

Extreme Events



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This book serves as the final report of the *Game Changers* project lead by **John Casti** and coordinated by **Leena Ilmola**. The project was established towards the end of 2009 as a part of the *Extreme Events in Human Society* initiative at **IIASA**, the *International Institute for Applied Systems Analysis* (Laxenburg, Austria).

Extreme Events

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Starters
conjunction

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Executive summary

The cover of Newsweek on 28 March 2011: *Apocalypse now: Tsunamis. Earthquakes. Nuclear Meltdowns. Revolutions. Economies on the Brink. What the #@%! Is Next?*

Yes, there will be more events of this nature due to a number of reasons, including **complexity, global networks, flat-world instability, paradigm shifts, global crises of maturity**, and several **in-built features** of modern societies:

- *Complexity* leads to a mismatch between the system and the mechanisms available to control it. Furthermore, complexity *per se* drops our ability to understand and control the system.
- *Flat-world instability* refers to the interdependence of individual actions *globally*, induced by instantaneous access to the same information. Instead of asynchronous and often balancing actions we previously had, this leads to *global* herd mentality and bubbles of various kinds.
- *Paradigm shifts* are major discontinuities in global socio-economic trajectories that typically take place in 40–60 year intervals. Such a shift is induced by a technological breakthrough. Arguably the world is current shifting to a new paradigm, which is a major source of turmoil.
- *Global crises of maturity*: There are more than half a dozen acute and inflamed global crises that are nowhere near to be solved. Reaching a *tipping point* in any these crises would have major consequences worldwide. The virtually complete lack of *effective* global governance exacerbates the risk of a meltdown of the global socio-economic system.
- *In-built features*: A modern society is lean, individualistic, specialized, just-in-time, and short-sighted. It excels in efficiency and dynamism. It also produces shocks internally and is quite exposed to external ones. Furthermore, these – coupled with a few other features – often lead to a situation where *no one* in the society has an interest to take a bird's eye view upon considering stability and responsiveness. As far as major shocks are concerned, a dynamic modern society is quite adequate *after* the fact; its performance is far worse as far as preventing, anticipating, or preparing for shocks is concerned.

No, we do not provide a list of disasters to come. The reason is twofold. First, the domain of *unknown unknowns* – the set of things we don't even know we don't know (more on this riddle in Chapter 1) – cannot possibly be completely exhausted. Second – even if the starting point may be an Act of God –, we are dealing with social randomness, which is inherently unstructured and untraceable. There is no overarching theory of surprise, but by employing a diverse set of approaches and tools one *can* get a better understanding of the future.

An **extreme event** (*Xevent*) is a rare incidence with potentially significant societal implications. While a *specific* Xevent has a low probability, due to the range of possible Xevents and due to a myriad of global networks acting as transmission paths, a small-open economy such as Finland experiences consequences of *an* Xevent quite frequently. The paradox thus is that everyone agrees that Xevents are possible and do happen but when the discussion moves to more specific Xevents, the consensus is that due to their rarity considering them is not worthwhile. Upon considering Xevents, we are easily captured by ‘*a failure of the collective imagination of many bright people*’.

The extreme events we have in mind tend to be *systemic* in nature. Their scope is often beyond any individual actor or organization within the society, which calls for emphasis on national-level action in preparing for them.

We insist on considering both positive and negative extreme events. Previous discussions have mostly touched upon the latter kind – for a good reason. It is simply a lot easier and quicker to destroy something than it is to build it – in part the X-ness of an event is related to its unfolding time.

The consequences of systemic Xevents are mostly addressed by taking decisive government action and by spending vast amounts of public money. Yet, the public willingness to devote resources for anticipation, planning, and preparation for Xevents *beforehand* is negligible. We argue that Xevents should be among central concerns of decision makers in the public and in the private sector.

Finland needs **resilience** – capacity to absorb and recover from negative Xevents as well as capacity to nurture and benefit from positive ones. A society’s ability to react on an Xevent crucially depends on its institutions and infrastructures as well as on the coordination and cooperation among its members. In these respects Finland compares favorably to virtually all other countries in the world. Finland’s challenges with respect to Xevents are different from the challenges of most other countries – Finnish focus should be more on having *adaptive* structures and on exploiting *opportunities* that might arise with Xevents.

Contingency planning should be considered as a part of good governance. We propose that Finland be turned to a model for an *anticipatory* society, which constantly prepares itself for contingencies of various kinds.

Introduction

In this book we consider unlikely incidences with significant societal implications – **extreme events** (*Xevents*).

A *specific* Xevent has a low probability. However, due to the range of possible Xevents and their transmission via global networks, *an* Xevent touches upon Finland quite frequently.

We argue that Xevents should be among central concerns of decision makers in both public and private sectors. Our conclusions provide some suggestions for further considerations.

This book concludes the *Game Changers* project. The ideas we present have been honed in countless discussions with our fellow researchers, the names of which are listed on the title page (the other contributions of the project are described in the Appendix). This project would not have been possible without the stimulus and support of *Tekes, the Finnish Funding Agency for Technology and Innovation*, as well as the other partner organizations listed on the title page.

Our warmest gratitude to all!

Preparing for the uncertain future

Tomorrow is much like today 99% of the time. This book on **extreme events** (*Xevents*) concerns the other 1% when this naïve prediction fails. The book serves as the final report of the *Game Changers* project (Exhibit 1.1). Its objective is to deepen the reader's understanding of the nature of future uncertainties to assist private and public decision-making.

*Apocalypse now:
Tsunamis. Earthquakes.
Nuclear Meltdowns. Revolutions.
Economies on the Brink.
What the #@%! Is Next?*
The cover of Newsweek (28 March 2011)

Upon writing in the spring of 2011, we have just experienced one of the greatest *nature*-induced catastrophes in terms of global socio-economic impacts, *Japan's disasters*, and we are still recovering from one of the greatest *human*-induced catastrophes in history, *the 2008–9 financial crisis*. The pervasive use of digital information and communica-

tion is changing the way we live and work, and we are still recovering from one of the greatest *human*-induced catastrophes in history, *the 2008–9 financial crisis*. The pervasive use of digital information and communica-

Exhibit 1.1

The *Game Changers* project in a nutshell

What happens if ...

... China's growth slows down and even reverses?

... A scientific breakthrough enables a price of electricity that is 10% of the current level?

... The pace of innovation accelerates and becomes tenfold of the current pace?

The *Game Changers* project was established close to the end of the year 2009 as part of the IIASA initiative on *Extreme Events in Human Society* (see Exhibit 1.2 for the game changers vs extreme events discussion); just one year after the financial crisis struck the world economy. A group of Finnish government agencies and global operating firms (all listed in the title page) asked us the following question: Assume the world economy is close to a tipping point. How would the global economic system then look in 2030? What may trigger such a transformation?

The project consists of three global and five more focused sub-projects. The alternative futures of the global economic system are described in the qualitative scenario project that explored five widely-used scenario methods and developed one new procedure based on network theory. As an outcome of the scenario process, we were able to illustrate different futures for the *Global Economic System 2030* by describing five alternative structures that produce three qualitatively different types of behaviors. The scenario work also led to a list of 18 Game Changers that may have a triggering role as shapers of the World 2030. We also constructed an agent-based simulation, the *Global Trade Network World*, which is employed to analyze the impact of different types of shocks on patterns of global trade.

The global economy considerations gave alternative pictures of the future at an abstract level. These global-level pictures were then examined at a more detailed level as part of five concrete case studies: *The global forest industry (printing papers) study*, *the communications technology ecosystem study*, *the digitalization of the printed communications*, *the Life Science*, as well as the *Food and Drink* studies. The case studies also developed and piloted planning tools for decision-making in an environments dominated by uncertainty.

Exhibit 1.2

The fit between *Extreme Events* and *Game Changers*

Initially the partner organizations of the *Game Changers* project had an interest to consider the potential transformations of the global economic system and extreme events that might trigger them. The representatives of the partner organizations and the project's researchers soon discovered that it was hard to identify potential extreme events (especially those without historical predecessors) and it is even harder to analyze them. The solution to the problem was to somewhat lower the threshold, and instead of focusing on only very radical extreme events, the research efforts partly focused on "moderately extreme" events that were called *game changers*. Game changers also have low probability and potentially a high impact, but they are still imaginable with the prevailing frame of reference and in the current context. The benefit of this "down grading" was that we were able to collect some data on game changers themselves, even though their *implications* were still hard to detect due their misfit with the current understanding (that is largely based on high probability drivers and trends).

tion technology is a still-unfolding positive event of a similar magnitude. These events illustrate humankind's near-complete focus on the short-term and *business as usual* in day-to-day life. In our opinion, dedicating a little time and resources to considering future uncertainties – including extreme ones – could pay ample returns.

"... standard modeling strategies provide virtually no information about the behavior of the economy when it is under stress."

Cecchetti (2006)

In the course of our work over the past few years, we found that considering extreme events is difficult. Most discussions we had on the topic soon turned to probable events and trends. Because extreme events are by definition improbable, they do not fit the prevailing *big picture*. Thus, they are mostly either ignored or misunderstood. To alleviate the problem, we embed our discussion in a broader consideration of uncertainties and in studies of megatrends, paradigm shifts, and the future in general.

Defining extreme events

Any all-embracing definition of extreme events is doomed to failure. The applicability of a definition depends on the context, point of view, level of aggregation, and time span. For example, the extremeness of an event might be alleviated by one's economic strength.

Economic, political, and social impacts are not symmetric. What is extreme for an individual or a company is not necessarily so for a country or the world. What seems overwhelming as an event unfolds, often appears less extreme with the benefit of hindsight.

Any all-embracing definition of extreme events is doomed to failure

Upon defining extreme events, it would be tempting to side with Justice Potter Stewart's definition of pornography: "*I shall not today attempt further to define the kinds of material I understand to be embraced within that shorthand description; and perhaps I could never succeed in intelligibly doing so. But I know it when I see it...*" (Potter Stewart, 1964, in the United States' Supreme Court *Jacobellis v. Ohio* decision; emphasis added).¹ However, we will provide a working definition, while understanding its limitations.

Xevents – Our working definition

Our working definition is this: An **extreme event** is *unlikely* but *potentially significant*. This refers not only to the immediate trigger event but also to the following sequence of linked events. The event is conditional on the surrounding context.

Unlikely

Unlikely refers to some concept of future probability or uncertainty in considering an extreme event. That uncertainty comes in two flavors: *probabilistic* and *fundamental*. *Probabilistic* uncertainty refers to a situation

The Xevents we talk about often have no basis for relevant comparison

in which there is some idea of the distribution of possible future outcomes. *Probabilistic* implies that even though the phenomenon

in question is stochastic, its nature is known. If phenomena followed a bell-shaped normal distribution, extreme events could be found far in the tails.² *Fundamental* uncertainty refers to a situation in which the statistical properties of the phenomenon are unknown; the phenomenon itself may be unacknowledged beforehand. As far as extreme events are concerned, fundamental uncertainty may be the more important concept of the two. For example: what is the probability that a flipped coin will land on heads or tails? Exactly 50%, one might say. But what if the coin is unfair? It might even have heads on both sides. One tends to assume away fundamental uncertainty upon considering familiar phenomena. Games of chance have nice statistical properties – the real world never does, as there is invariably something outside any conceivable artificial setup.

Significant

The word *significant* in our working definition is tricky. Significant to whom? In which situation and in what manner? When in time and for how long? These are all relevant questions, but they can only be answered

"... less than 0.1% of risky events will cause at least half your losses."

Taleb, Goldstein, and Spitznagel, (2009)

in a specific situation. This is what we refer to by stating that the event is conditional on the surrounding context, which is not only constantly evolving but also changes due to an event.

Event

Defining an event is not any easier. For example, what was **the** Event in the 2008–9 global financial crisis? Was it the collapse of *Lehman Brothers* investment bank in September 2008? Or was *Lehman* just the final nail in the coffin built with slack regulation, a tsunami of Chinese savings seeking a safe haven, and the detrimental ingenuity of the US financial sector in turning subprime “junk” into highly rated assets? Perhaps *Lehman* was irrelevant, i.e., did the phenomenon simply reach its *tipping point* in the fall of 2008? Or was the real phenomenon the collapse in mutual trust among market participants? In our working definition, an Event consists of a sequence of linked events.³

As hinted above, we insist on considering both *positive* and *negative* extreme events.⁴ This is, in fact, a significant departure from the prevailing thinking to the extent that it is problematic to use certain other conventional concepts such as *resilience* (more on the concept of resilience in Chapter 7). Furthermore, positivity and negativity are conditional. **Any** extreme event will create *winners* and *losers*. However, we again have to ask, from whose point of view? Winning and losing depends on the *time horizon*. For example, Finland was among the losers in the immediate aftermath of World War II. Yet it has had a stellar performance in the post-war era, a performance that has direct links to its war efforts, experiences, and indemnities. Another example: in the 1970s OPEC was successful in curbing the supply of crude oil, with considerable immediate financial gains to its members primarily at the expense of oil importing developed countries. In the longer run the experiences of the 1970s led to a furious search of both new oil deposits and alternative sources of energy.

According to our working definition, an extreme event is *potentially* significant. Some trigger events lead to an *amplifying* sequence, although *subsiding* sequences are perhaps more common. Somewhat independently from the properties of the event itself, the context greatly influences how things unfold. Changes in the *animal spirits* (individuals’ non-economic motives and irrational behaviors as well as expectations, confidence, and mutual trust, Akerlof & Shiller, 2009) and in the *social mood* (the collective sentiment of the society, Casti, 2010) influence how events unfold and what their impacts are. These changes may also be the *cause* of an event. For example, the origin of the 9/11 terrorist attack in New York was arguably the Arab world’s widespread anger at the Unit-

“... extreme events, while costly at the aggregate level, may induce a positive response in terms of entrepreneurial activity...”

Brück, Llussá, and Tavares (2010).

Too euphoric behavior is every bit as problematic as too conservative one – this is in part why “jump starting” the post-crisis economies has been so difficult

ed States and at the politics it practices. Ultimately the attack's most far-reaching impacts may be funneled through lavish US Homeland Security spending and the polarization of the Arab/Islamic vs the rest of the world. The realized impact of an event also depends on *responsiveness* and *adaptableness*. What is the immediate response? What are the subsequent actions?

"... present financial crisis springs from a catastrophic collapse in confidence ... Financial markets hinge on trust, and that trust has eroded."

