenuate the scale or frequency of risks arising from various sources. These drivers are typically independent of how individuals and institutions cope with particular risks, and thus the drivers of risk are not typically the target of risk-specific governance measures, which we address in section 4.

Conceptually, an amplifying driver increases the likelihood/frequency of risk and/or exacerbates the adverse outcomes of a risk (above baseline levels). An attenuating driver operates in the opposite direction: lowering the frequency of risk and/or diminishing the severity of harm from an emerging risk. Strictly speaking, only the sources of risk described in section 2 “cause” risks to occur

but the drivers we address in this section can play a powerful role in magnifying or diminishing a risk that emerges from natural and/or man-made sources.

While we have advanced a conceptual distinction between sources and drivers, we recognise that the distinction is not routinely made. Lumping sources and drivers together may be adequate for risk managers in some cases, since the distinction may not be relevant to risk assessment or the design of particular management measures. But when we consider broad social efforts that address multiple emerging risks (e.g., poverty reduction, expanded scientific research, improved educational systems, and better health care), it may be useful to understand the drivers separately from the natural and man-made sources of particular risks.

The proposed drivers are neither exclusive nor exhaustive. Major risk issues are systemic and several *drivers* may be relevant to them. Additionally, each driver will impact differently and over different time periods and some drivers will have an immediate impact, others will not.

3.1 Knowledge of emerging risks

When adequate knowledge about an emerging risk exists, a formal risk assessment can be undertaken, the risk can be evaluated as acceptable, tolerable or unacceptable and, when appropriate, risk management options can be developed and implemented to avoid, reduce or mitigate the risk. But, when critical knowledge about it is missing or unavailable to decision-makers, the risk may be ignored or overlooked, which can allow the risk to become more likely, more widespread, and/or more harmful.

At the early stages of the AIDS epidemic, for example, scientific understanding of the HIV virus was insufficient to assess risk and design meaningful risk management actions. During the period that the virus was studied, the virus spread further and the epidemic accelerated. Knowledge acted as an attenuator with respect to the risks from CFCs and other ozone-depleting substances. The Montreal Protocol, which led to the prohibition of the manufacture and use of CFCs (1989), was signed only 16 years after scientists discovered the link between CFCs, their release of chlorine into the stratosphere, and the destruction of ozone [UNEP, 1987; Benedick, 2007].

Who has possession of the knowledge can also be a significant factor in risk amplification. *Asymmetry of information*, where some stakeholders have more knowledge about an emerging risk than others, can lead to incorrect risk assessments and imprudent risk management decisions. In the financial sector there are often asymmetries between the suppliers of financial products and the consumers who buy and use them. Such asymmetries played a large part in bringing about the sub-prime mortgage crisis in the US in 2007-08, as purchasers of mortgage-backed securities, for example, did not realise how risky an investment they were making, as they did not have full knowledge of how the financial product had been created and rated.

Perceived knowledge – what a stakeholder *thinks* he or she knows, as opposed to what he or she *actually* knows – can have a similar effect on risk amplification. For instance, in the example above, an investor buying a mortgage-backed security might feel secure and be over-confident because he believes he has good knowledge about the financial market and confidence in

the high rating of the product, but in reality he does not really have adequate knowledge to do a proper risk assessment.

In the context of emerging risks, uncertainty is a cause of confusion, controversy and delay of precautionary measures. Indeed, uncertainty creates space for obfuscation by stakeholders, who may seek retention of the status quo even when it seems likely that serious risks are emerging.

3.2 System complexity

Some emerging risks are driven – positively or negatively – by the complexity of organisational and/or technological systems. There are numerous definitions of "complexity", but IRGC defines complexity as the "difficulty of identifying and quantifying causal links between a multitude of potential causal agents and specific observed effects [IRGC, 2005]. Here we refer generally to the tendency to expand the interdependency of various components of systems, including the interdependency between entire systems. Interdependency can increase resilience or vulnerability to systemic risks, and it is not obvious when complexity is acting as an amplifier or attenuator.

The scale and connectivity of the complex systems on which society depends are both increasing. Formerly discrete complex technical systems, such as electricity distribution systems, are now interconnected and operating in ways not intended at the time of their original design and construction. Adding functionalities to existing systems that were not conceived for those additional purposes increases their fragility and the risk of cascading failures. The supply chains supporting most of the world's food, energy, and information and communication sectors are increasingly interlinked. Many cities are themselves becoming increasingly large and densely populated, requiring ever-increasing supplies of energy, food and other essentials from elsewhere.

Scale and connectivity can be risk drivers. The rapid spread of SARS to many countries, and its impact on trade, tourism and the economy (as well as its direct impact on public health), is an illustration of an emerging, systemic risk. Others include the cascading failures of interconnected electricity grids and how climate change will affect, differently, various segments of the world's populations and ecosystems.

For many networked systems, within limits, the average fitness of the system increases as the level of connectivity increases. One can see this in the use of portfolios to spread asset and investment risks, in how the modern electricity grid both allows power to be transmitted over large areas and reduces the risk of localised blackouts, and in how trade linkages (as between the US and China) may reduce the incentive for international conflict.

However there is also evidence that, as connectivity increases, so does the probability of major failures. The networks literature uses the term "robust yet fragile": "a system may appear stable for long periods of time and withstand many external shocks (robust), then suddenly and apparently inexplicably exhibit a large cascade" [Watts, 2002]. "Increasing the number of connections causes an increase in the average fitness of agents, yet at the same time makes the system as a whole more vulnerable to catastrophic failures on a near-global scale" [Ormerod and Colbaugh, 2006]. The literature relating to socio-ecological systems also refers to a system becoming increasingly inflexible prior to a "chaotic collapse and release phase" [Walker et al, 2004].

Many are concerned that the same interconnectivity that makes the electricity grid more resilient also increases its fragility and the risk of cascading failure.

The economy, demographics, the environment, energy and food supply, and climate constitute five “tectonic stresses" in key global systems. These stresses, combined with multipliers such as interconnectivity between people and between systems, greatly increase the risk of a cascading collapse of systems vital to our well-being — a phenomenon sometimes called "synchronous failure” [Homer-Dixon, 2006].

As seen in section 2.3, some risk sources are a complex combination of human and natural sources. These more complex sources of risk arise owing to the existence of complex and interpenetrating human, technological and natural systems that co-evolve along contingent and path-dependent trajectories to produce sets of factors that cause outcomes some people regard as dangerous (i.e., risks). Since human and technological systems are *adaptive*, they tend to become more complex and connected over time. Rising complexity is therefore a deep characteristic of our global system’s change through time (with the caveat that many natural systems are being simultaneously simplified by human degradation).

3.3 Social and cultural dynamics

Change in society is not necessarily risky but social and cultural dynamics can play a significant role in amplifying or attenuating risks and, therefore, need to be monitored closely.

Changing lifestyles and behaviours are examples of how social and cultural dynamics may drive emerging risks. This can be illustrated by obesity, an increasing problem in the US and elsewhere. Although obesity is not new, it was only rare during most of human history. Its increasing prevalence now can be seen as the result of economic and social dynamics. In the US, the price of food has fallen steadily in real terms while the fraction of meals consumed outside the home (often at fast-food restaurants) has risen. The food industry is under competitive pressure to offer enticing products to customers, products that tend to be high in caloric and fat content. At the same time, the growing role of television and computers in American life is causing more people to live sedentary lifestyles. The combination of more calories and less exercise exacerbates the risk of obesity. The long-term costs of obesity are spread throughout society (individuals, families, employers, food companies, health care providers, health insurers and taxpayers), and thus there is an external aspect of a phenomenon that appears to be “self-hazardous” behaviour. On the other hand, other social changes, notably changes in education levels, have the capacity to attenuate risks like those linked to obesity. More people having greater understanding and access to information about what constitutes a healthy diet and lifestyle could contribute to reducing rates of obesity.

Whenever any single process in society changes at a rate that exceeds the adaptation capability of a related process, there is a risk of dysfunction. Thus, if technological, biological or social change occurs rapidly at the same time that industrial associations, NGOs, international organisations, nation states or political institutions are faltering, emerging risks can be amplified. In this context, it is not surprising that the epidemic of AIDS in Africa has proven to be far more devastating than in developed countries around the world where functional governments – including public health, educational and medical

organisations – have worked together with some degree of effectiveness in slowing the epidemic.

There are three specific dynamics which appear to be of particular importance to the amplification and attenuation of risks: the process of technological innovation, changing population dynamics and globalisation.

Technological innovation and diffusion

Technological innovation offers many benefits as well as risks. Products created using synthetic biology are potential examples of technological innovations with the capacity to attenuate risks (for example via the creation of new drug and vaccine development pathways), but in some circumstances, synthetic biology techniques might amplify risks (for example by enabling the construction of new 'weapons' that could be used by bioterrorists).

Risk may be driven by the rapid diffusion of new technologies throughout society – especially diffusion that occurs without careful monitoring of impacts on human health and the environment, and adequate regulation. Such diffusion can be a potent influence on the scale and impact of emerging risks. Devices such as mobile phones, for example, are rapidly entering the daily lives of hundreds of millions of people around the world. The economic and social benefits of these devices have been enormous. Belatedly, though, questions are being raised about whether drivers of motor vehicles should use these devices (hand-held versus hands-free versus no use) and whether distracted pedestrians and cyclists are inadvertently placing themselves at risk.

The speed of innovation and diffusion is such that regulatory processes designed to assure safety often cannot keep up (see 4.2, Regulation). This applies equally to novel technologies with multiple fields of application (such as nanotechnology, which challenges regulators of foods, pharmaceuticals, chemicals, medical devices and electronic goods) as well as a single technological innovation for which there is no regulatory framework (e.g., the geological storage of CO_2 captured from coal-fired power plants).

Technology diffusion also acts as a powerful attenuator of risk. Some countries now deliver emergency awareness messages to their populations using text messages sent over mobile networks. Airbags in cars, new medicines and surgical techniques, and automated trips in electrical networks are all innovations that dampen risks to people and society.

Population dynamics

Population changes, whether slow or rapid, can influence the pace and severity of emerging risks. For example, many societies are forecasting fiscal and social imbalances from the growing ratio of senior citizens to younger workers. The ageing of populations has been slow and predictable, yet faster than the ability of political and economic institutions to respond. Likewise, the urbanisation of many developing countries may exacerbate the spread of some risks (e.g., viruses) while creating vulnerability to large-scale losses from faulty or outmoded infrastructure.

Some population changes occur quite rapidly, and they may generate risks that are worrisome to affected populations. In some countries the rate of both legal and illegal immigration has outpaced the ability of social institutions to cope with individuals and families who confront language and cultural barriers in daily life. Immigrants offer many economic and social benefits to host countries

but they also create costs and risks for schools, social services, and law enforcement institutions. Resistance to rapid immigration is a persistent source of social and political conflict and, in extreme situations, can precipitate discrimination, terrorism, border conflicts and military conflict.

Cultural, social and economic globalisation

The rapid growth of international trade has had many beneficial consequences but it has also been a source of risk and conflict. Proponents of globalisation argue that it has been a force for wider prosperity, modernisation, and democracy around the world. Opponents counter that many impoverished communities have been unaffected – or have even been hurt – by globalisation. It has also been linked to rising social and economic inequality. As mentioned earlier, globalisation also creates distance between agents who generate risks and agents who incur risks, as when citizens of one country are harmed by products imported from another where regulatory standards are less rigorous.

3.4 Degree of development, poverty and inequality

A community that lacks income, wealth, literacy, formal education and social capital may be highly vulnerable to an emerging risk. Likewise, a community strong in these assets may be better able to muster the human and/or financial resources necessary to implement preventive and mitigating responses.

Both within and between countries, the degree of social and economic inequality is also influential. Communities with huge inequalities in access to medicine, public health, education, the Internet and social activities may be more vulnerable than communities with a more equal distribution of these assets. Thus, when a community's vulnerability to emerging risk is assessed, it is important to assess the degree of inequality in the community as well as the absolute, average levels of social capital.

Individuals and communities also differ in their preferences, or what has variously been called risk appetite, risk culture or degree of risk aversion. The world's poorest face a daily challenge to obtain food, water and shelter; to them, some of what are considered risks by wealthier populations are an irrelevance. Rich and poor may therefore identify and prioritise risks differently, meaning that an emerging risk with potential global consequences may spread more or less rapidly depending on how important it is to the people who first experience it.

Attitudes toward risk are not determined solely by economic variables such as per capita income. Societies with similar degrees of development often exhibit quite different tolerances for specific risks. For example, the European Union has tolerated more risk from tobacco, lead and tailpipe pollution than the US while the US has tolerated more risk than Europe from firearms, motor vehicle crashes and innovative methods of food production. Social scientists have found that societies engage in an implicit process of risk selection, and the risks a society worries about help define its "risk culture". Without understanding these risk cultures, the path taken by emerging risks may seem perplexing to observers who consider only the technical issues.