Joseph Stiglitz (Guardian, 16 Sep. 2008)

Upon providing the above two examples of recent catastrophes, we made the distinction between *nature*-induced and *human*-induced events. If the trigger may be considered an *Act of God* – for example, a tsunami hitting the coastline of Japan or the eruption of an Icelandic volcano – we might talk about *nature*-induced events. Scientific breakthroughs and acts of war may be considered *human*-induced events. Often, this distinction does not really matter, especially if one takes a broader perspective. In the Japanese case, malpractices at the Fukushima nuclear plant were a significant contributing factor, as was the choice to build on low-lying coastal land. The eruption of Eyjafjallajökull in 2010 led to the shutdown of much of the European airspace for weeks. Individuals' and organizations' uncoordinated private responses tempered the eruption's impact so effectively that what could have been quite dramatic was largely a non-event. The trigger may be an Act of God, but the responsiveness and adaptableness are always very human.

The paradox in our working definition is that virtually *any* event is extreme – for somebody. Any exact future realization is unlikely beforehand. For example, the probability of **you** having an Apfelstrudel and a Mélange (a cup half-filled with coffee and topped with hot frothy milk) in the Café Landtmann (Vienna) next Wednesday may be close to zero. Yet it might happen – for your sake, we certainly hope so. If it does, you might fall in love, which could have a significant impact on the remainder of your life. This is an extreme event, to *you*. However, unless

The interpretation of what is an Xevent is not objective – My X might be your normal

something occurs to cause that event to take on significance for a broader population (e.g., the spirit of Sigmund Freud entering you at the Café causing you to re-revolutionize psychoanalysis), that event will hardly be noticed by anyone other than your family and friends. Because our focus is on events having significance at a somewhat broader organizational or societal level, we mostly ignore this paradox.

There is another paradox *not* to be ignored – let us call it *the black swan paradox* (more on the animal kingdom later). A *specific* extreme event in a given context is quite unlikely. There is, however, a range of possible Xevents. Furthermore, due to the global village with its myriad networks,

Xevents have impacts outside their immediate domains. Thus, an internal Xevent happens in Finland or an external one reaches Finnish shores quite frequently.

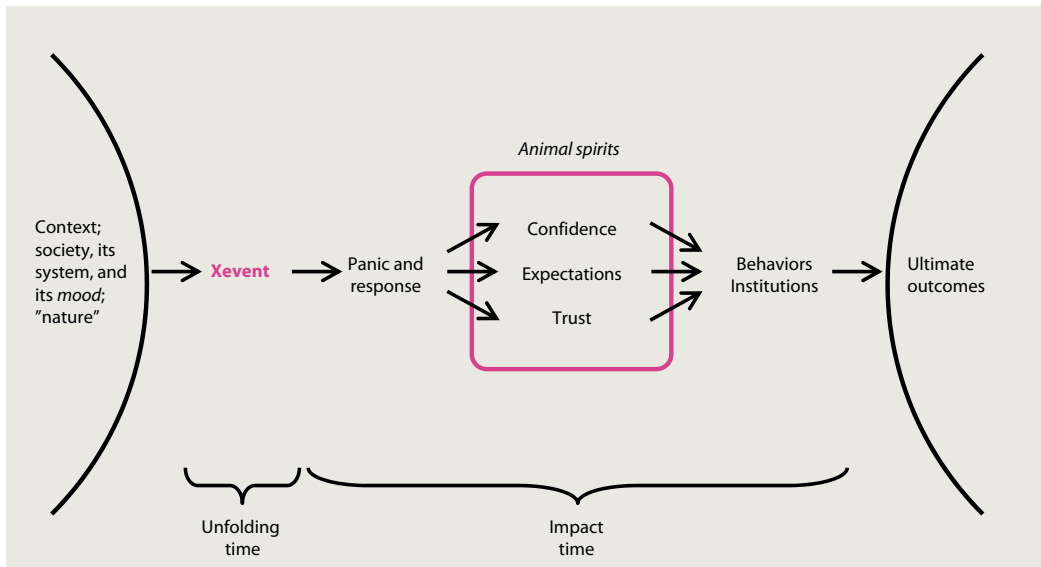
The black swan paradox is reflected in discussions on Xevents: It is generally agreed that Xevents are possible and do happen. When the discussion moves to more specific Xevents, the consensus seems to be that, due to their rarity, considering them is not worthwhile.

From social mood to Xevents and their ultimate impacts

Exhibit 1.3 is a rough illustration of the dynamics of Xevents, i.e., something that we constantly return to through this book. Human-induced Xevents arise from the prevailing social mood in a specific context; nature-induced events are initiated by Acts of God. Importantly, there might be some post-warning but pre-Xevent time, which is not adequately captured in the Exhibit (Mileti & Sorensen, 1987); more on the unfolding and impact times in Chapter 5. The most crucial aspect that is missing, however, is countless interlocked positive and negative feedback loops, which make any attempts to capture the dynamics of the system highly sensitive to small changes (Orrell & McSharry, 2009).

Social systems have countless interlocked positive and negative feedback loops, which make any attempts to capture their dynamics sensitive to small changes

Exhibit 1.3
From social mood to ultimate outcomes
 A rough illustration of the dynamics of extreme events



Examples of extreme events

As Exhibit 1.3 suggests, the extremeness of an event is partly a function of the anticipation/preparation time (not shown), the unfolding time, and the impact time. As discussed above, these times are influenced by responsiveness and adaptableness. Without further specifying these dimensions, any list of extreme events is inaccurate and incomplete. Nevertheless, we give some examples below.

In the aftermath of the 2008–9 “biggie” (only so far, we are afraid), it is easy to say that a financial crisis is a good example of an extreme event. We agree, although these crises are not too rare or unpredictable.⁵ The world has experienced a financial crisis approximately every ten years for the last eight hundred years, and we have had eight with global implications since 1987 (Kindleberger, 1978; Reinhart & Rogoff, 2009). In fact, Minsky (1974) has pervasively argued that financial crisis is a central in-built feature of a capitalistic society.

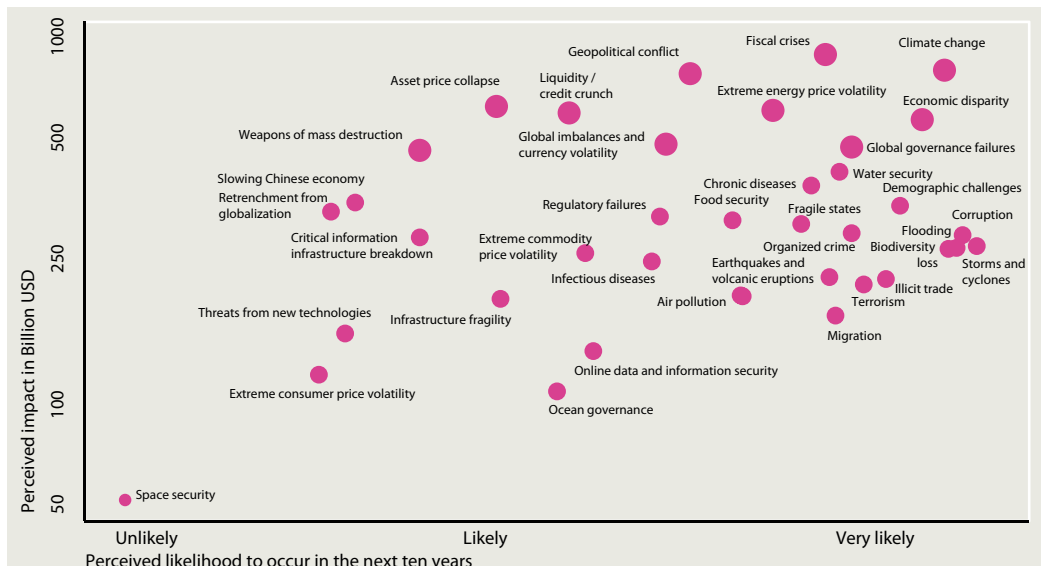
Financial crises seem to surprise us about every ten years

Other examples of human-induced events are major acts of war (including, for example, the end of the cold war era), corporate scandals (e.g., Enron), and terrorist attacks. On a more positive note, the invention of SMS text messaging and the shift from analog to digital technologies in

Exhibit 1.4

Global Risk Landscape 2011

Experts' perceptions on the impact and likelihood of possible (negative, we might add) future events



Source: WEF (2011, a modified version of Figure 1).

computing and communications have had an enormous impact. Likewise, the cultivation of the potato in the Northern Hemisphere as well as the standardization and universal use of the shipping container have been major events.

Examples of Acts of God include heat waves, pandemics, and tsunamis. Global warming is related to nature and is beyond any single individual or organization – and is thus *external* at this level (exogenous) – but it has direct links to human activity worldwide. Global warming, therefore, is at least partly *internal* to humankind (endogenous). Global warming might induce a host of other events. For instance, a change in the ocean’s thermohaline circulation could turn Finland into a year-round ice box (instead of just a good half-year currently).

When we acknowledge that an event is endogenous at some level we are a part of, we realize that we can influence it

Weather – and climate change and its contingencies more generally – is one of the few domains in which the consideration of extreme events is quite prevalent. We do not confine ourselves to this domain, even though we use weather as an example on occasion.

As discussed above, at the micro level X-ness is induced more easily. For an organization, an event does not necessarily have to be a tsunami in order to be extreme. An event is surprising, if it fundamentally challenges some of the assumptions previously applied in planning. Just one example for recent history: Russia rising export tolls on timber was an Xevent for some actors of the Finnish forest-related sector.

Exhibit 1.4 represents one recent evaluation of the “global risk landscape”. Events that would be extreme *generally* and *globally*, should be found towards the upper left corner of the chart. Thus, strictly speaking this exercise has not identified any Xevents (which is precisely our point in this book). In a slightly more confined domain or at a lower level of aggregation – e.g., at the level of a country – any of the events in Exhibit 1.4 could be extreme.

How to approach uncertainty

The former US Defense Secretary Donald H. Rumsfeld has immortalized the basic categorization of the current state of knowledge. In a 12 February 2002 news briefing (we recommend the YouTube video – follow the link mentioned in the endnote),⁶ in reference to

“But there are also unknown unknowns – the ones we don’t know we don’t know.”

events leading to the US military presence in the Middle East, Rumsfeld stated that *“There are known knowns; there are things we know we know.*

We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don’t know we don’t know. And if one looks throughout the history of our country and other free countries, it is the latter category that tends to be the difficult ones.”⁷

The above Rumsfeld’s riddle implies a two-by-two matrix of *beliefs* and *reality*, which we have drawn in Exhibit 1.5. Taking into account that most of what we believe we know will be invalidated in the course of his-

Extreme events largely emerge from the set of “unknown unknowns”

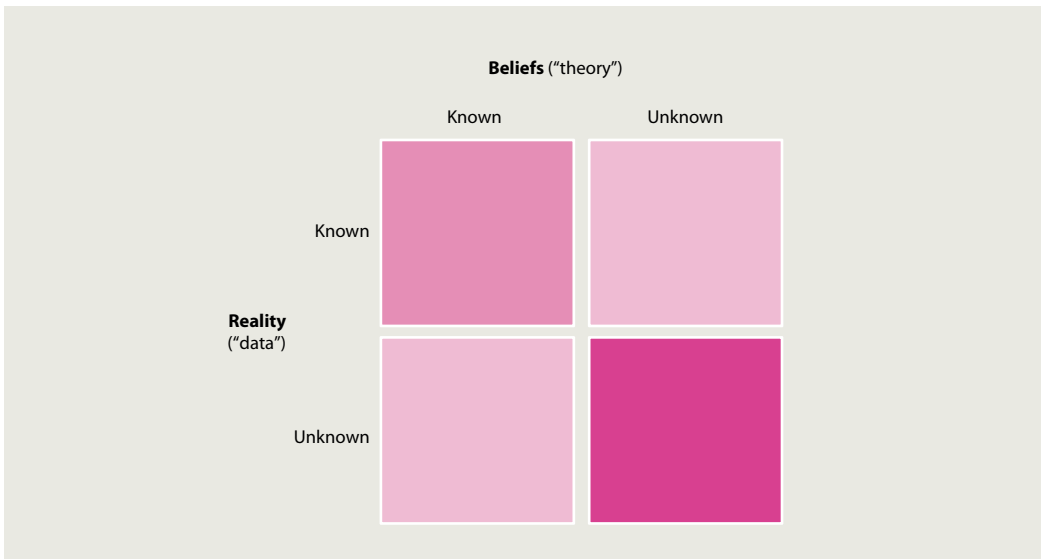
tory and that the reality of which we are unaware is probably larger than what we are able gauge, the set of the “known knowns” shrinks. Extreme

events largely emerge from the set of “unknown unknowns”. In research terms, one might liken beliefs to *theory* and reality to *empirics*. Upon considering extreme events, we are thus dealing with something that is outside the current theoretical understanding *and* about which we have no historical data or past reference to learn from. These limitations render most traditional research tools obsolete. Indeed, much of the *Game Changers* project has been about building tools that would be useful in the unknown territories. For example, the project experimented with *agent-based models* trying to exploit dynamics that emerge for the agents’ properties and rules for interaction as well as with *scenarios*, *attractor analysis*, and *equifinality*.

Exhibit 1.5

Extreme events largely emerge from the set of “unknown unknowns”

An illustration of the riddle by the former US Defense Secretary Donald H. Rumsfeld



Source: The authors’ illustration on the basis of the 12 February 2002 news briefing of The US Department of Defense.

Points of departure in studying extreme events

Events that do not have at least some societal implications are of little interest to us. Upon considering how events come about, evolve, and eventually cease, we are thus dealing with *social randomness*, which is inherently unstructured and untraceable. One implication of social randomness is that the probability of any *exact* future scenario is virtually *zero*. Indeed, future anticipation, planning, and preparation can easily be of the “wrong kind”, i.e., too specific and too conditional on a certain realization. Obviously, the most fatal mistake of all is not to consider the future.

“Since we feel psychologically comfortable with cause-and-effect relationships, we try to impose that pattern on nature as well.”

Casti (2010, p. 173).

After being briefed on the financial crisis at the London School of Economics, Queen Elizabeth II asked, “*Why did nobody notice it?*” (Andrew Pierce at *The Telegraph*, 5 Nov. 2008).⁸ Professors Besley and Hennessy

Exhibit 1.6

The project’s experiences in planning for uncertainty

The *Game Changers* project studied uncertainties in multiple cases. For instance, in the context of the global forest industry it was discovered that it is not easy for the experts to detect game changers within their own field of expertise: digitalization of the printed communications were mentioned only 6 times within 431 comments that we collected from 178 international experts and it was only the 36th in the list of the most probable drivers of the change for the printing paper industry. There are many reasons for this phenomenon, but the research result revealed that even the game changers that potentially have the power to completely destroy the industry are not always easy to recognize.

How to include uncertainties to the every-day planning procedures? The *Game Changers* project used several tools for this purpose:

What if... consideration is simple to use and does not require a lot of resources.

Implementation: Collect a small team for a session. First, list the organization’s basic assumptions on the future development of the environment (such as market growth and deepening globalization) and then simply turn them upside-down.

The question posed is: are our existing plans still valid, if the market does not grow or the global logistics become impossible.

Scan uncertainties with a group that is as diverse as possible and then focus your analysis to those drivers of change that are *not* popular and are challenging the existing shared perception of important trends and megatrends.

The Space of Uncertainty process will require some resources, but if uncertainties are great, this web-based process is a good investment. In brief: The first phase collects key uncertainties from participants, describes the hypothetical extreme environments where different alternative developments takes place and suggests strategies for each of these environment. The outcome of the process is a portfolio of actions that are useful *across* of these different extreme environments. These actions are examples of actions that produce success regardless of what happens.

of the British Academy eventually sent a letter (22 July 2009)⁹ to their Queen stating that the problem was “*a failure of the collective imagination of many bright people*”. This is also true, more generally, for extreme events. Humans have a strong tendency to filter the world via their pre-existing and recent experiences. In most cases, people’s thinking is only applicable to the near-the-mean behavior in their current living environment – far-from-the-mean and out-of-one’s-own-context thinking is difficult or even impossible. With varying success, we fight this basic human tendency in this book.

Even if much of today’s cutting-edge thinking takes place in academia, scholars are no better in the afore-mentioned respects. In many fields, academic reputation building and the related “publication filter” can even be hostile to truly outside-the-box thinking. The safest career path of a young professor is to confine oneself to a few well-established research traditions.

Current approaches with respect to extreme events

Ignore-and-hope is by far the most widely employed current strategy with respect to extreme events. Most individuals and organizations do not seriously consider the possibility of extreme events at all; they implicitly assume that *it will not happen here*, and if it does, *it can be dealt with* then.

Ignore-and-hope is by far the most widely employed current strategy with respect to extreme events

Often **no** concept of uncertainty whatsoever is employed upon planning for the future (Goodwin & Wright, 2010). The focus is on some specific future state, which can be likened to a “best guess” point estimate (or just wishful thinking). Studies of actual real-world decision-making situations reveal that there is a strong tendency to underestimate the actual risks and to overestimate one’s ability to gauge uncertainties.

There are most certainly exceptions to the ignore-and-hope strategy. In the domain of *national defense*, virtually all countries in the world incur huge expenses in preparation for a war that should not and, in most countries, will not happen in a lifetime. Indeed, the primary motive for this spending is to bring the propability of a war close to nil. Besides the military, the police and a host of other authorities prepare for the worst.

Many are also paid to be paranoid and to be on the lookout for extreme events. For example, central bankers are arguably hired to maintain the stability of the financial system regardless of the shocks it might face.¹⁰ The problem is that paranoia wears out and devolves into worrying about business-as-usual.

Most organizations and individuals benefit from a boom economy. Even when paranoia prevails, it may not be of much use unless one has the ability and willingness to take the punch bowl away when the party is going with a swing, e.g., by curbing raising asset prices. Furthermore, humans are social creatures and thus do not want to be either wrong or nasty for too long. For instance, an observer of North Africa should have been warning others about the instability of its totalitarian regimes in excess of twenty years before being proved correct (we return to incentives later).

The ultimate goals in considering extreme events

Upon considering extreme events, it is worthwhile to distinguish what takes place before, during, and after an event. *Before*: Is one able to connect the dots others have not? Can one prepare by “saving for the rainy day” or in some other manner? *During*: What are the institutions and infrastructures for appropriate and immediate response? How do we combine diverse and widespread responses with sufficient cooperation and coordination? *After*: What economic, political, and social structures best support the desired post-event dynamics? How do we induce the animal spirits and the social mood these dynamics might require?

The extreme events we have in mind tend to be **systemic** in nature. Their scope is often beyond any individual actor or organization within the society, which calls for emphasis on *national-level* action to prepare for them. However, as discussed in Chapter 4, their consideration is not easily introduced to existing administrative structures.

Extreme events tend to be systemic in nature. Their scope is beyond any individual actor or organization within the society.

The *objectives* of preparing for extreme events are relatively straightforward. Regardless of the type of event or the stage (before/during/after), the associated costs and losses should be minimized and the benefits and gains maximized. The probability of positive events – such as major innovations – should be maximized, and the probability of negatives ones – such as acts of war – should be minimized.

What kind and level of preparation actually takes place is related to the society’s willingness to pay. A well-run society should apply some form of cost-benefit analysis to determine the desired level of preparedness. However, even if all relevant information were at society’s disposal (which is an enormous if), the cost-benefit analysis may not be applicable to events with almost *zero probability* and nearly *infinite loss or gain*,¹¹ i.e., to the events that are of primary interest in this book.

As an outcome of the political process, the society may determine that some outcomes are simply *unacceptable*, which makes cost-benefit analysis unnecessary. The society still needs to determine how much (and of who's) resources can be devoted to avoiding the unacceptable.¹² For instance, global warming is arguably an unacceptable outcome, the advance of which should be stopped “at all cost” – what is lacking is any consensus on who should pick up the bill.

Structure of this book

In Chapter 2, we suggest that extreme events are arguably becoming both more prevalent and more substantial for a number of reasons. Chapter 3 identifies some common mistakes and wrong assumptions upon thinking

Due to in-built features of a modern society, too little time and resources are spent on considering extreme events

of extreme events. Chapter 4 suggests that, due to several in-built features of a modern society, too little time and resources are spent on considering extreme events, while the very same features often make it quite vulnerable to them. Chapter 5 provides an in-depth discussion of societal uncertainty by extending some of the considerations in this introductory chapter. Chapter 6 considers major paradigm shifts and their links to Xevents. Chapter 7 concludes with some of our observations and recommendations.

2

Expect to be surprised

In a networked world external extreme events transmit more rapidly and more efficiently. Thus, even if the global number of Xevents remained constant, Finland would be affected more often and in a larger magnitude.

Furthermore, in this Chapter we suggest that Xevents themselves might be getting more common and bigger. There are more than half a dozen acute and inflamed global crises that are nowhere near to be solved. Reaching a tipping point in any these crises could lead to X-ness beyond what humankind has experienced in its history so far.

Finland's internal developments have made it more prone to Xevents. Finland is open and deeply engaged in global networks. It is also increasingly an experimental society aiming to nurture and commercialize innovations that "break the bank" globally. Finland is an efficient and dynamic capitalistic economy, the very features of which make it exposed to Xevents.

More Xevents?

We observe more Xevents – but have they actually become more prevalent? It is indeed the case that media worldwide has become both more “sensational” and more global, which means that each media outlet engages in a keen search for stories hinting to Xevents across geographies.

3.3 million Deaths from natural hazards since 1970

The World Bank and the United Nations (WB & UN, 2010)

We argue, however, that what one observes is more than just noise.

Open networked organizations and societies are more exposed to Xevents. And Xevents are becoming more common and larger in magnitude. Admittedly our proposition is not entirely clear in light of available data, although for instance global damage from hazards (primarily droughts, earthquakes, tsunamis, volcanoes, extreme temperatures, floods, and storms) have indeed become more costly over time (Exhibit 2.1).

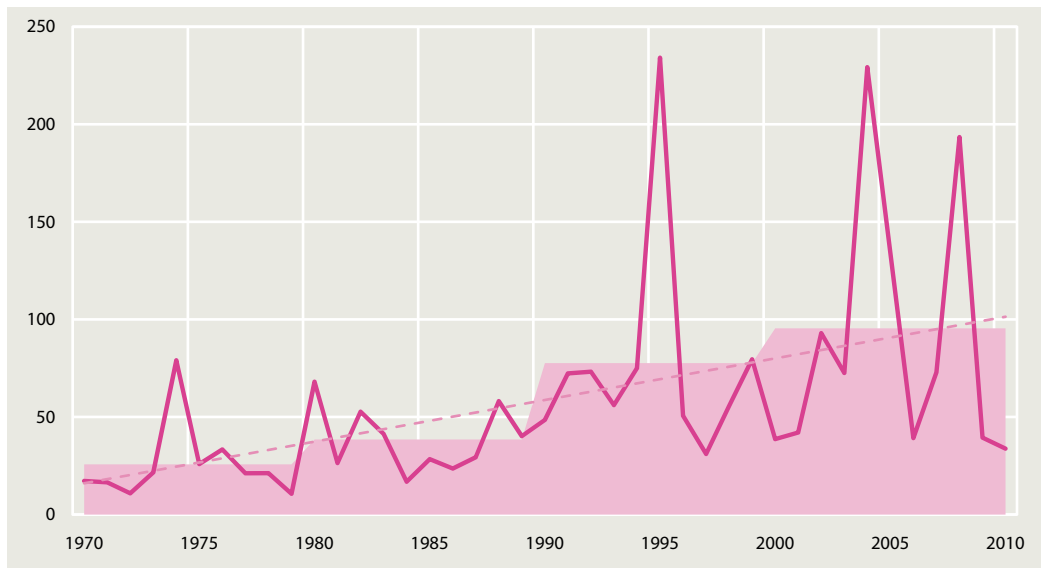
In a networked world, my event is your event

With both the 2008–9 financial crisis and Japan’s recent disasters, even experts have been continually surprised by the unexpected connections and unforeseen contagions of these events (Economist, 2 Apr. 2011). We believe that these cases can teach us a lesson.

Exhibit 2.1

Global damage from hazards on the rise

Damage in billions of US dollars and 2008 prices (line), the average by decade (area), and a linear trend



Source: The World Bank and the United Nations (WB & UN, 2010, p. 29 – modified).

Even as late as the beginning of 2009, some observers in Finland thought that the country would be largely unaffected by the global crisis. However, with its real GDP dropping by 8.2% in 2009, Finland was, in economic terms, one of the most severely hit countries worldwide, although Finland had virtually no role in most direct cause, the US subprime crisis. Furthermore, in the late 2000s, Finland's domestic financial sector was solid and its economic situation sound. Finland was hit by the *second wave* of the crisis, during which it was badly wounded, as some of its export markets collapsed.

In 2009, Finland was hit by a second wave of the global crisis

As for Japan's disasters, it may seem natural that *Toyota's* plants worldwide have been affected. It is less intuitive that many companies that are not as active in Japan, for example *Apple* and *Nokia*, have announced disruptions in production (due to reduced supply of the BT resin used in printed circuit boards).¹

The above examples suggest that the world is networked and inter-linked in a way that is nearly incomprehensible. Either directly or through a few linking nodes, there are myriad connections. Most of these connections are only uncovered and acknowledged when they no longer exist. Even if direct links are non-existent, secondary market-mediated effects are equally important and touch upon great many.

Flat-world instability

A national economy is best understood as a flow. In the past, national creeks have been quite independent; now, it is increasingly just one huge global stream. *CNN World News* – directly and via parroting and rephrasing by other media – influences animal spirits and social moods in all geographies.

Global instantaneous access to the same information may lead to *flat-world instability*. Individual actions are no longer independent, which may lead to global herd mentality and bubbles of various kinds. Events in other parts of the world come across more easily and more rapidly. Because external events are transmitted more efficiently, they appear larger and touch upon a bigger population. As everyone is increasingly in the same network and reacting to the same information – often with the hope of preceding others in taking action – events are also more easily caught in an amplifying sequence. Thus, even if there were no change in the actual number or scale of extreme events locally (we argue otherwise below), society would still be increasingly exposed to these events.

Media not only reports but may also both causes and mitigates Xevents

Elusive competition – Watch out for the little guy

The ability of individuals and smaller businesses to reach markets and compete with incumbent companies has changed fundamentally with the pervasive use of information and communication technology and with better opportunities for outsourcing and offshoring. At a more aggregate level, the relative position of the developing countries has improved *vis-à-vis* the developed ones – even without (and especially with) heavy-handed industrial policies such as in China.

This empowering of the previous “little guys” and “underdogs” is most certainly a source of extreme events for companies and industries. Because many smaller countries depend on a few companies and industries, this may also be true at the national level.

Apple iPhone and its *iOS* operating system re-defined the concept of a smartphone (Kenney & Pon, 2011). With *Google Android* the two had enough mass to change the industry – for *Nokia* as a company and for Finland as a country.

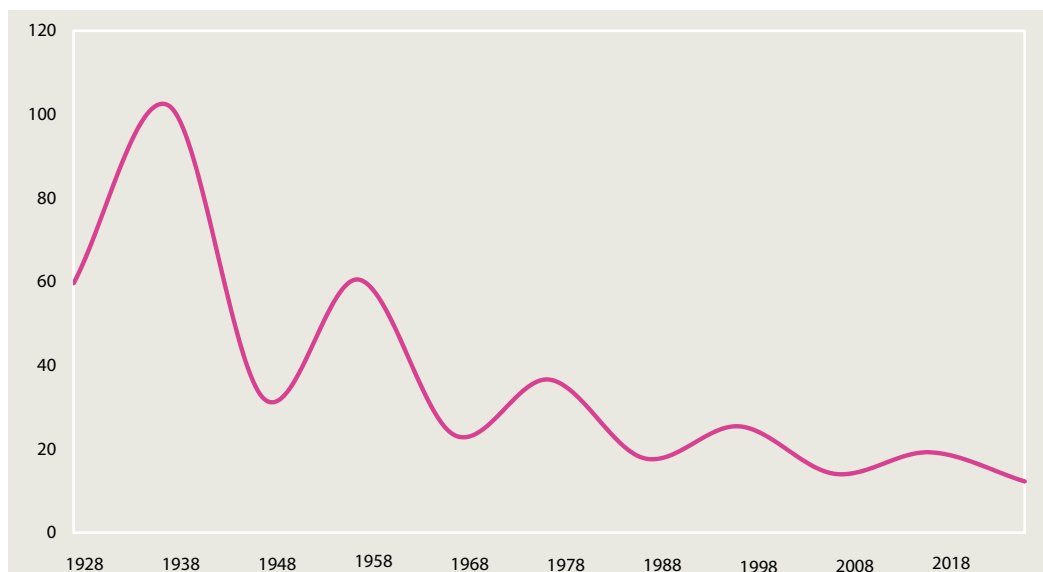
Incumbents are being challenged more frequently and aggressively

There is indeed some empirical evidence that the positions of industry incumbents are being challenged more frequently and aggressively. Exhibit 2.2 represent average lifetime of S&P 500 companies and future projections by Foster and Kaplan.

Exhibit 2.2

The industry incumbents' period of ascendancy is growing shorter

Average lifetime of S&P 500 companies (in years)



Source: Foster and Kaplan (2001, p. 13).

Maturing crisis induce eruptions

Technical advances and fewer political barriers in moving people, goods, and ideas have created a globally connected world, which is (implicitly) governed by a global superstructure. As a group, multinational corporations have an important role in it. Even the mightiest countries – also China and the US – are often at the mercy of this superstructure.

But the *global* world continues to be governed by *national* institutions. While we do have a wealth of international organizations, they have virtually no power over sovereign states. The lack of real global governance mechanisms makes it difficult to address issues that are above and beyond any single country.

“Global governance failures create and exacerbate systemic risks.”