3.5 Natural resources and the environment

The emergence of some risks can be linked to a variety of stresses placed on the environment as a result of human interaction and interference. Over-exploitation of natural resources and the pace of environmental change are noted here because, while they are not the only stresses, they are recurring factors in the emergence and amplification of many risks (e.g., ozone depletion, species extinction, food and water shortages and international conflicts).

Access to natural resources

Economic development over the last 100 years was facilitated by the extraction and use of many of the world's natural resources. The rate of use continues to increase, primarily due to the growing world population and the increasing spending power and resulting demand for goods from emerging economies such as China and India.

Much of the attention is devoted to energy resources such as oil and natural gas, but many of the world's other natural resources, such as those provided by ecosystems, are also being consumed. They include fresh water, capture fisheries, or wood fuel, and there are warnings of future supply shortages of phosphates (used as an agricultural fertiliser), aluminium, copper and others. As the pressure on these resources continues to mount, sustainability experts are concerned that global population and resource consumption will outstrip the ability of mankind to survive without imposing unacceptable risks on ecosystems and the welfare of future generations.

Some countries are resource-rich, others are not. Almost no country has access to all the natural resources it needs, whether oil, agricultural land, fresh water, food, or metals. Without effective trading systems and foreign assistance, regional shortages and imbalances of natural resources – or even the perception of future shortages – may be drivers of risk, having the capacity to either attenuate or amplify conflicts between and even within nations.

Environmental change

Some features of ecosystems (many of which provide services vital to people) may be particularly slow to adapt to economic, social, or environmental change and are therefore vulnerable to rapid escalation of stresses caused by external factors.

Biodiversity is threatened when change is too rapid. Thus, it is not necessarily the absolute rate of change in a process that triggers risk but the relative rate of change in one process compared to another. In the case of global climate change, the pace of change needs to be considered as well as the amount of change because adaptation is more feasible and effective if the pace of change is lessened. In this respect, climate change is itself an environmental stressor that operates as a specific driver of risks.

Environmental change may in turn amplify or attenuate emerging risks in sectors of society, and a particular aspect of this is the use of natural resources.

Competing interests, ideologies, values and religions

Cultural diversity builds a degree of resilience into society and, therefore attenuates the breadth or severity of harm from some risks. But a more perverse effect of diversity is that it may amplify risks as conflicts over different visions of the future slow a society's reaction time or spawn ancillary risks related to the original conflict.

Religion, ideology and, more generally, values and culture, have a significant influence on risk-taking. Indeed, risks may be driven by religious, ideological or cultural beliefs that motivate dangerous or conflictual behaviours and/or discourage protective or preventive actions. For example, intolerant religious beliefs may foster war, terrorism and human rights violations (if adequate governance systems are not in place). Also, some public attitudes towards technologies, and the risks they pose, may be linked to beliefs, religion and/or ideology. For example, opposition of some religions to blood transfusions prevents the improvement of health status. Also, organised resistance to technological development, such as genetic engineering, nanotechnology or nuclear power, may be rooted, at least in part, in cultural resistance to developments that seem "unnatural", although those technologies could, if pursued competently, contribute to the resolution of some of the risks related to food and energy supply.

Not all attitudes and opinions are based on religion or ideology. Some that have been linked to warfare have geopolitical origins (e.g., border regions around the world that have been sources of conflict for generations). Other attitudes that exacerbate or diminish risk are grounded in material interests and behaviour such as consumerism and access to resources and wealth.

3.6 Variability in susceptibility to risk

Risk does not affect all individuals or populations in an equal manner. Contextual factors such as geographical location, genetic makeup (biological fitness) or prior experience all affect susceptibility to risk.

Many weather-induced risks – drought, hurricanes, ice storms – affect only limited parts of the world and a minority of the world's population. The impacts of climate change will be felt all over the world, but the precise impacts will vary: coastal areas affected by rising sea levels will not be affected equally, depending on local factors such as coastal slope, the built infrastructure, the occurrence of storms and surges and the ability of coastal ecosystems to adapt to sea level changes and storm damage. Most people view the melting of the Arctic ice sheet as an event with only adverse consequences, but it has already opened up a summer shipping route north of Russia that can shorten some voyages.

Evolution is an ongoing process and is, for example, the natural phenomenon behind the emergence of new viruses and bacteria and the ability of bacteria to mutate and develop resistance to antibiotics. Natural selection, a key mechanism of evolution, explains why some human populations are less susceptible to some diseases than others (e.g., some populations are more resistant to malaria than others). But the genetic variation that is a driving force of evolution can also create gene variants that predispose individuals to disease. For example, specific gene variants are known to contribute to the causation of obesity, some cancers, and other diseases.

Within a lifetime, people also adapt their behaviour in response to risk. Learning from past experience is a key factor, as the experienced skier or sailor is less at risk than a beginner, particularly in difficult conditions. In Japan, for example, the knowledge of what to do in case of an earthquake is widely spread in the population. In economic policy, governments have learned over time that free-floating exchange rates are less dangerous to their economies than fixed rates.

Thus, in order to project the future of an emerging risk, analysts need to account for the variability in the susceptibility of the exposed population as well as the population's likely adaptations.

4. Governance issues

How individuals and organisations deal with emerging risks, and the underlying uncertainty about them, will determine how severe their consequences will be. We acknowledge that the early handling of an emerging risk may require that decision-makers take decisions and act in situations of uncertainty – without as much knowledge as they may feel they need. Here we consider, in broad terms, what organisations responsible for risk governance do when they try to prevent or reduce the adverse consequences of emerging risks, and that these governance issues interact with how the risks emerge.

4.1 Tackling complexity

How business and policymakers *deal* with risks that arise from complexity will determine the gravity of potential consequences. The characteristics of many interdependent systems – notably deep uncertainty (see 4.2), disproportional causation/non-linearity and time lags – render their governance particularly challenging. The failure to deploy "systems thinking" can be a critical shortcoming in risk management activities. By "systems thinking" we refer to rigorous examination of the linkages between social, physical and natural systems in order to avoid fragmented, sub-optimal and hence unsustainable solutions (e.g., fragmentation of technical systems, as with electricity grids, or of regulatory approaches, as with patents). Some systems can be loosely coupled and can be adequately handled by dealing with sub-elements separately, but some technical systems (such as the network for European electricity distribution) have become so tightly coupled and complex that it is difficult even for experts to understand them and their associated cause-effect relationships. There may also be unawareness, or even deliberate ignorance, of the risks involved.

Governance problems may arise because policymakers view risks one at a time with a "silo mentality." For example, critics of recent mandates of ethanol as a petroleum substitute argue that the mandates exhibited this failure in thinking. A preoccupation with a desire to reduce oil consumption was acted upon without carefully considering the complex ramifications for land use, climate change, water supplies and food prices. A failure to think at a systems level has also been an obstacle to the design of intelligent health care policies. Efforts to expand access to health care often fail to consider cost ramifications while efforts to control costs often fail to consider impacts on the quality of patient care.

Thus, when a risk is addressed in its emerging phase, it is crucial for risk managers in the private and public sectors to see how the emerging risk is connected to complex systems, and how various solutions that are proposed will impact, directly and indirectly, on the entire society, including the environment. Governance of complexity is often associated with the use of scenario analysis, which is one useful tool for exploring the many possible future 'pathways' along which a complex system may develop. Without assigning each scenario anything approximating a precise probability, risk managers can seek to identify sets of elements (sources, drivers, governance issues) that might jointly cause risks to emerge.

When there are concerns about emerging risks from complex systems, managers often consider ways to build in redundancies and resilience that reduce the probability and/or consequences of adverse events. This strategy, sometimes called "defence in depth", originated in military strategy and has been widely used to enhance the safety of nuclear power plants and space exploration vessels.

4.2 Dealing with tractable and deep uncertainty

Uncertainty is by no means specific to emerging risks, but dealing with it when risks emerge is a specific challenge. First one has to characterise the kind of uncertainty that affects the scientific knowledge about the risk and the complexity of the system in which it operates (see 3.2). Different kinds of uncertainty will imply exploring systems boundaries, variability in risk management and uncertainty in implementation.

Scientific uncertainties come in many forms. Tractable uncertainties are those that *could* be resolved by qualified scientists but are not resolved due to insufficient funding, inadequate facilities, misdirected scientific effort, or adherence to outmoded hypotheses or theories. More troubling are the deep unknowns – situations of deep and structural uncertainty where scientific resolution is unlikely for the foreseeable future. The distinction between tractable and deep uncertainty is not always obvious when decision-makers are faced with the unknown but it is crucial to recognise that some scientific uncertainties will not be resolved in the time-frame necessary for effective risk management.

People trying to manage complex interdependent systems usually cannot estimate with any precision future system behaviour or its associated risks. Particularly during the emerging phase of risks, risk assessors and managers are often surrounded by 'known unknowns' and 'unknown unknowns', which means, in the latter case, that they are ignorant of their own ignorance.

4.3 Governance of change and adapting institutions

As seen in 3.3 (social and cultural dynamics) change is a normal process that can play a role as an amplifier or attenuator of risk. Therefore, how apt an organisation is at dealing with change, how well it can adapt its own structures and processes in order to effectively mitigate the emerging risk, will determine how it is impacted by this risk. A number of specific aspects of governance structures and processes are important to emerging risks:

Early warning systems

In the absence of the capabilities to detect early signals of risk, there is a large chance that the risks will materialise with maximum impact, given that no-one saw them coming in time to undertake prevention or mitigation efforts.

Of particular importance are:

- detecting “hidden” concentrations or accumulations of exposures whose size, scale and impact could have a material adverse effect;
- complex and “opaque” products or services which are understood by only a few experts;
- looking for discontinuities or tipping points which indicate either unclear ”rules of the game” or a likely change;
- lengthy dependent “chains” of any type, since they are only as strong as the “weakest link”;
- more scenario analysis and “stress testing” outside the range of “business as usual”;
- imagining unintended consequences of public policy and regulation, and looking for connections which could arise between “seemingly unrelated” trends; and
- measuring trends in diverging views between groups on critical issues such as genetic testing, genetic engineering or climate change, as such diverging views can be precursors to emerging risks or can complicate efforts at taking precautionary or mitigation measures.

Many risks have been allowed to emerge because there has been no early detection of signals due to a lack of surveillance, monitoring and appropriate assessment of relevant indicators. Additionally, particularly in cases of systemic risks with high complexity, there are often long periods of time between the occurrence of a change driver and its visible effects on the system it has influenced. Because of this, there may be no apparent indication that a tipping point has been reached. Early warning systems must therefore extend beyond observing changes in first-order risks to examining changes in their root causes.

The science-society relationship

When risks begin to emerge, the degree of cooperation between science and society is crucial. When cooperation is inadequate or non-existent, risks tend to be amplified. Likewise, harmonious cooperation between science and society tends to attenuate risks. For example, scientific understanding of how pollination services are rendered by ecosystems should enable farmers and the agricultural industry to adapt their methods and products so that any harm to the pollination process is minimised. The decline of pollination services is a concern that scientists and society can and should address together.

The decoupling of science and society, sometimes due to neglect of the relationship and sometimes due to public mistrust of science and technology, is a matter of concern. Negative public perceptions of science and technology are of particular concern, since they threaten the science-society cooperation that is critical to dealing with emerging risks. These negative perceptions are variable but they include a feeling that the benefits of science are often elusive, that realised benefits are not shared equally, that the process of science threatens cherished values (e.g., religious and ethical beliefs), and that the promise of scientific progress is oversold to enhance taxpayer funding of science.

Negative perceptions and decoupling can be addressed through concerted efforts by colleges and universities, professional societies, and science-policy organisations (e.g., in the US they include the National Academy of Sciences and the American Association for the Advancement of Science). Long-term efforts to raise the scientific literacy of the public are also crucial, since they create a societal context in which scientific advances are more likely to be understood and appreciated. Equally, science itself needs to be aware that merely by conducting research into sensitive issues or controversial technologies, it can trigger a perception of risk amongst sectors of the public.

Assessment of innovative technologies

Business and regulatory practices sometimes allow the rapid diffusion of risky technologies without adequate ex-ante risk assessment or ex-post monitoring and surveillance of the impacts (intended and unintended). For example, ex-ante risk assessment of prescription drugs is often quite rigorous but the quality of post-market surveillance systems, which are crucial for detecting severe side effects, is uneven.