WEF (2011, p. 11)

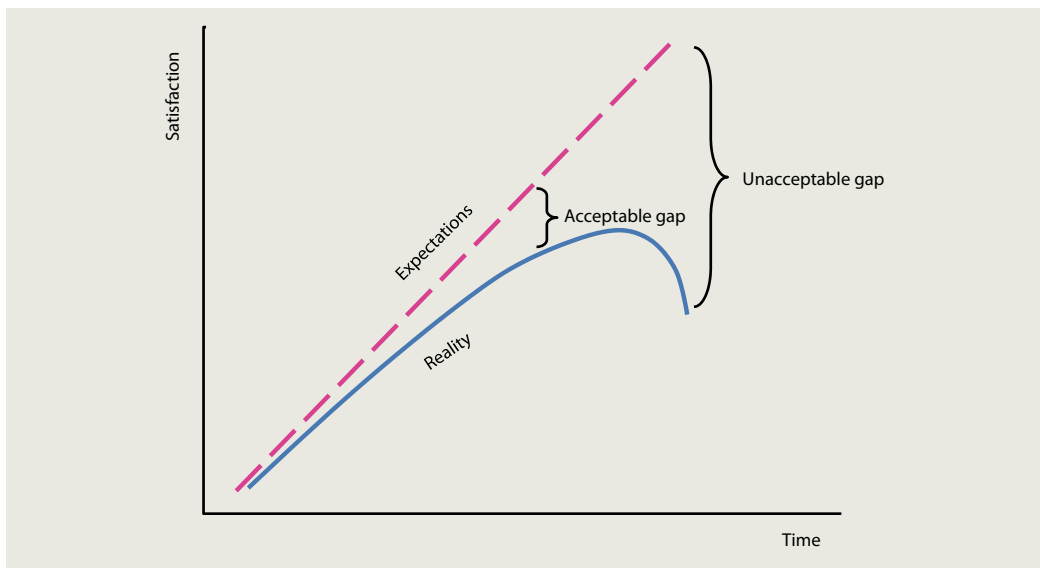
Futurists have been discussing the *global crises of maturity* for quite some time. *The Club of Rome* and other leading think tanks have for decades anticipated and called for massive global transformations – for a good reason. The world is facing a number of interrelated problems that are crying for sophisticated global solutions, solutions that are hard to imagine, let alone implement.

The world’s acute and inflamed crises include the following: the environment, the economic and financial system, poverty, security, health, energy and natural resources, and food supply. Let us point out a specific

Exhibit 2.3

The tipping point – A society can tip from hope to despair when dreams seem unattainable

Social tension raises when the perceived gap between the “haves” and “have nots” in the society widens



Source: Casti (2010).

aspect of the poverty dimension. The fact that a large share of the world population trying to get by with just pennies a day is a global tragedy of epic proportions but in itself is *not* necessarily a source of social tension. If one's immediate neighbors are all in the same state (and one is unaware of something better), it may seem that there is nothing to gain by inducing a revolution. Social tension raises when the perceived gap between the "haves" and "have nots" in the society widens, which in many parts of the world has happened quite strikingly with deepening globalization and the Anglo-Saxon flavor of capitalism.

The afore-mentioned global crises have been accumulating for quite some time – and they are nowhere near being solved. As they continue to mature, they are increasingly likely to be a source of turmoil, including civil unrest. Reaching a true *tipping point* in any one of these crises could

“... 20% decline in rainfall increases the probability of a civil war by 3.6%.”

Hendrix and Glaser (2007)

potentially be a major milestone in human history and a true extreme event. A tipping point may, e.g., be reached by an increase between what “should be” and what “is” in Exhibit 2.3 (cf.

also the previous paragraph). A discontinuity with one of the above crises would push one or more of the *others* over the edge. So far, we have not seen many extreme events that would be directly linked to the global crises. However, considering how severe they are, we are afraid this is about to change in coming decades.

Further considerations

Besides the above, there is a host of other reasons that might make Xevents more common and large.

Paradigm shifts

Societal dynamics may in themselves be a source of Xevents. In Chapter 6 we discuss *long waves*. The weakening of the previous wave marks the shift to a new but initially unknown trajectory – there is a feverish search for something new, in which most attempts will fail. The key attempt that succeeds starts the new wave – it is typically a fundamental scientific breakthrough having a wide range of potential applications. In the new situation old industries are hit and even killed by dynamics they initially consider either impossible or unimportant in part because they misinterpret the trajectories they are in.

Leverage and imbalances

Economic issues are obviously just one source of Xevents. Since money plays a role in all aspects of society, however, virtually any event also has

economic dimensions. Two issues are of particular interest – *leverage* and *imbalances*. The idea in *leverage* is to use debt – that typically earns interest – as a lever to jack up the return on own equity. This works wonderfully as long as the return on the debt+equity is above the interest rate on the debt. It is all too often forgotten that the lever works to the other direction with equal force, which may cause, e.g., “fire sales” of assets as well as bankruptcies of businesses that could have been sound in longer term. Thurner (2011) verifies that high levels of leverage may indeed induce extreme price movements. On a related note, currently the global economy features large and sustained *imbalances*. The developed countries are accumulating debt, which is primarily provided by the oil exporting Arab countries, China, and a few other developing countries. This situation was arguably among the root causes of the 2008–9 crisis. Since the imbalances seem to be on the raise rather than *vice versa*, the seeds for the next crisis are being planted. Occasional violent eruptions of these imbalances should be expected.

Urbanization

According to the UN estimates, the world’s urban population exceeded the rural one in 2008. Urban areas are often more prone to external Xevents and often have less scope to respond. Urban areas are also a better breeding ground for internal Xevents due to more frequent and intense social interaction.

Technology

Any technology may be used for good/legal and bad/illegal purpose. Technological opportunities mixed with globalization have provided alarming opportunities. Relatively free cross-border movement of capital, goods, information, and people have made it quite easy to live outside a certain (and even any) national jurisdiction. This is good for legitimate businesses at least as far as their direct beneficiaries are concerned. However, for example in the 2008–9 crisis the dominos started to fall in the previously amazingly profitable *shadow banking*, i.e., in the aspects of banking that had escaped normal banking regulation. The new opportunities are a real boon for *organized crime* – guerrilla networks with deep pockets outside the rule-of-the-law are a major undesirable and unpredictable element across societies worldwide.

Unprecedented technological change is partly caused by Xevents and produces Xevents itself

There are increasingly accessible means of *mass impact*. With the collapse of the Soviet Union weapons of mass destruction – not only nuclear but also suitable chemicals and bacteria – have become more readily available. With bio- and particularly nanotechnology, normal scientific work

is more likely to lead to unfavorable contingencies. On a more positive note, social networks and chain/mass emails/SMSs are already potentially accessible to nearly half of the world's population and occasionally succeed in producing a massive impact for a very humble seed.

Overall we should note that digital information and communication technology (ICT) potentially have a peculiar role as far as Xevents are concerned. ICT can add X to an ordinary event – or *vice versa* – in a matter of seconds. ICT can certainly both harm and help but as for communication, command, and control in case of an Xevent, analog backup systems would be desirable.

Finland specific issues

Finland's internal developments have made it more prone to Xevents. First, Finland is more *open* than ever with respect to the rest of the world in most relevant dimensions. By adapting the euro Finland re-defined the economic rules governing its openness, purposefully forcing itself to adjust internally rather than continuing to adjust the external value of the Markka.

Finland's internal developments have made it more prone to Xevents

Second, Finland has been actively engaged in *globalization* including its latest phase – *trade-in-tasks* (Grossman & Rossi-Hansberg, 2008) or the *second unbundling* (Baldwin, 2006). According to Baldwin, at the national level the core aspects of this globalization phase is unpredictability, suddenness, and very micro impacts (ultimately at the level of job assignments). While this also offers some advantages, it makes both anticipation and response challenging.

Third, Finland's past success may lead to both internal and external Xevents. In the postwar era Finland has caught up with the global productivity and technology frontier. One implication of that is the countries future well-being increasingly depends on intense selection of firms and managers – and *creative destruction* more generally. Finland should also become an *experimental* society, i.e., it should be able to nurture and commercialize innovations that “break the bank” globally, which may in themselves be considered Xevents of a specific kind. Finland has successfully transformed itself to an efficient and dynamic capitalistic economy with the features outlined in Chapter 4. The very features of this type of society mean that the consequences of an external Xevent are felt rapidly (see Chapter 4 for discussion).

3

Wrong assumptions

Society is exposed to an infinite number of changes and dynamic forces, many of which are uncovered only under very specific conditions. Also in a static sense society is complex beyond any one person's comprehension.

Everyone's decisions are necessarily based on some *simplified* and *partial* version of the broader real-world operating environment and its dynamic tendencies. This may be all right as long as one acknowledges the limitations of his/her view.

In the course of the *Game Changers* project we found that complex systems and their dynamics cannot possibly be captured with just one method or one model. We also learned that the social behavior is "wildly random" and inherently untraceable (which is not to say that it would not obey some recognizable rules also under stress).

There is no overarching *theory of surprise*, but by employing a diverse set of approaches and tools a better understanding of Xevents and their dynamics is feasible.

Little can be taken for granted

The context as well as the way problems are framed and approached is often taken for granted. Well, as far as Xevents are concerned, virtually nothing should be taken for granted. In the course of our work we have discovered a number of common mistakes in the prevailing thinking. Below we discuss a few we consider especially detrimental upon considering Xevents.

The context is often taken for granted, which is a mistake in considering Xevents

It gets bigger & better

In the postwar era, the expectation in the developed countries has been that the standard of living improves with every generation; it will just get *bigger and better* for us and our children. Before assuming that this trend will continue, one should ask what has been driving it.

The global average standard of living remained virtually unchanged for a thousand years, from about year 1 to year 1000. Up until about 1800, gains were modest. Since the industrial revolution, however, the growth of living standards has been explosive compared with the preceding centuries and millennia. Growth is now taken for granted – much of current societal planning is based on the assumption that the explosion of the last two hundred years will continue into the foreseeable future.

Societal planning assumes that the explosion of the last two hundred years continues

Exhibit 3.1

X-robust strategies

The *Game Changers* project conducted a thorough literature survey to uncover prevailing beliefs of global dynamics. The following stood out:

- Prolonged economic growth,
- Deepening globalization,
- Spreading of democratic ideals of the West,
- More ubiquitous, robust, and useful Internet,
- Increasingly shared global values and governance,
- Expanding world population,
- Finding of ways to curb global warming, and
- Continuous raise of energy prices.

The project developed a planning method and tools for devising strategies that would be robust to changes (including reversals) in one or more of the above assumptions.

The continuous rise in the standard of living is based on three things: *specialization* – each person concentrating on something he or she does well; *institutions* – structures such as property rights, joint-stock companies, and labor market bargaining, which harness individuals’ self-interest for the improvement of societal welfare; and *capital* – the accumulation and employment of tangible and intangible assets (including information and knowledge) in the provision of goods and services. Can these three things be a source of future growth until hell freezes over?

Specialization reaches its limit when every individual concentrates on one task. The core capitalistic *institutions* have not evolved much in recent decades, and their evolution in the coming decades is uncertain. As far as physical *capital* is concerned, its accumulation has some limits – at least the benefits from employing additional units eventually decrease. The case of intangible capital is less obvious. On the one hand, humans’ ability to absorb, comprehend, and employ information has **not** evolved much since the Stone Age. On the other hand, there are no natural limits to accessible bits of information. All-in-all, there is undoubtedly still steam left in the locomotive set in motion by the industrial revolution, even though it has perhaps seen its best days.

“Add 2.2 billion Chindians to the global economy and, of course, the relative wage of unskilled workers in the advanced economies will tend to fall with implications, for example, on income and equality.”

Nouriel Roubini (Scott, 2011).

More importantly, one should account for the exceptionality of the most recent decades. *Globalization* has turned the world’s countries from a series of isolated *Galapagos Islands* to an almost true *World Village*. Since the mid-1980s, the global economy has effectively gained two to three billion new active members. *Digitalization* since the early 1970s has changed our professional and private lives fundamentally. Even separately, but especially jointly, these changes have been an unprecedented boon to the world economy. Still, both are arguably past their prime.

A part of the “the next generation will be better off” story in the developed countries is that they have simply enjoyed an overly privileged position over the developing ones. With the rise of the BRIC countries, in particular, this scenario is about to change.

On the basis of the above, the current developed countries are rightly worried about their future growth prospects. Without major Midas touches, they need to generate fairly extreme internal changes in the near future to maintain their current positions, let alone to continue getting bigger and better.

Society as a machine

Society is complex beyond any one person's comprehension. Thus, politicians, civil servants, and experts dealing with broad societal issues necessarily form some simplified *illusion* of it. Over time, one starts to equate the illusion with the reality and starts to assume that the illusionary relations are carved in stone. Implicitly, society is likened to a machine: *'turning this small cog invariably influences the big machine this way...'*

Economists have turned the mechanist view of society into an art form. The most elaborate macroeconomic models – often found behind economic forecasts by major research institutes – embody thousands of

"A modeler's Hippocratic oath which pledges, among other things: "I will remember that I didn't make the world, and it doesn't satisfy my equations."

*Emanuel Derman and Paul Wilmott
(Economist, 13 Feb. 2010)*

equations capturing the behavioral patterns of recent history. Even in normal times, the models offer little improvement or a naïve statistical prediction (Nelson, 1972). In non-normal times – and when faced with extreme events – solely relying on these models is inadequate.

In astronomy, engineering, physics, and in several other “hard disciplines” accuracy and predictability in controlled experiments is almost

Exhibit 3.2

Psychological vulnerabilities

Extensive research has shown that a range of cognitive biases lead decision makers to ignore or underestimate approaching (negative) Xevents. According to Watkins and Bazerman (2003), the most common biases are:

- Things are better than they are. Potential problems won't materialize or their consequences won't be too severe.
- Weighting the evidence that supports preconceptions and discounting evidence that calls those preconceptions into question.
- Paying little attention to what other people (and organizations) are doing. Overlooking “predictable surprises” resulting from others' decisions and actions.
- Living in the present. Maintaining *status quo* while downplaying the importance of the future, which undermines the motivation to consider and the determination to act on some distant event. Preference to avoid a little pain today rather than a lot of pain tomorrow.
- One is not compelled to prepare for an event that one has not personally experienced in the past or that has not been made real through pictures or other vivid information.

All of the above biases have one thing in common – they are all self-serving. The world is seen as one would like it to be rather than as it truly is.

Source: Watkins and Bazerman (2003).

magical. Unfortunately human behavior – especially if individuals are pushed well beyond their “comfort zones” by an extreme event – does not obey exact patterns and relationships.

Societal changes as weather patterns

The forecasts of tomorrow’s weather have improved considerably in recent decades due to the following: improved *modeling* of terrain and of the phenomena that influence weather; more frequent, detailed, and widespread *data collection*; and harnessing of massive *computing power* to calculate possible future outcomes.