When technology assessments occur, they may be primitive, flawed in their design or embedded in an ineffective regulatory system. Common deficiencies that act as risk amplifiers include:

- A lack of early methodological work to set out the appropriate evaluation instruments;
- A lack of constructive dialogue and collaboration between developers, scientists and regulatory authorities;
- Resistance to requirements for minimal standards of pre-market assessment and post-market surveillance;
- Insistence on unrealistic safety standards such as zero risk;
- Unclear allocations of the burdens of proof concerning risk and safety; and
- Weaknesses in the regulatory framework when risks are identified.

Countries around the world vary considerably in the stringency of their requirements for pre-market and post-market safety studies.

Regulation

One of the principal tools of risk governance, regulation, is a stabilising factor in society and the economy, and is needed as such. In many countries, regulations have achieved cost-effective improvements in the safety of cars, the quality of foods, the extent of workplace hazards, and the amount of tailpipe pollution from motor vehicles. But regulation has also proven to be clumsy, resistant to change, subject to abuse, and costly, thus possibly acting as a risk amplifier. Thus, better regulation is integral to any comprehensive effort to deal with emerging risks.

Once established, regulatory structures, as well as the processes that produce regulations, are rarely revised. Sometimes outmoded regulations stifle the development or diffusion of safer technologies (e.g., drug innovation in the US was stifled in the 1960s by overzealous federal regulation) while in other cases outmoded regulations do not address new risks being created by science and technology (e.g., some experts are concerned that nanotechnology products are creating risks to human health and the environment that are not controlled

by traditional regulatory policies). Fortunately, the OECD, academic centres, and think tanks around the world have fostered a systematic effort toward better regulation, which includes building more science, economics, flexibility, and urgency into regulatory structures and processes.

4.4 Organisation and authority

A basic requirement of effective governance of emerging risks is an organisational capacity (resources, staffing, expertise and allocation of responsibility) to anticipate and respond to risks before and as they emerge. Anticipating emerging risks is a task that requires specific skills and resources. If authorities do not give this task as a priority to dedicated teams, emerging risks may be amplified.

Emerging risks may be amplified if a) managers have not designed policies aimed at preventing, reducing or spreading the anticipated damages from risks, or b) if they have not designed monitoring systems, whether formal or informal, to ensure that policies are implemented, enforced, evaluated, and modernised over time in light of experience.

If an emerging risk is unfamiliar, it may not have been foreseen when the jurisdiction and authorities of regulatory agencies were established. As a result, the unforeseen risk may fall through the cracks of existing authorities, leaving no regulators accountable for a serious risk that is emerging or has already emerged. Thus, when unfamiliar risks emerge, it is vital for regulatory responsibilities to be clarified as soon as possible. Sometimes interim arrangements may need to be established by existing agencies until the relevant political authorities provide clarification with regard to responsibility and authority.

For emerging risks that transcend national boundaries or threaten shared global resources, the most effective response often requires an international strategy that includes participation by many nation states and which involves first assessment and then management. Yet the scope of international regulatory authority for emerging risks is quite limited and the legitimacy of international regulatory authority is sometimes questioned. Where possible, such global risks (for example, those affecting food safety) should be addressed through cooperation among nation states but, in the long run, effective international regulatory regimes may be the optimal strategy, at least for some emerging risks.

4.5 Better agenda-setting

The number of new or potential emerging risks is so large that societies cannot possibly address all of them. Whether implicitly or explicitly, societies engage in a process of risk selection that determines priorities. In other words, some emerging risks are selected for priority attention, while others are ignored or deferred until later for consideration. For example, climate change was addressed by regulators in Europe earlier than in the US.

Priorities are sometimes misordered due to the influence of interest groups, the mass media, and popular opinion. For example, NGOs may highlight emerging risks that have the greatest fundraising appeal among their donors rather than the emerging risks that represent the greatest threat to human health, safety

and the environment. Likewise, the mass media may focus on emerging risks that generate controversy rather than emerging risks that are serious. The result may be that politicians and regulators focus on what is controversial rather than what is important.

The trend toward "hyper democracy" (the ability for every voter to weigh in on every issue that affects their country) also complicates the governance of emerging risks, particularly systemic ones. They are typically ill-suited to hyper-democratic methods (e.g., ballot propositions) because they are scientifically complex and lay opinions may be based more on factors such as fear and stigma rather than a careful understanding of science and regulatory alternatives.

When regulatory authorities are unsure about what to do about an emerging risk that has generated controversy, there may be a tendency to "under-consult" or "over-consult" with the public. When an emerging risk is controversial, it is crucial for regulators to understand what people are concerned about, including the mental models and perceptions that underpin their opinions. At the same time, it is unrealistic to expect that complete reliance on public opinion (which can be quite unstable or ill informed) will lead to a wise decision about an emerging risk.

The growing role of the Internet in society means that information about emerging risks can be rapidly spread around the globe in a matter of minutes. For managers of emerging risks, such rapid dissemination is both a blessing and a curse. It allows for rapid warnings of possible harm, including steps that citizens, businesses and governments can take to prevent possible harm. But such information may also be inaccurate, misleading, or easy to misinterpret by lay citizens and activists. For governments that seek to conceal information about particular risks from the public the Internet can have a destabilising effect that further undermines public confidence in government, science and society. Thus, the presence of the Internet underscores the necessity of a climate of openness about how emerging risks are being assessed and managed.

In short, better priority setting in the face of multiple emerging risks is one of the major challenges faced by practitioners. A climate of openness can help build the required trust to make difficult decisions but decision-makers need to avoid either too little or too much stakeholder involvement in the priority-setting process.

4.6 Resolving conflicts

The management of emerging risks frequently entails making trade-offs among opposing interests. Conflict resolution is a crucial process whenever emerging risks trigger disagreements among people with different perceptions, values and interests. As we observed in 3.6, the failure of authorities to foster some degree of public consensus – or at least a workable reconciliation of conflicting views – can act as a driver of risks.

Managing trade-offs through analysis and deliberation

Trade-off management is a normal task for risk managers, who routinely apply methods such as cost-benefit analysis to balance opportunities with emerging risks. Trade-off resolution can act as an attenuator to an emerging risk. Even though the future of emerging risks is highly uncertain, modern methods of cost-benefit analysis can shed light on the economic value of acquiring better

information (before making a final decision) as well as promising strategies that are robust under a large number of future scenarios.

However, when emerging risks are highly controversial, cost-benefit methods are likely to be ineffective at resolving conflict. In some cases, excessive reliance on such methods can exacerbate conflict if sponsors of the analysis are perceived as hiding ethical assumptions or key intangible considerations in a complex mathematical exercise. When emerging risks are highly controversial, managers need to explore strategies of deliberation that involve key stakeholders and the public. Deliberative processes range from small, informal meetings of interest group leaders to high-level commissions with representatives from multiple interest groups as well as experts and laypeople.

Overcoming the short-term orientation of reward systems

When risks emerge, they may not immediately exert any harm. Sometimes the period of emergence is quite long, spanning years, decades or even centuries.

Unfortunately, the short-term orientation of reward systems in business and government acts to discourage prevention of such long-term risks, thus often acting as a risk amplifier. Business leaders are under intense pressure to attend to concerns about near-term profit and shareholder value. Politicians are geared toward election cycles, which have a shorter time horizon than many of the long-term risks facing the welfare of citizens and ecosystems. Even the leaders of NGOs dedicated to preventing long-term risks may find that a short-term orientation is best for enhancing visibility and raising funds for organisational needs. Thus, for long-term risks that can be prevented or mitigated only by imposing near-term costs or inconveniences, the short-term orientation of businesses, governments and NGOs is a major barrier to effective action.

Illustrations of this short-term orientation are pervasive in the literature on emerging risks: less attention to the long-term aspects of global climate change (e.g., damages from sea-level risk and ocean acidification), more focus on the traumatic risks at work rather than the long-term risks of disease from chronic exposure to toxic agents that cause disease only after a long latency period (e.g., asbestos), and more focus by corporate executives and their boards on near-term profitability rather than the long-term sustainability of corporate strategies.

One solution that has produced some success is an emphasis on the short-term benefits of policies that also prevent the emergence of long-term risks. In China, for example, where concern about localised air pollution (e.g., due to immediate health and aesthetic concerns) is greater than concern about global climate change, advocates of clean energy sources (e.g., nuclear power and renewables) emphasise the near-term benefits of alternative energy as well as the long-term protection against climate change.

Coping with concentrated interests

When the management of emerging risks threatens concentrated interests in society, efforts to avoid the risks may be blocked or weakened. For example, efforts to require that vehicle manufacturers produce more fuel-efficient vehicles are slowed by a potent coalition of interests: companies and labour unions whose livelihood is linked to the production of large cars, sport-utility vehicles and pickup trucks. Likewise, pro-environment efforts to reduce coal

use confront well-organised pro-coal interests that include coal companies, their miners, investors in railroads, and utilities with coal-fired power plants.

Since virtually all political systems grant – implicitly or explicitly – concentrated interests substantial political power, creative – and seemingly expensive – solutions may be necessary to accomplish effective control of emerging risks. For example, green-car mandates in the US and Europe are accompanied by substantial subsidies to assist industrial conversion to cleaner technologies. And mandatory limitations on greenhouse gases are sometimes coupled with generous subsidies (e.g., to support demonstrations of geological storage of carbon dioxide emissions from coal-fired power plants). The process of providing some compensation to concentrated interests may appear to be inefficient and potentially unfair to uncompensated interests but there may be no practical alternatives to compensation of concentrated interests that accomplish control of the emerging risks.

When seeking to prevent, reduce or spread the damages from emerging risks, managers should give some consideration to valid, evidence-supported claims of equity, such as concern for highly disadvantaged populations (e.g., the poor) and populations or species that are subjected to multiple risks from different sources.

The governance of emerging risks may be complicated by political conflict that is rooted in religious differences, competing world views or ideologies, or deeper struggles for power between competing regions or nation states. Some sources of conflict about emerging risks are more resolvable than others, and it is critical for risk managers to ascertain, insofar as possible, what values, beliefs and interests are at the heart of apparent disagreements about how to prevent, reduce or spread emerging risks.

Conclusion

This concept note has advanced preliminary elements for understanding why risks emerge in societies. These elements comprise risk sources, drivers, and specific governance issues.

In future work, we seek to validate and refine these elements based on case studies of real-world risks of different types in various sectors of the world. We will then also seek to develop guidelines for use by specific organisations because a practitioner in a specific organisation needs to identify those emerging risks that are relevant to his or her organisational interests. In the course of developing their own emerging-risk guidelines, they will need to consider each of the elements that we have identified, coupled with an analysis of their vulnerability, a specification of their risk profile, their degree of risk tolerance, and the principles that will govern their management strategy.

For the IRGC project to be of most benefit to those responsible for risk assessment and management within governments and business, IRGC will develop deliverables which will help such people:

- Understand what dimensions can be representative and anticipative of the risk environment of their organisation;
- Link their conceptual understanding of the risk sources, drivers and governance issues to their operational environment in order to improve their anticipation of new risks;
- Identify critical areas (environment; health; food; etc) under tension; and
- Make the analysis truly practicable by linking it to conventional methods for anticipating the future (e.g., foresight and scenario development methodologies, environmental scanning, issue management, emerging issues analyses, horizon scanning, long range planning, etc).

Appendix I: Organisations working on emerging risks

In the course of preparing this concept note, IRGC analysed the work of other organisations working on innovative ways to detect and control emerging risks. While these organisations do not necessarily use the term "emerging" risks, they focus on closely related concerns such as systemic risks, global risks, long-term environmental risks, or low-probability, high-consequence events. Whatever term they use, all of these organisations are concerned with risks having the following characteristics:

- They are associated with a **high degree of uncertainty** (little information is available for risk assessment);
- They could have a significant impact or high loss potential, which is unquantifiable;
- They are **systemic in nature** and span beyond the capacity of a single country/company/organisation to contain;
- They are new and/or continue to develop and change in unpredictable ways, making them **hard to classify**; and
- The **risk is complex** – it is interlinked with many other risks and it is therefore difficult to establish causality between the source of the risk and the ensuing loss.

In this section we offer a brief survey of organisations with a strong interest in such risks.

The insurers

The insurance industry seeks to understand as much as possible about emerging risks since they may already be impacting their portfolios or may do so in the future. Insurers seek to raise awareness of emerging risks within their own companies but also externally, in businesses and society at large. Internally, with greater understanding of emerging risks, future damages can be incorporated into an insurer's terms, including coverage, pricing, reserves and capital allowances. Externally, insurers can advocate for business and policy responses that will curtail emerging risks and associated damages.