“There is an increasing recognition that models do not play the same role for complex systems as they do for simple mechanical systems.”

Orrell and McSharry (2009)

A more sophisticated version of the society-as-a-machine view likens societal changes to weather patterns. It is thus believed that as long as we invest enough in data collection, modeling, and computing, we can gain almost complete understanding of society. The problem is that we can never exhaust the “unknown unknowns” quadrant in Rumsfeld’s riddle (Exhibit 1.5).

Taleb, Goldstein, and Spitznagel (2009) note that “... *when we studied the pharmaceuticals industry, we found that most sales forecasts don’t correlate with new drug sales. Even when companies had predicted success, they underestimated drugs’ sales by 22 times! Predicting major changes is almost impossible.*”

Risk cannot be completely removed with any imaginable level of effort

Not thinking butterflies

The two mistakes above suggest a deterministic view of the world: all occurrences take place in accordance with natural laws. As far as the timing of specific events is concerned, however, we should rather think in terms of chaos theory and its “butterfly effects”. One can perhaps infer *suitable conditions*, but an event needs a suitable detonator in an immediate (unobserved) context that is “just right”.

Prior to the *African Spring* one could have measured social mood and get a signal of these countries are in the “change zone” – for decades in fact. Finally the detonator of the African Spring was one fruit vendor’s frustration of not being able to make an honest living: his fruit confiscated and beaten up by the police, Mr. Mohamed Bouazizi’s set himself on fire and set off a chain reaction – the action itself or its consequences could not have possibly been foreseen.¹

There are an infinite number of changes and forces. Most of them lead to nothing that should concern us, yet each of them has the potential to unleash powerful forces elsewhere and change the course of history.

Fooled by equilibrium

What goes up must come down (and *vice versa*) is often a good rule of thumb when thinking of economic matters. The rule implies a tendency to revert toward a base level, which is heuristically determined from recent history. When faced with new and surprising empirical observations, one often either discredits them or resorts to this rule of thumb

Extreme events tend to induce a pattern that may be characterized as punctuated equilibria – one concept of equilibrium prevailing before an Xevent and another one after it

or similar equilibrium concepts. This thinking may be rational in normal times. However, when faced with extreme events, one has to ask, is the base level the same in the new context and are the forces that determined the equilibrium in the past still in place? Extreme events have some tendency to induce a pattern that may be characterized as *punctuated equilibria*, i.e., one concept of equilibrium prevailing before an Xevent and another one after it. Some Xevents are mean-reverting, some are not.

Exhibit 3.3

Extreme Events lead to extreme behavior... sometimes

After hitting an iceberg the RMS *Titanic* sank in 2 hours and 40 minutes. Three years later, after a torpedo attack by a German U-boat, *Lusitania* sank in 18 minutes. For both vessels, 32% of the persons aboard survived. Frey, Savage, and Torgler (2011) use these two disasters to study human behavior in extreme situations.

The common assumption is that self-interested desire to survive will predominate and the rules of social behavior are disobeyed in a situation of life and death.

The above assumption turned out to be true on the *Lusitania*, while on the *Titanic* the adherence to social norms and social status dominated: Women and children had a higher probability to survive, not men. People in the first class had better chances. Well-mannered British passengers, on a vessel carrying their flag, and well-informed crew members did *not* exploit their advantages and were more likely to perish.

Due to the difference in the time it took the vessels to sink, the prevailing rules of social behavior were applied on the *Titanic*, but “brutal” survival instincts dominated on the *Lusitania*.

The analysis of Frey, Savage, and Torgler suggests that under extreme conditions human behavior is not completely random but it is strongly conditional on the specifics of the immediate context.

Source: Frey, Savage, and Torgler (2011).

Stay with the trend, my friend

Stay with the trend, my friend is a real pearl of wisdom that continues to be shared among seasoned stock traders. It has proved to be a reasonable trading strategy most of the time. It embodies the assumption that what went up/down yesterday, will continue to do so today. This assumption is often reasonable (cf. Chapter 5). When considering extreme events, however, it is best forgotten.

Failing to account for a changing context and constant re-optimization

Any real learning from one's own history or from others' experiences is conditional on having a similar context or being able to adjust the "lesson" in accordance with differences between contexts. When faced with uncertainty, people desperately seek historical analogs, yet they often fail to adjust the lessons to their current contexts.

A related failure is to assume that past agreements (on future courses of action) continue to bind. However, agreements are broken as easily as they are made. Human systems constantly adapt and re-optimize as new information accumulates and the system and its context change.

There is no silver bullet

After the above list of wrong assumptions, it may sound as if there is *nothing* one can do. Indeed, there is no silver bullet, i.e., no *one* approach, empirics, or theory that could provide the solution.

The following quote from Orrell and McSharry (2009) also applies to studying Xevents in social contexts: *"To make progress, systems biology has needed to embrace new mathematical techniques from network theory, complexity, and nonlinear dynamics. Instead of seeking concise mathematical "theories of everything", the idea is to develop partial models that capture aspects of the system."*

Instead of all-embracing theory of Xevents, the idea is to have a range of approaches and models that capture relevant aspects of related dynamics

The invisible hand is choking us

In the *longer* run an innovative entrepreneurial society – with plenty of *creative destruction* – should adapt well to any negative or positive impacts of an Xevent. Such a society excels in dynamism and efficiency; it may be characterized as being lean, individualistic, specialized, just-in-time, and short-sighted.

None of the above features is particularly helpful in the *immediate* impact of an Xevent – quite the contrary in fact. Furthermore, such a society typically provides *no* incentives for *a priori* consideration or prevention of *systemic* Xevents. Many individuals rather have something to gain from ignoring systemic risks.

As far as Xevents are concerned, a dynamic modern society is quite adequate *after* the fact. Its performance is far worse as far as preventing, anticipating, or preparing for Xevents is concerned; also the first line of response poses challenges that public decision makers have to consider separately.



Why did the beloved (financial) market bring the world to its knees?

A dearly held belief among economists is that a competitive market maximizes societal welfare.¹ In part, this enthusiasm for the *invisible hand* of the market relates to the bleak track record in employing the *visible hand*

“America’s housing market – the source of the greatest excess – has the government’s fingerprints all over it.”

The Economist (2008, p. 4)

and relying on public decision-making. As summarized by Akerlof and Shiller (2009, p. 2), “According to traditional economics, free market capitalism will be essentially perfect and stable. There is little, if any, need for government interference. On the contrary, the only risk of major depression today, or in the future, comes from government intervention.”

It should be noted that the Anglo-Saxon flavor of capitalism has served the world quite well in many respects: economies worldwide have opened up and prospered. Hundreds of millions of people have been lifted out of poverty and many developing countries now have a sizable middle class, the existence of which is often considered to be a necessary condition for functioning democracy. We should also separate the failure of the financial system from the failure of the market *per se* (Commission on Growth and Development, 2008).

Economists’ unholy alliance with politicians has contributed to the celebration of uncontrolled capitalism and consumerism in the past few decades. At least in the still prevailing hangover of the 2008–9 crisis, this era is seemingly coming to an end, although alternative globally shared values are yet to emerge. Why did the beloved market bring the world to its knees? And in the context of this book, is there something in a capitalistic market economy that makes it prone to extreme events such as the recent crisis?

It’s all about incentives

We believe that monetary, psychological, and social incentives play a major role in nurturing excess. Consider the following: Both privately and professionally – regardless of whether one is employed in the private

Financial markets are already ahead of the game – Deutsche Bank’s ELVIS index generates returns when market volatility increases

or in the public sector – these incentives are asymmetric. That is, one is likely to be rewarded for any *gains* that he or she is associated with, and one is partly or wholly insulated from any *losses*,² especially when one has not directly caused losses but, for example, has simply failed to observe some external conditions. It is thus privately optimal to pay attention to the po-

tential of large gains, ignore the possibility of losses (big or small), and *disregard systemic risks*.

As Nouriel Roubini (Scott, 2011) points out (in reference to the financial market and the 2008–9 crisis): *“There shouldn’t be an expectation of bailouts. As long as we have this expectation and a one-sided compensation model, where in good times you make high profits and bonuses, while in bad times the worst that can happen to you is that you don’t get a bonus, then there will be bias in risk-taking.”*

Furthermore, we are almost never rewarded for something that did not happen. Extreme events are by definition rare. If considering extreme events involves *any* private cost, including the opportunity cost of one’s time, in a viable scenario, *no one* in the society is motivated to consider them. If anything, individuals are seduced into *causing* extreme events both intentionally and unintentionally. For us, at least, these are terrifying yet realistic thoughts.

World-famous investor George Soros turned causing Xevents to a billion dollar business

Private and collective risks are not the same. The society’s interest is on a complex unbounded system. The individuals in the society tend to be concerned with smaller and more confined problems.

Exhibit 4.1

The 2008–9 crisis – What really happened

Subject: Risk memo

To: Jack Ass, CEO, Sleazy Brothers

From: Math Genius, PhD

You should take a look at our extreme events team: What they do seem to be both inefficient and redundant. They only come up with scenarios with probabilities that round to zero. Furthermore, what they provide is hopelessly inexact. Thus, upon calculating our *value-at-risk*, I’ve ignored fat tails (not implemented in my software; besides, I’m a vegetarian) and ignored extreme values – in technical terms: I considered the middle 99% of the normal distribution. I’ve fitted my model with 6,000 daily observations spanning over 30 years – with just one exception in 1987 it fits perfectly! A black Monday is abnormality – even if it would not be, we would face a complete loss only once in every 30 years.

Subject: Re: Risk memo

To: Math Genius

From: Jack Ass

Drop the tech talk – I’m a business man. I’m also retired in 30 years, so forget the long run – inform me only if the probability of a complete loss next year gets to something high like 3.3%. The quotas your model gives to our traders are large, which is good. If we make a billion next year, I’ll give you a big bonus – do not worry about losses. Isn’t it ok to say in my dinner talk: *“We are prepared for all possible future scenarios!”* If somebody asks about that fat tail thing, I’ll blame it on junk food.

Economics, the dismal science, has a dismal theorem: *under quite general circumstances, the society has an infinite expected loss from a low probability event, in which case standard economic analysis cannot be applied* (our interpretation of Weitzman, 2009). Thus, it is in the society’s interest to incentivize at least some of its members to consider extreme events.

Societal objectives in considering Xevents

But what should society’s objective function be in considering, and inducing the consideration of, extreme events? To answer this, let us first

The objective of a nation-state is to promote happiness and the well-being of its citizens

consider the general objective of a nation-state, which is *promoting happiness and the well-being of current and future citizens*. While neat, this objective is not operational. Albeit unsatisfactory (Stiglitz,

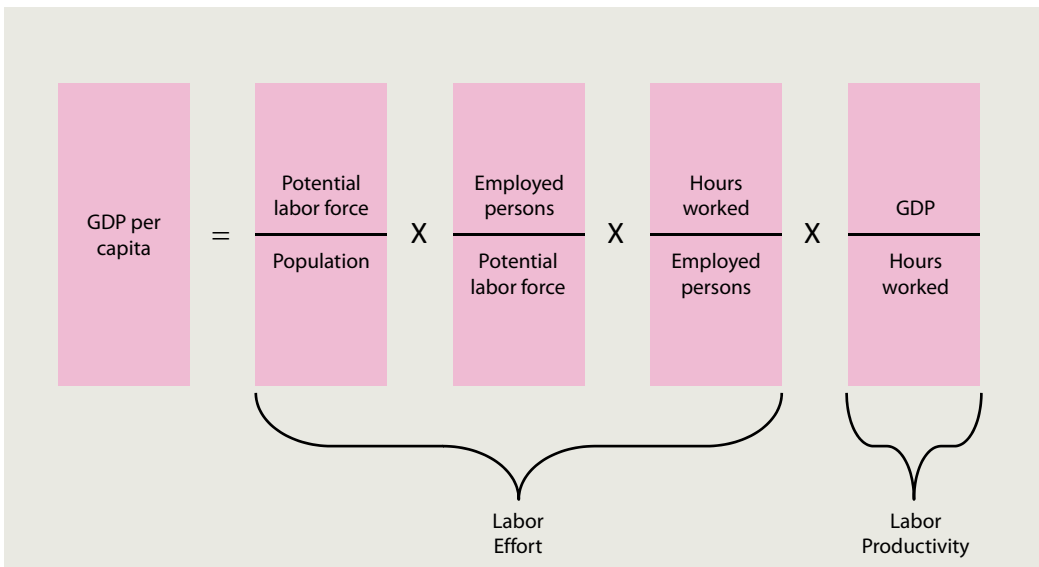
Sen, & Fitoussi, 2010), one way to escape the problem is to concentrate on material welfare, commonly measured by the gross domestic product (GDP) per capita, which has been broken down to its components in Exhibit 4.2.

Because the first three items in Exhibit 4.2 have natural bounds and tend to be relatively stable over time, in the longer run the GDP per capita mostly depends on labor productivity. Exhibit 4.3 considers the basics of labor productivity at the level of a business establishment.

Exhibit 4.2

In the longer run, the GDP per capita mostly depends on labor productivity

A de-composition of the GDP per capita



Consider Exhibit 4.3: by subtracting all the raw and intermediate goods and services the establishment purchases from all the goods and services it sells in the market place, one obtains the *value added* of the business establishment. This value added pays for the efforts of the employed labor force and for the returns on tangible and intangible capital. The *labor productivity* of the establishment is the ratio of its value added and the total number of labor hours it took to bring the value added about. GDP is the sum of the value added of all market goods and services produced within national borders in a given time window, most commonly in a calendar year.

Labor productivity is the ratio of value added and labor hours

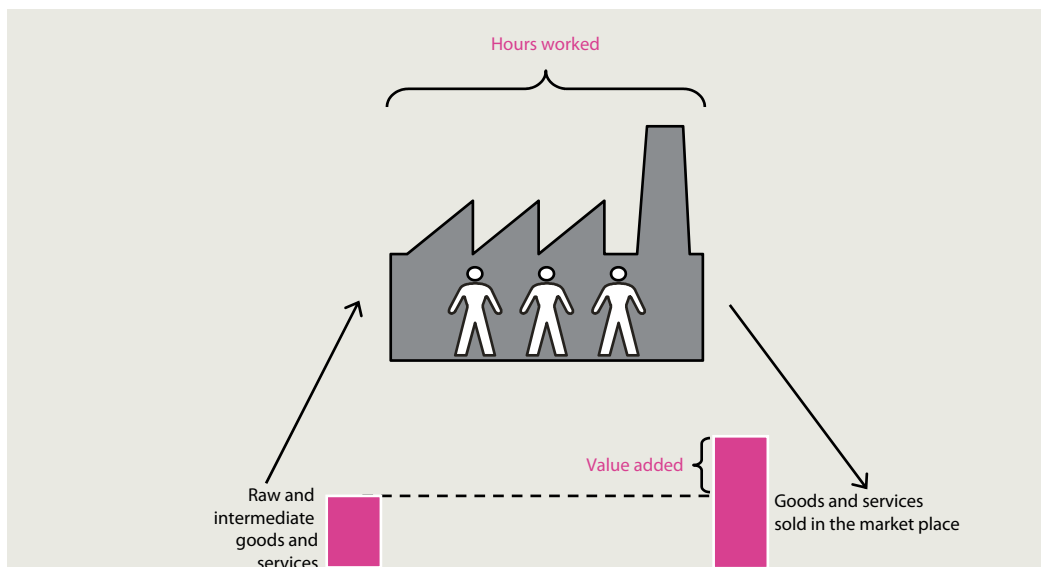
Value added is determined by being able to provide goods and services the customers are willing to pay for. In principle, value added is the result of a bargaining process between the seller and the buyer. On the customer side, the outcome reflects the desirability of the goods and services in the buyer's eyes (in absolute terms and relative to other available offerings). On the producer side, it reflects the ability to bundle real and imaginary features to form an attractive offering as well as the ability to organize production (the value chain) efficiently.