To take Swiss Re, one of the world's leading reinsurance companies, as an example, it has developed its own early warning system for emerging risks, known as SONAR (Systematic Observations of Notions Associated with Risk). SONAR is a risk perception network designed to detect initial risk indicators and track their potential impact on the insurance business. It uses internal and external sources for input of perceptions, observations and comments regarding potential new risks, which are then triaged according to a set of defined criteria. If this results in the identification of a potential emerging risk, then the processes of risk assessment and eventually risk management may be undertaken. Essentially, SONAR is a method of continually monitoring the risk landscape.

Emerging risks anticipated using tools such as this will then be given further attention – for example, Swiss Re, Lloyds, CRO Forum and Allianz all produced detailed reports outlining the risks and opportunities of what they see as major emerging risks for the insurance industry (for example, nanotechnology, pandemics and obesity).

Management consultants

Emerging risks can have such damaging impacts on business and society that management consultants are developing tools aimed at helping managers detect and respond to emerging risks. For example, PricewaterhouseCoopers has recently developed a framework for embedding the discipline of addressing emerging risks into an expanded application of traditional enterprise risk management. This framework can help organisations better prepare for the management of emerging risks.

Also widely used in the insurance and private consulting sector is the technique of scenario planning (or scenario analysis). This method does not anticipate or identify emerging risks but is, rather, useful for estimating the potential consequences of emerging risks, in terms of risk exposure to a company and its level of preparedness for dealing with the emerging risk. This technique can be used for generating and evaluating strategic options for dealing with the risk in question.

The public sector

The public sector also uses these tools. One method of anticipating emerging risks that is becoming increasingly popular with governments is horizon scanning. Horizon scanning is "a policy tool that systematically gathers a broad range of information about emerging issues and trends in an organisation's political, economic, social, technological, or ecological environment. It is also used as a synonym for a variety of so-called 'foresight activities' that aim to develop the capabilities of organisations to deal better with an uncertain and complex future" [Habegger, 2009]. This tool does not specifically focus on risks, but can be used to improve the anticipation of emerging risks and opportunities.

The UK set up a cross-government Horizon Scanning Centre in 2004 which is designed to support the horizon scanning and foresight activities carried out in a wide variety of UK government departments by providing useful tools and spreading good practice. In addition, the centre produces a broad horizon scan (the Sigma Scan), which looks at potential future issues and trends that may have an impact on public policy, with the ultimate aim of informing Government strategy and policy-making.

The UK horizon scanning programme is widely viewed as effective and has influenced the establishment of similar programmes abroad. Other countries that have experience with horizon scanning projects include the Netherlands, Singapore (with a focus on issues of national security) and Australia (with a focus on health).

Regulatory agencies and their scientific advisors have for decades sought to forecast the emergence of risks in order to set priorities and establish effective risk-prevention activities. Although such long-range planning is sometimes short-changed when crises cause immediate attention to the "risk of the month", agencies have undertaken some notable efforts to gauge the relative size of future risks. Sometimes these exercises do not distinguish current (emergent) from emerging risks as defined in this concept note.

For example, in the late 1980s and early 1990s, the US Environmental Protection Agency (EPA) sponsored a variety of analytic exercises aimed at ranking the major environmental risks facing the US. Influenced by EPA's lead, numerous states initiated their own "comparative-risk" exercises in

collaboration with academics and stakeholders. A key finding of these exercises was that the risks of strongest concern to the public (e.g., hazardous waste sites) are not necessarily the risks of strongest concern to the scientific community (e.g., global climate change and radon levels in homes).

In Europe, the European Food Safety Authority (EFSA) was established to provide EU regulators with authoritative information on emerging risks related to food, including risks to humans, animals or plant health. EFSA sees knowledge of emerging risks as a strategy to help policymakers and agenda-setters to anticipate potential societal problems, threats and opportunities. EFSA has set up a working group on emerging risks which has developed an overall procedure for emerging risk identification, including priority indicators and signals in the areas of chemical, microbiological and nutritional hazards. A filtering methodology and a collaborative network between other key partners working on emerging risks will be developed in future.

The European Network and Information Security Agency (ENISA) is another example. Its main role is to give expert advice and recommendations to EU Member States and institutions on network and IT security, and thus it is concerned with identifying emerging risks for IT assets. ENISA has developed two different framework approaches to anticipating emerging risks – a layered risk model and a scenario-based model – and it provides step-by-step explanations of how to use these approaches so that EU institutions can apply them as necessary

Think tanks, scientific academies, and academic centres

A wide range of analytic groups are producing research and guidance on emerging risks or closely related concerns. These groups vary widely in funding base, topics of interest, and degree of scientific rigour in products.

The US Government Accountability Office (GAO) carries out strategic planning efforts to identify key themes and trends (and risks along with them) that are likely to shape US society and the place of the US in the world in decades to come. Its aim in doing this is "to help the Congress and the federal government address the challenges that affect the well-being and financial security of the American people" [GAO, 2007]. Much of this activity amounts to a forecast of emerging risks and opportunities for the US, although GAO does not use the term emerging risks as defined in this concept note.

Some international organisations also work on emerging risks. The OECD, for example, plays a major role in disseminating information about its member countries' experiences in identifying and managing risks and it has work underway on emerging risks with the goal of helping to prepare its member countries to anticipate and deal with them. In 2003, the OECD published 'Emerging Risks in the 21st Century', which explores how risks are evolving and changing and how society's capacity to manage them will be affected. The book also lays out recommendations for how OECD countries can improve the management of emerging systemic risks. This work was mainly to identify driving forces and key issues that, by modifying the context in which organisations operate, will "reshape conventional hazards and create new ones" [OECD, 2003].

The US National Academies, through the National Research Council (NRC), has published a wide range of reports on emerging risks, and issues of risk governance. For example, recent NRC reports have addressed how emerging

environmental risks should be assessed and managed, how analysis and public participation should be combined in risk management, and how uncertain risks should be communicated to the public [NRC, 2009].

Another example is TA-Swiss - The Centre for Technology Assessment (a centre for excellence of the Swiss Academies of Arts and Sciences), which is interested in emerging risks related to new technologies, has as its main purpose to make both politicians and the public aware early on of technical potentialities and the opportunities and risks of new technologies. Some of the key working methods used by TA-Swiss are: expert project studies (where experts study new technologies, e.g., anti-ageing medicines, and produce reports indicating potential risks and opportunities and giving recommendations); discussion forums (where citizens' opinions on topics, e.g., nanotechnology, are gathered and communicated to decision-makers); and, communication (hosting events for members of parliament to disseminate project findings).

Also concerned with emerging risks in the technology sector is iNTeg-Risk – a multi-stakeholder European research project involving many technical agencies, which aims to create an integrated scientific and technology framework for emerging risk management.

In the environmental field, there are a wide range of think tanks producing reports on emerging risks. For example, Resources for the Future, based in Washington DC, has a focus on the economic aspects of emerging environmental risks. And the World Resources Institute (focussed on protecting the environment and improving human lives) in conjunction with the International Finance Corporation (focussed on advising investors to build the private sector in developing countries) recently published a report on emerging risks related to environmental trends in developing countries in Asia and the financial implications of these risks for investors.

The ProVention Consortium focuses on funding and conducting work on emerging risks that are relevant to disaster reduction in developing countries, with the goal of reducing the risks and social, economic and environmental impacts of natural hazards on vulnerable populations in order to alleviate poverty and contribute to sustainable development. It does this, for example, by developing and promoting tools for integrating risk reduction strategies into the framework of overall development.

Academic institutions, such as the Wharton Risk Management and Decision Processes Center (University of Pennsylvania) or the Crisis and Risk Network (ETH Zurich) conduct basic and applied research into risk decision-making, uncertainty, risk management and the challenges facing the risk community. Publications, conferences and training courses contribute to communication and dialogue on emerging risk issues and may even offer prescriptive analyses. While academic work tends to be broad and not necessarily focussed on emerging risks, it is nevertheless a relevant topic – for example, the Wharton Center concentrates on research into the risk management of low probability/high consequence events. Academics may also serve on advisory committees and be part of partnerships with government, NGOs or industry interested in anticipating emerging risks.

Appendix II: What others say of emerging risks

On converging stresses and breakdowns:

"I am a believer in nonlinear systems theory. I don't think that a lot of these things will manifest themselves in an incremental way. I would expect, instead, that we might see some pretty sharp system shocks… I think that the kind of crisis we might see would be a result of systems that are kind of stressed to the max already, where policymakers are trying to keep ten balls in the air simultaneously and keep all the various constituencies satisfied as best they can. And then there's some exogenous shock on an already highly stressed system that produces a kind of overload situation. I've always thought that "overload theories" or "overload explanations" of social breakdown are probably the most persuasive. The best theories of revolution and civil instability generally stress that societies face crisis when they're hit by multiple shocks simultaneously or they're affected by multiple stress simultaneously".

Thomas Homer-Dixon, the Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization, Souvenir Press Ltd, 2007- also in Foreword to "Impacts of Climate Change, a System Vulnerability Approach to Consider the Potential Impacts to 2050 of a Mid-Upper Greenhouse Gas Emissions Scenario", Global Business Network, 2007

On collapse of societies:

Easter Island: "the clearest example of a society that destroyed itself by overexploiting its own resources… a metaphor, a worst-case scenario for what may lie ahead of us in our own future… rational bad behaviour"
More generally nowadays: "just as in the past, countries that are environmentally stressed, overpopulated, or both, become at risk of getting politically stressed, and of their governments collapsing. When people are desperate, undernourished and without hope, they blame their governments, which they see as responsible for or unable to solve their problems. They try to emigrate at any cost. They fight each other over land. They kill each other. They start civil wars. They figure that they have nothing to lose, so they become terrorists, or they support or tolerate terrorism."

Jared Diamond, Collapse: How societies choose to fail or survive, Allen Lane, 2005

On driving forces and key issues:

"The changes likely to affect risks and their management in the coming years will occur in four contexts: demography, the environment, technology and socioeconomic structures. These will reshape conventional hazards and create new ones, modify vulnerability to risks, transform the channels through which accidents spread, and alter society's response. Different forces acting on the same risk can neutralize each other's effects, or reinforce each other for a compound effect".
"… the key issues that could challenge risk management… fall under five headings: heightened mobility and complexity, increasing scale and concentration, a changing context and major uncertainties, shifting responsibilities, and the importance of risk perception".

Emerging risks in the 21st century, an agenda for action, OECD, 2003, p.10, p.13.

On different perceptions of security and privacy: biometrics:

"Although biometrics seem to be an integral part of many applications that – some would argue – improve everyday life, increase security and serve as privacy enhancing technologies, they also constitute a serious threat to the individual's privacy. Just as an affirmation might be simultaneously both true and false, so can biometrics simultaneously act *for* and *against* privacy. The interrelatedness of security and privacy is hence once more highlighted in this way, as security becomes the balancing force that determines whether biometrics are *for* or *against* privacy. The mere act of using biometric technologies to capture sensitive biometric data constitutes an immense privacy concern if security is jeopardised, whereas in a scenario where security remains intact, privacy is enhanced and identity theft becomes significantly more difficult. However, as experience shows, there is no such thing as perfect security and hence biometric implementations are likely to see trade-offs between the two ends of the privacy spectrum (truly enhanced or severely jeopardised). This makes vital the need for prudent management of the cases where security is threatened."

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http://www.pwc.com/gx/en/research-publications/exploring-emerging-risks.jhtml

Provention Consortium
http://www.proventionconsortium.org/

Resources for the Future
http://www.rff.org/Pages/default.aspx

Singapore Risk Assessment and Horizon Scanning system
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Swiss Re
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TA Swiss – The Centre for Technology Assessment
http://www.ta-swiss.ch/e/them_aktu.html

UK Foresight Programme (including the Horizon Scanning Centre)
http://www.foresight.gov.uk/index.asp
http://www.foresight.gov.uk/Horizon%20Scanning%20Centre/index.asp

Wharton Risk Management and Decision Processes Center
http://opim.wharton.upenn.edu/risk/

World Resources Institute
http://www.wri.org/publication/emerging-risks-asia

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The International Risk Governance Council (IRGC) is an independent organisation based in Switzerland whose purpose is to help the understanding and governance of emerging, systemic global risks. It does this by identifying and drawing on scientific knowledge and the understanding of experts in the public and private sectors to develop fact-based recommendations on risk governance for policymakers.

IRGC's goal is to facilitate a better understanding of risks; of their scientific, political, social, and economic contexts; and of how to manage them. IRGC believes that improvements in risk governance are essential if we are to develop policies that minimise risks and maximise public trust in the processes and structures of risk-related decision-making. A particular concern of IRGC is that important societal opportunities resulting from new technologies are not lost through inadequate risk governance.

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