The suitable skills and competences of employees as well as abundant tangible and intangible capital are necessary conditions for creating value added. Once in place, both value added and productivity is first and fore-

Exhibit 4.3

The key aspect of value added: The desirability of the goods and services in the market place

Value added at the plant level



most about *being in the right line business*. Second, it is about organizing production sensibly. An establishment is commercially viable if the compensations for its labor and capital inputs do not exceed its value added.

Short-term: Maintain productivity and labor use

When faced with extreme events, in accordance with Exhibit 4.2, the economic objective of a society is twofold: keep labor in full use and main-

A necessary precondition for a recovery is that previous capital stocks are restored and resources are again in full use

tain and increase the level of labor productivity. The *immediate* concern is any disruptions in the value adding process that the event might cause. These disruptions may be related to the real or monetary aspects of purchased inputs, the labor and capital employed, the organization and other aspects of production, and the ability to reach customers (that are still able and willing to pay).

Long-term: Adapt to lasting impacts of the event

The *longer-term* concern is how to adapt to any lasting impacts of the event. What is the optimal business mix within national borders in the post-event global context? Some yet unexploited opportunities may have arisen. Is there enough entrepreneurial activity that new opportunities get exhausted? Are there enough exits of the old and entries of the new establishments? Is the re-allocation of resources among establishments sufficiently intense? Some establishments may no longer be commercially viable. An establishment's scale, scope, and mode of operation might need adjustment. Are resources being shuffled accordingly and with minimal adjustment costs? Has some tangible or intangible capital become obsolete?

Exhibit 4.4

Scottish Food and Drink

Our study of the Scottish Food and Drink sector consisted of nine sub-sectors that reacted very differently on the chosen game changers.

We found that the most vulnerable were those sub-sectors that had a high value added and that relied on a very special strategy.

Those sub-sectors that did not export to a significant extent and had a lower value added were not disrupted severely by most of the game changers analyzed. The balancing act was thus between high current earnings potential and resilience to change.

An economy should perhaps have a mix of activities: not only high value added export-intense companies but also ones that are more domestically-orientated and not so "sexy". The potential impact of an Xevent weakens with diversity. A game changer that has a fatal impact on one of the sub-sectors may create a high business potential to another.

Surprisingly enough, some key policy questions are not affected by Xevent considerations

Upon crafting economic policy, some questions are *not* affected by an extreme event: Do national institutions and incentives encourage individuals to accumulate employable skills and competences? Do national institutions and incentives encourage investment in tangible and intangible capital? Are skills and competences as well as tangible and intangible capital being put to full and optimal use (earning maximal returns given the external context)?

A more sophisticated arm's-length financial system may be more vulnerable to sharp contractions in economic activity

Cardarelli, Elekdag, and Lall (2009).

By and large, what is otherwise considered to be a dynamic modern economy, with plenty of “creative destruction” driven by innovative entrepreneurial competition, should not fare too poorly when faced with extreme events. Commerce is in private interest – if at all possible, actors up and down value chains will try to restore old or establish new links. There is, however, a caveat.

A modern economy is *lean* – it has little unemployed resources, excess, or spare capacity. It is *individualistic* with no particular motivation to take others into consideration. Its individuals and organizations tend to be *specialized*, i.e., they have well-defined narrow roles and related expertise (and little or nothing “on the side”). It is *just-in-time*, i.e., has distaste for inventories and storage and desire for purchase only when faced with an immediate need. Partly due to intense competition, the future is heavily

Exhibit 4.5

Networked smaller companies – a source of resilience?

The analysis of the communications technology ecosystem (one of the sub-projects in the *Game Changers* project) revealed a trade-off between the sector's ability to generate growth and its resilience.

Ecosystems that consist of large companies are often focusing on process innovation and thus on more efficient production. However, with drastic changes in the operating environment fine-tuning production and existing products might not be particularly helpful. Industries dominated by a few large companies may be more prone to Xevents.

Industrial ecosystems consisting of smaller companies have some tendency to focus more on radical product innovation, which – along with the structure of the ecosystem – make them quite resilient with respect to Xevents.

Existing large companies and industries are sometimes prisoners of their own histories. The past recipes of success may not be applicable in a new environment. Larger companies may offer advantages in normal times, but more networked industries with smaller companies may be more resilient.

Exhibit 4.6

Economic resilience to shocks: The role of structural policies

Duval and Vogel (2008) find that the OECD countries exhibit different degrees of resilience in the face of common shocks.

Policies and institutions associated with rigidities in labor and product markets are found to dampen the initial impact but to make their effects more persistent, while policies allowing for deep mortgage markets lower persistence and thereby improve resilience.

Simulations suggest that in English-speaking countries shocks have a significant initial effect on activity but this impact then dies out relatively quickly. By contrast, in many continental European countries the initial impact of shocks is cushioned but their effect lingers for longer. A few, mostly small, European countries combine cushioning of the initial shock with a fairly quick return to baseline.

Source: Duval and Vogel (2008).

discounted, which leads to *short-sighted* behavior. None of these aspects are particularly helpful when faced with extreme events. In fact exactly reversing *all* of the above features would seem like a reasonable recipe for resilience with respect to Xevents, although this conclusion may be too simplistic.

“Just-in-time may now be fortified with “just-in-case” systems to limit the damage from disruptions.”

An expert at HSBC (Economist, 2 April 2011).

For example, it is indeed the case that the real-time resilience of a just-in-time system is virtually non-existent; on the other hand it may make longer-term adjustment easier as hiccups are attended to immediately and supply chains are re-configured accordingly.

With the recent experiences private companies are starting to see their own best interest in a new light – *The Economist* (2 April 2011) notes that “*Industrial firms, having spent years becoming ever leaner in their production techniques and, in the process, making themselves more vulnerable to these sorts of supply shocks, will now have to go partly into reverse, giving up some efficiency gains to become more robust.*”

A dynamic capitalistic system may be good after an Xevent but not in a priori considerations

Economic dynamism is beneficial in both calm and turbulent times. It is a source of prosperity, and it accelerates post-event adjustments. The anticipation of and preparation for extreme events does *not* arise directly from the prevailing economic mantra. It has to be attended to separately.

Surprise, uncertainty, and extreme events

In this chapter we refine some of the concepts and thoughts introduced in Chapter 1.

Any realization one can observe in a given point in time is a combination of the *background circumstances* of the moment and an unforeseeable *random element*.

One *can* gain insight on the circumstances – for example, one can get a sense how favorable the prevailing conditions are for a certain Xevent or even develop a “thermometer” on how far these conditions are in the “change zone”.

One cannot, however, completely exhaust the random element. Accurate predictions – with exact timing, location, and other details – are thus impossible. We cannot forecast but we can – to an extent – anticipate Xevents.



The ordinary and the surprising

As a filler of time between birth and death, life for an individual, a nation, or even a civilization consists of *one long sequence of events*. To paraphrase a well-known saying, *it's just one damned event after another*.

It's just one damned event after another

Most of events are inconsequential. You order a steak at the restaurant instead of lobster; that's an event for you and for the chef at the restaurant, who has to prepare the meal. The city of Vienna decides that road traffic will be banned on Graben; that's an event that has long-lasting effects on the lives of residents of the First District of Vienna and for tourists, but no one else. The decision of the American government to invade Iraq is an event of major impact on the entire world for decades, maybe longer. Most such events, regardless of the level and magnitude of their impact, are rare in the sense that our expectation of seeing exactly that event and not something else prior to the event's actual occurrence is small, negligible actually. But they are not in any way **extreme**. If it's extreme events (*Xevents*) you're after, then it's the degree to which the event's occurrence is *surprising*, together with its *impact* on society as a whole, that matters. Let's take a moment to deconstruct two defining aspects of an Xevent.

The idea of an event's potential vs its realization

TV weather forecasts illustrate the distinction between a space of potential events and the space of actual ones

For the sake of definiteness, think about the weather forecast given on the evening television news. What does it mean when the forecaster says, "Sunny and a high temperature of 75 degrees Fahrenheit tomorrow"? He is saying that among all possible weather patterns based on currently available information (temperature, wind velocities, humidity, etc.) and changes in that information constrained only by the laws of physics, this forecast is the most likely weather event over the next 24 hours.

Notice here that the space of all possible events is pretty coarsely conceived, both in time and in space, as the forecaster is talking about "tomorrow's" weather, which might be anytime during the next 24 hours as the pattern unfolds over a fairly large spatial region. If either the time scale or the spatial extent were more finely drawn, then there would be many more potential weather patterns since they would not then be smeared out over a single region of space and time. This fact, in turn, means that whatever weather event is actually realized tomorrow in the particular region and time period, it would necessarily be rarer than the weather event that's experienced over a larger region and longer span of time.

A television weather forecast then illustrates the distinction between a space of potential events and the particular event in this space that is in fact realized. Of course, this assumes that the space of potential weather patterns does indeed contain every possible pattern that could conceivably arise from the information available today. If that space is too narrowly defined, then something totally unexpected (truly surprising!) may occur. Generally speaking, this would happen if the laws of weather formation are in some way incomplete and thus don't allow us to imagine all possible weather implications of the current data as to what may or may not happen tomorrow.

Despite the fact that any given weather pattern for tomorrow becomes increasingly rare the finer we draw the space-time grid, the actual *realized* weather is still *not* an Xevent simply by being rare. To move further in that direction, we need the distinction between an event being *unlikely/improbable/rare* as opposed to its being *surprising*.

Xevents

When the weatherman says that the chance of rain tomorrow is 60%, he means that the meteorological model predicts that tomorrow's temperature, wind velocities and the like have in the past led to rainfall 60% of the time during the next 24 hours. So the weatherman is statistically processing the historical record of predicted meteorological quantities, looking for the fraction of the time that "rain" ultimately came pouring down.

Generalizing from this example, when we speak of an event E being *unlikely* or *improbable*, the tacit background assumption is that the event belongs to a set of possible events that have actually occurred before, usually many times. We then look at the frequency with which E has taken place relative to the total number of realized events, calling that frequency the likelihood or probability of E occurring.

The crucial element here is that we have a sufficiently large database of past events available to drawn upon, so that we can employ the tools of probability and statistics for estimating how likely or probable it is that E will turn up.

What if we have no historical record of an event that is even remotely similar?

The idea of statistically processing past historical data underlies not only weather forecasting, but almost all forecasting techniques. But, and it is a *big* but, the historical record must be rich enough and broad enough to encompass the event E whose likelihood we're trying to estimate. But what if it isn't? What if the historical record is too short, too thinly populated or simply does not contain an event even remotely similar to E ? What happens then? How can we get a handle on the chances of E turn-

ing up? This is the domain where *rare*, *improbable* and *unlikely* morphs into *surprising*. And the more surprising, the greater the *X-ness* of the event.

The surprise value of an event when data is too limited

Every sport has its defining mythic achievement, an event that by common consensus will remain in the record books until the record books themselves crumble into dust. For baseball in America, that mythic event is the 56-game hitting streak by Joe DiMaggio set during the 1941 season, seventy years ago and still counting.

Folk wisdom has it that this streak of consecutive games with at least one hit was essentially impossible. But it did happen. So how likely was it, really? Was it a once in the lifetime of the universe fluke? Or in a second Earth on the other side of the galaxy could it have happened many times over the last seventy years?

A couple of years back, Cornell researchers Samuel Arbesman and Stephen Strogatz (2008) decided to answer this question. To do so, they envisioned ten thousand parallel Earths, all with the same players but subject to different whims of chance in each one. In essence, what they did was replay each and every of the seasons from 1871 to 2005 ten thousand times, looking for the longest hitting streak in each of those seasons. We need not go into the finery of their experiment here, as the details can be found in their paper. What's important right now is that instead of asking how rare DiMaggio's hitting streak was, the investigators asked a vastly more general and interesting question: How likely was it that anyone in the history of baseball (up to 2005) would have had a hitting streak of at least 56 games? The answer? Not unlikely, at all!

In the 10,000 parallel seasons the longest hitting streaks ran from a modest 39 games to an astonishing (and definitely rare) 109 games. More than two-thirds of the time the longest hitting streak was between 50 and 64

An event that seems so rare as to be accorded the label mythical, may in fact be quite hum-drum – in another universe!

games. In short, there's nothing very extreme at all about a 56-game streak. Furthermore, DiMaggio ranked only as the 56th most likely player to hold the record for the

longest streak in baseball history. Who's the most likely? I'll leave it to baseball fans to read Arbesman and Strogatz's paper to see the answer to that question.

For us right now, what matters is that an event that seems so rare as to be accorded the label *mythical*, may in fact be quite hum-drum – in another universe! The problem is that our database may be just too small to be

able to say how rare something *really* is. So what is and isn't an Xevent is a *relative*, not an absolute, property of any particular event. Just because you and your friends think it's rare doesn't necessarily make it so.

One last ingredient: Impact!

It's no exaggeration to say that the memorable events, those that matter are the ones that in some way change a person's – or a nation's – destiny. That change may be for better or for worse. But game-changer events are by definition those that have an *impact*. Using our weather example, rain tomorrow has little memorable impact for individuals unless they happened to be planning an outdoor wedding or are a farmer worrying about irrigation of his fields. But if the weather turns out to be a tornado, then your life might well be changed as your house is reduced to matchsticks in a minute. In such a case, the surprising event has serious impact – and not for the better. It's fair then to call the tornado an Xevent, at least for those impacted by it. At a broader level, Hurricane Katrina was both surprising in magnitude and of huge impact over a wider area than a tornado, and thus is an even bigger Xevent. It's not hard to extend this notion of surprise plus impact into the domain of events generated by humans, and to consider 9/11, the crash of the US housing market in 2007–2008, and the 2003 East Coast power failure in the USA as all being Xevents.

Game changing Xevents are by definition those that have a significant impact

Common features of Xevents

The common features characterizing all Xevents are an *unfolding time* (*UT*) for the event from its beginning to end, an *impact time* (*IT*) during which the cost or benefit of the event is experienced by some individual or group, and a *total impact* (*TI*) that measures the overall magnitude of the event, usually measured in dollars or lives lost. It is possible to combine these three factors into a single formula allowing us to measure the *X-ness* of the event on a scale that ranges from 0 (not an Xevent, at all) to 1 (the most extreme of all possible events). It's not important for our story here to go into these fine-grained, technical details. What is interesting, though, is to ask why when the term *extreme event* is mentioned, we almost always think of it as characterizing an event that's *threatening* or *destructive*? Insight into this question comes from looking just a bit harder at the three quantities, *UT*, *IT* and *TI*.

Why when the term extreme event is mentioned, we almost always think of it as characterizing an event that's threatening or destructive?

We tend to think of events as generally being an occurrence of something having a rather short unfolding time, probably because we ourselves tend to have fairly short attention spans, ones that are becoming ever shorter

with advances in communication and travel. An event occurring quickly (short *UT*) that generates a big impact (large *TI*) having long-lasting effects (long *IT*) is an event that's surprising, difficult to prepare for (short *UT*) and nasty (large *TI* and long *IT*). The March 2011 Japanese earthquake and its attendant nuclear power plant meltdown qualifies nicely as an example of this sort of Xevent.

You might wonder if there could be *nice* events that might also qualify as Xevents? The answer is that there definitely **can** be such events. But such benevolent Xevents always involve a relatively *long unfolding time*. Think of things like the Marshall Plan that helped rebuild Germany after World War II, or on an even longer timescale the development of agriculture and the domestication of animals that enabled modern civilizations to develop. These sorts of events take decades or even centuries to unfold and involve the building up or development of something, such as a business, a nation, or a technological innovation.

The 2nd Law of Thermodynamics tells us that it's always a lot easier and quicker to *destroy* something than it is to *build* it. So events with a short unfolding time, at least at the level of nations and societies, are almost always destructive. Of course, the timescale of an individual life is much shorter than that of a nation, so the kinds of events that could be positive game changers for an individual must have a correspondingly shorter unfolding time, like the few seconds it takes to win the PowerBall Lottery or the year or two required to create an Oscar-winning film. But our focus is on events that impact an *entire society*, or even the *world*, and do it via an event having an unfolding time much shorter than the typical lifetime of even a country, let alone the world.

It's always a lot easier and quicker to destroy something than it is to build it

So now we have a more refined idea of what constitutes an Xevent. While definitions, even loose ones, are useful, what we really want to know is how such surprises *come about* and what we can do to either *prevent* them, or at least *prepare* for them.

White Doves and Black Swans

Following Hurricane Katrina's devastation of New Orleans in 2005, General Carl Strock of the US Army Corps of Engineers stated:¹ "... *when the project was designed... we figured we had a 200- or 300-year level of protection. That means that the event we were protecting from might be exceeded every 200 to 300 years. That is a 0.5 percent likelihood. So we had an assurance that 99.5 percent of this would be okay. We, unfortunately, have had that 0.5 percent activity here*". Strock's claim rests on the as-

sumption that hurricanes of the size of Katrina occur with a frequency that can be described by the classical bell-shaped curve, the so-called normal probability distribution. Sad to say for New Orleans (and General Strock), hydrologists and statisticians have known for more than a century that the extreme events falling near the ends of a statistical distribution usually **cannot** be usefully described in this way. Just as with the meltdown of the global financial system in 2008, the normal distribution dramatically *underestimates* the likelihood of *unlikely* events. Such events follow a different type of probability curve, informally termed a *fat-tailed* distribution.

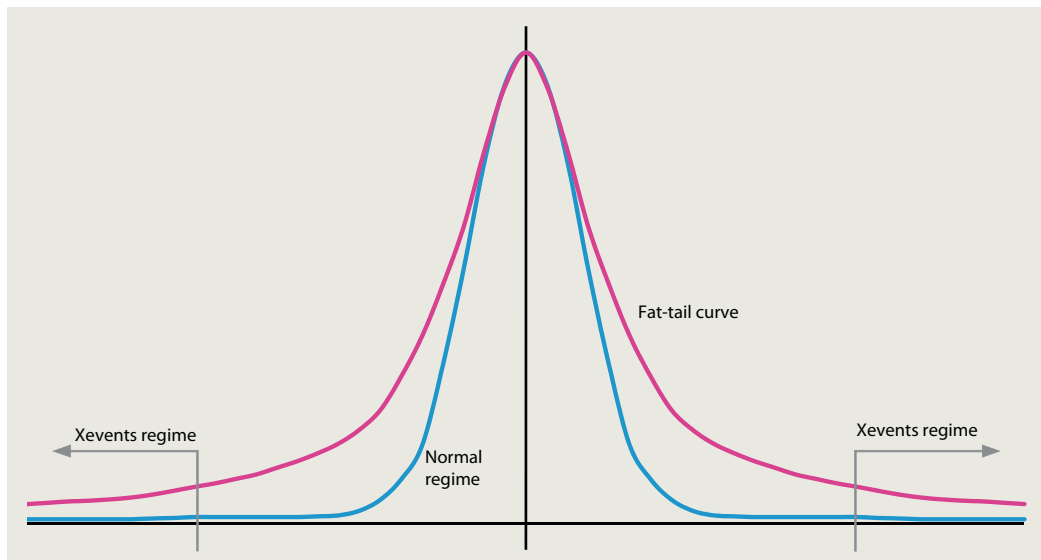
The extreme events falling near the ends of a statistical distribution usually cannot be usefully described using the standard bell-shaped distribution

The difference is shown in Exhibit 5.1, which displays the normal regime and the Xevents regime out in the tails. Using this fat-tail law to describe the New Orleans situation, the 0.5% mentioned by General Strock would have been closer to 5% and the 300 years would have shrunk to about 60 years.

Looking at Exhibit 5.1, you might think that the Xevents-regime region of the fat-tail distribution for Xevents doesn't really differ so much from that of the bell curve. To show the difference more graphically, have a look at Exhibit 5.2. Here we see the likelihood of events taking place that depart from the average event for both the bell-shaped curve and for the Cauchy distribution, one of the most common fat-tailed distributions.

Exhibit 5.1

The bell-shaped vs fat-tailed distributions



Here the departure from the average event is measured in standard deviations, with three or more standard deviations representing an event that is very far from the average. The horizontal line spacing on the figure measures the likelihood of an event occurring that is 0, 1, 2 ... standard deviations away from the average. Note that these lines are spaced on a logarithmic scale, which means that the space between each pair of lines represents a likelihood factor **ten** times larger than the spacing between the adjacent pair of lines.

An event on the bell-shaped curve that has virtually zero probability is 6,000 times more likely if it arises from the Cauchy distribution

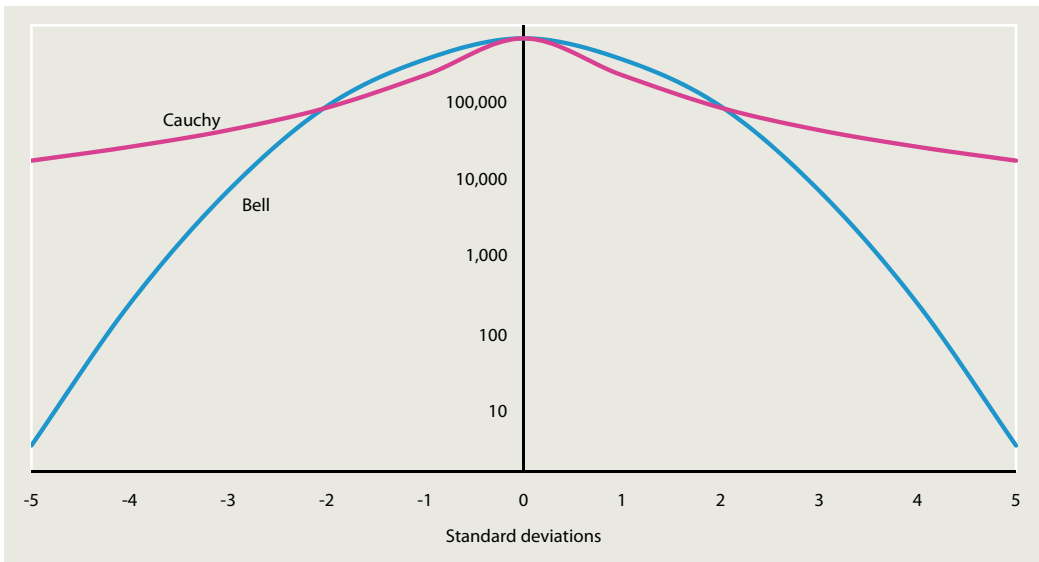
lines represents a likelihood factor **ten** times larger than the spacing between the adjacent pair of lines.

To illustrate the implications of Exhibit 5.2, a five standard deviation event on the bell-shaped curve is very unlikely, essentially *zero*. The same event, though, is about *6,000 times* more likely if it arises from a family of events following a fat-tailed Cauchy distribution instead of the bell-shaped one.

If an insurance company was selling insurance against unlikely events and based its risk premium on the bell-shaped curve, it might charge a fee of a *million* dollars. But if the family of events obeyed the Cauchy probability law, the firm's true exposure would be *\$6 billion!*

The key reason fat tails exist in financial market returns is that investor's decisions are *not fully independent*, which is **the** key assumption underlying the normal, bell-shaped distribution. At extreme lows, investors are gripped with fear and they become more risk-averse, while at extreme

Exhibit 5.2
The bell-shaped and the fat-tail Cauchy distributions of events



market highs investors become *irrationally exuberant* (Shiller, 2000). This type of interdependence leads investors to *herd* or cluster together, which in turn causes them to buy at ridiculous highs and sell at illogical lows. This behavior, coupled with random events from the outside world, *push market averages to extremes much more frequently* than models based on the normal distribution would have one believe.

A graphic illustration of this point is that the technical *casus casusorum* of the ongoing global financial crisis is the almost universal use of the so-called Black-Scholes formula for pricing asset returns like options and other derivative securities. This rule, for which Myron Scholes and Robert Merton received the 1997 Nobel Prize in economics (Fisher, Black having died in 1995), is – to put it simply – *just plain wrong*. Why is it wrong?

One of the principal reasons is that it is based on the bell-shaped distribution, which causes the formula to vastly underestimate the likelihood of the very types of high-risk events that actually occurred, thus setting off the chain reaction of bank failures and financial havoc that continues to this day. As one of our friends puts it every year when the Nobel announcement comes around for the prize winner in economics, “*Yet one more reason why there shouldn’t be a Nobel prize in economics!*”

The bell-shaped distribution vastly underestimates the likelihood of extreme events

If one wanted to point to the moment when this entire line of bell-shaped thinking was exposed as an emperor with no clothes, it’s hard to do better than point to the publication of Nassim Nicholas Taleb’s bestseller *The Black Swan* (Taleb, 2007), which argued forcefully and provocatively that *the whole edifice of theoretical finance rests on quicksand*.

Taleb’s argument

Taleb had spent many years as a trader in exotic financial instruments before growing up and entering into the more contemplative life of an academic, public intellectual and general gadfly. So his perceptive and caustic views on the huge risks being taken every day in financial centers around the world were both enlightening and, it must be said, a bit energizing as well. Here’s why.

In his writings, Taleb has described **Black Swans** as events that, “*Lie outside the realm of regular expectations, carry an extreme impact, and human nature makes us concoct explanations for their occurrence after the fact.*” Well, you can’t argue with a definition, but only with whether it leads to interesting and useful ideas, methods, debates and results.

While we don't quibble with Taleb's definition of a Black Swan, or in the terminology here an *Xevent*, it's somewhat incomplete, or at least too aggregated in a couple of ways that matter. So let us deconstruct his definition to put it into a form somewhat more useful for our discussions here.

Our response to, and an extension of, Taleb's Black Swans

First of all, **rarity**. This is certainly the least controversial aspect of what does or doesn't constitute a Xevent, as we've already considered. By common linguistic usage, Xevents are *by definition* (if you'll pardon the weak pun) outside the realm of everyday expectations. Whether they are totally unexpected, as Taleb's definition suggests, is another matter. After all, even events as rare as an asteroid impact or a 9/11-style terrorist attack *are* to be expected. The only surprise component is *when* they will happen, *where* they will occur, and *how* damaging they will be. But happen they will, regardless of the wishes and hopes and fears of us puny humans to change that state of affairs. Like hurricanes and earthquakes, we can only try to prepare for such events so as to mitigate their damage.

Things become rather more interesting when we turn to the **extreme impact** aspect of Taleb's trinity, since rarity and impact are properly separate matters.

A Force 5 hurricane that drowns New Orleans is one thing; the same hurricane blowing itself out over the Caribbean is something else. To a hurricane specialist, the two events are equally interesting; to CNN, (re)insurance companies, and of course the residents of New Orleans the two cases are very different matters indeed. The difference, of course, resides in the impact of the event, be it measured in dollars, lives and/or psychic disruption. So both rarity and impact have to go into any meaningful characterization of how black any particular swan happens to be.

By far, the most interesting component of Taleb's trichotomy is the one addressing the after-the-fact **stories** we humans tell ourselves by way of explaining an Xevent. Of course, this leg of the triangle is clearly the part

Taleb argues that the explanatory ex post stories are the aspect of an Xevent that give rise to what he argues is the illusion of being able to both forecast and control the Black Swans

Taleb relishes most, since the explanatory stories are the aspect of an Xevent that give rise to what he argues is the *illusion* of being able to both *forecast* and even *control* the Black Swans.

It's not at all evident that this part of Taleb's definition is necessary for the study of Xevents, although it certainly is necessary for the story told in his book. In fact, it is the central issue in the story Taleb is telling the world to counter the stories the world tells itself about Xevents. Here we take a more moderate position.

In accord with Taleb, we do not believe that there is any person or method, living, dead or yet-to-be-born, that can reliably and consistently forecast *specific* (X)events. Here by **forecast** we mean predict the *timing* and *location* of an event with enough *accuracy* to be useful in preventing, preparing for, and/or surviving the predicted event. Such a forecast might be something like, “An earthquake of magnitude 6.7 centered near Chula Vista will hit southern California on February 24, 2013 at 7:47 pm.” To believe otherwise is to succumb to a hubris that’s both dangerous and totally ill-conceived. Forecasts of such a sort occasionally work in the natural sciences, primarily in astronomy and engineering, and without exception involve events in the *regular regime* of Figure 5.1 and that generally occur over short time scales in a limited spatial region. Thus, we agree with those who say that *truly forecasting an Xevent is a fool’s errand*.

*Truly forecasting an Xevent
in the social domain is
a fool’s errand*

Chance and necessity

On the other hand, it seems perfectly feasible to develop tools for **anticipating** Xevents. To understand what this means, bear in mind that Xevents, especially those that are human-induced, unfold as a combination of what the French biologist Jacques Monod termed *chance* and *necessity*. At any given time, there is a societal background, a kind of playing field, within which human events take place. And that *playing field* is continually shifting, giving rise at a particular time and place to a socio-psychological climate that tends to favor the occurrence of some types of events and work against others. One might think metaphorically of this space as creating the **flow** of events. Sometimes the flow is moving to favor a particular sort of event, sometimes the flow shifts and that very same event becomes far less likely. This entire background creates the *necessity* part of Monod’s duo. It does not *require* any particular event to take place, but only *biases the likelihood* of what may or may not actually occur.

The other half of the story is the *chance* component. In a given environment many things might happen. What actually does take place is determined by *essentially random* actions (i.e., without a discernible pattern) at a particular time, actions that force one of the potential events to actually occur. Think of an event space that looks like a sharp mountain peak surrounded by many valleys. Currently, you’re sitting on top of the peak. A random shove pushes you in one direction, taking you down into one of the many possible valleys. That random shove might be a gust of wind or the “help” of one of your fellow climbers. Suddenly, all the valleys except one cease being candidate destinations. At the next instant, though, the landscape may transform in such a way that the former peak is now a plateau. In that case, the same shove would only have moved you over a

bit on the plateau and not send you into any valley at all. In other words, nothing much happens. Or the peak may become asymmetric, in which case it takes a bigger shove in one direction to get into a certain valley than to any of the others.

The point here is that what we actually observe is always a combination of the *background circumstances* of the moment, together with a *random element* that cannot be foreseen at all. Our belief is that we can use many

An actual observation is always a combination of the background circumstances and a random element

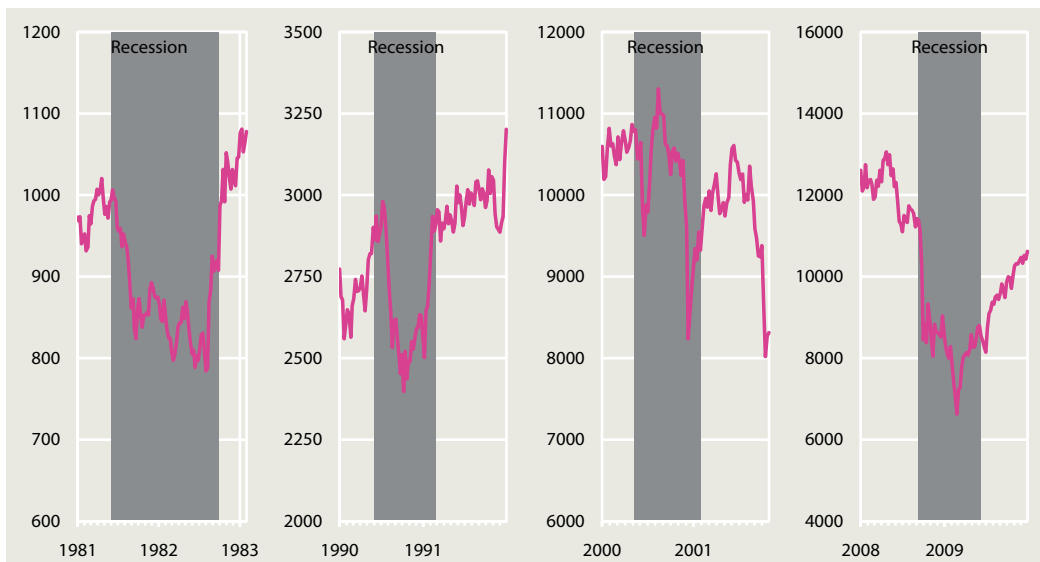
different ways to get *insight* into the shape of the playing field and its gyrations, thus gaining useful information about what is more or less likely to be seen by way of any type of event, Xevent

or otherwise, at a particular moment in time. So any talk about *forecasting* Xevents means simply anticipating how the *playing field* will change; it definitely does **not** refer to the prediction of *specific events*. For that, you need a card-layer, astrologer or a crystal-ball-gazing fortune teller, not a complexity scientist.

Social mood

There is a growing body of evidence suggesting that the *beliefs a population holds* about the future – optimistic (positive social mood) or pessimistic (negative mood) – strongly bias the qualitative character of all types of collective events, ranging from the types of books or films that will be popular to the sorts of political ideologies that will be in vogue.

Exhibit 5.3
The Dow Jones Industrial Average (DJIA) as a leading indicator of recessions



Data source: Yahoo! Finance / Dow Jones Industrial Average.

This **social mood** is a strong determinant of what we've just called the *landscape* within which events unfold.

How can social mood be *measured*? And can this measurement of mood be used as a *leading indicator* of what to expect by way of events over different time frames?

To answer this question, the first thing to note is that it's a well-established fact that a financial market average like the *Dow Jones Industrial Average* (DJIA) in New York is a leading indicator of macroeconomic trends. The picture in Exhibit 5.3 below tells this story for the last three economic recessions, prior to the one we're mired in right now. During nearly all eleven recessions prior to the current one, the DJIA began to climb six months *before* the economy began to recover (as measured by GDP). The only exception was the 2001 recession shown in Exhibit 5.3, where a scandal-wracked market didn't hit its low until nearly a year after the recovery had begun. The message here is that stocks are more than just a measure of investor expectations; they are a measure of **confidence**. So if we were looking for an early-warning indicator of where the economy is heading tomorrow, an indicator of where the stock market is heading today is an excellent place to start.

Stocks are more than just a measure of investor expectations – they are a measure of confidence

The above statement – investor confidence is the key to market action – gives a starting point for our indicator, as it's really the mood of the population, how people feel about the future that dictates when a macro-trend like GDP or, equivalently a recession, will shift gears. Fortunately, there are many indicators that have been employed to project stock prices into the future, some of which even work for a while! In this connection, measures like the VIX volatility index of put/call options, advances-versus-declines ratios, moving average indicators, the McClellan Oscillator, and numerous other technical indicators are well known.

The stock market is *one* good indicator of social mood. But there are others, less well-explored. Internet search engines that quantify terms people are searching for is one intriguing possibility. So are Internet markets where people bet on the likelihood of various events. In another direction, textual data-mining, whereby intelligent computer programs search for previously unrecognized patterns in media reports, Twitter tweets, Internet blogs and the like seem likely to yield useful insights into how demographic groups or even entire populations see the future.

The stock market is one good indicator of social mood – Internet searches may be another one

Trends, turning points, and Xevents

The majority of people operating as *futurists* of various sorts generally make the following type of forecast: *Tomorrow will be just like today except a little better or a little worse*. In short, they are trend followers and simply extrapolate whatever the current trend is into the future.

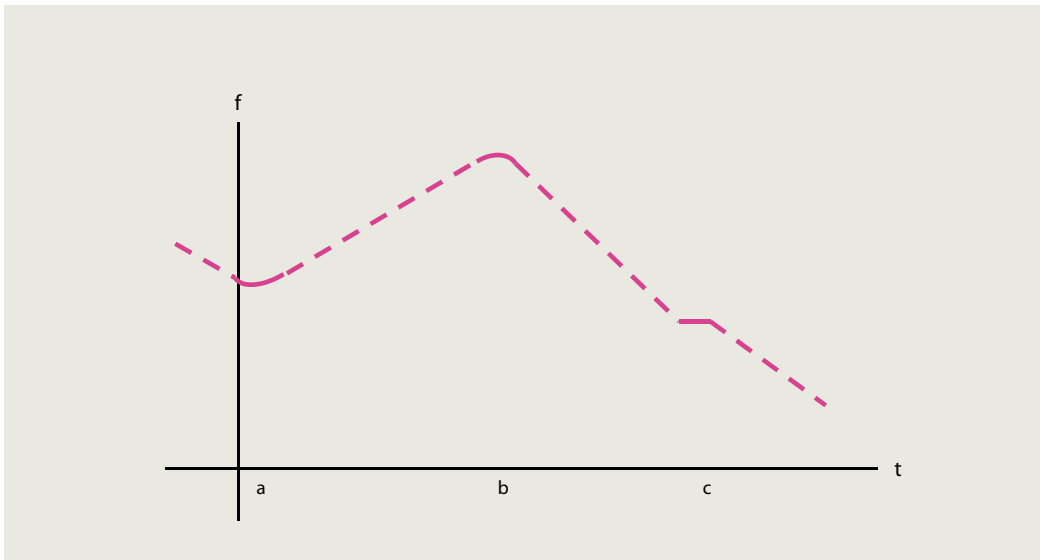
Surprisingly, trend following is almost always right

For such people, surprises never occur and trends never change. Strangely, this kind of trend following is *almost always right*. But it's also often *useless* too, and you certainly shouldn't pay any money to a so-called futurist for this type of forecast. What you should be ready to pay for, though, is information about the **turning points**, those moments in time when the current trend is rolling over and beginning to morph into a counter trend. That type of information is real – not fool's – gold. Mathematically, such turning points are called *critical points* and there is a well-developed theory about them in the dynamical systems literature. Oddly, though, that theory has been very little employed for the kind of practical questions about Xevents that concern us here.

Exhibit 5.4 illustrates why trend-following is almost always right, as well as suggesting the relationship between the critical points at which trends are changing and Xevents. Here we see a time-series of data f with three critical points, marked a , b and c . Note that the two points a and b are what's called *non-degenerate* critical points, and do indeed represent turning points in the current trend. The instant c is a *degenerate* critical point, where the current trend is, in effect, taking a breather before con-

Exhibit 5.4

A time-series with three critical points



tinuing on its way. Mathematicians know, however, that such degenerate critical points where the data series is *flat* are unstable, in the sense that a very small disturbance to the data in the region of point c will transform the critical point to one like a or b . So a degenerate critical point is not something to be expected in the real world, since every time-series of data has some error term which can be invoked to remove the degeneracy.

Note also that the three critical points in Exhibit 5.4 taken together form an infinitesimally small subset of all the time points. Technically, they form what's termed a set of *measure zero*. More informally, this means that if you close your eyes and pick a time point at random, you have *essentially zero likelihood of choosing a critical point*. But since away from the critical points the time series is following its current trend, this means that regardless of which instant you choose, you will be virtually certain to select a time where you can say that the current trend, whatever it may be, will continue to the next moment of time. In short, *trend-following is almost always correct*. But it doesn't take a futurist to make this call. It's a simple mathematical fact that holds universally for all time-series of data.

When does a trend roll over?

What is really tricky, though, is nailing down the moments like a or b when the trend is rolling over. How to do that? The problem is easily solved if you have a **model** for the process that is generating the time-series. In other words, if you have a closed-form mathematical expression for the function f . In that case, we simply use calculus to find those points where the slope of the curve is zero. That's it. *Problem solved*.

If only one had a closed-form mathematical expression of the world...

Exhibit 5.5

Early detection of future changes desirable... but is it possible?

One of the research themes in the *Game Changers* project was to develop an anticipation system – *The Observatory*. It proved to be the most difficult one out the ten areas of research. We had two different lines of development; our own scanning system development project and a simultaneous test of the several open source or the commercial scanning services. The development of our own scanning system was terminated after the pilot phase. Pilot results were promising, but the next stage of the development proved to be far too expensive for the limited resources of our project. We evaluated altogether over 15 different web-based scanning methods and services for 7 months. The key challenge here was that most of the tools and services available for testing in September disappeared from the market by the end of the year. The best solution tested proved to be the service called Recorded Futures (www.recorderfuture.com) but it proved to be useful only scanning for something that is simple to distinguish (such as name of a person or a company).

But the real world almost never gives up its secrets that easily, and we almost **never** have that magic formula for expressing the data in a closed-form expression. The usual case is that we have a set of measurements and that's it. And, in fact, it's often not even that simple as the measurements themselves are corrupted by noise, are incomplete in the sense that they're not available at every time instant, or there is some other problem casting doubt of one type or another on the validity of the data. But never mind. Suppose we have a set of clean data, taken over a sufficiently large time period to be representative of the phenomenon under investigation. In that happy case, there are a variety of tools that have been developed to identify when the data is beginning to "flatten out" (Casti, 2010; Prechter, 1999; Stewart & Poston, 1978). *Now what about Xevents?*

It's clear that **not** every critical point is an Xevent. It's equally clear that every Xevent is indeed a critical point. Roughly speaking, what it takes for a critical point to be an Xevent is that *the change of trend is sufficiently rapid* to be a short unfolding time (*UT*). Geometrically, this means that the curvature at the critical point is very great, so that the change from the current trend to its opposite is very quick. In short, the peak at the critical point is **sharp**.

One cannot forecast but one can anticipate Xevents

Again, we have tools for measuring the sharpness of the critical point, and even more importantly to identify when the data is pointing to a slowing down of the current trend. With data alone it's almost impossible to nail down the exact moment when the critical point will occur, since as we noted a moment ago those points are an very small subset of all time points. But it's usually sufficient for practical purposes to be able to identify when we are getting into the neighborhood of a trend change.

The upcoming socio-economic wave

This chapter explores, analyzes, and makes use of the next long wave of development known as the 6th *Konratieff* cycle, assumed to take place in 2010–2050.

We study the implications of this cycle putting with a special emphasis on disruptive factors that might occur. The current early phase of a cycle is arguably particularly prone to Xevents.

With the forthcoming 6th wave the world will become much more complex, which creates both opportunities and vulnerabilities. With many additional layers and structures, societies will become more fragile.

There is a growing *mismatch* between the inherent features of the system and its control mechanisms.



Long waves and extreme events

What is the relationship between long-term trends in society at large and disruptive events? For us the relationship is quite obvious: The likelihood of Xevents must correlate to what kind of society and dynamics we are in.

There are structures, institutions, and situations that are more prone to Xevents than others

In other words: there are societal structures and institutions as well as situations that are more prone to Xevents than others. Our thesis here is that we are entering a new wave of societal development – we call it the 6th Kondratieff wave – that is more likely to engender extreme events than previous cycles. In what follows, we embark on explaining what we mean by this.

The information wave

Futures research – almost by definition – refers to the analysis of longer-term patterns of economies and societies. Perhaps the most renowned effort has been that of Alvin and Heidi Toffler in their theory of The Third Wave.¹ The theory assumes that after the agricultural and industrial waves, we are now entering *the information wave*, i.e. *the Third Wave* that will sweep across the whole civilization and bring new structures and modes of organization.

While this theory certainly has some explanatory power, for us the most fruitful approach appears to be the theory of structural cycles developed by the Russian economist *Nikolai Kondratieff* in 1930s. According to him, modern economies fluctuate in a cycle of 40–60 years (known as Kondratieff's waves), always starting with technological innovations that penetrate economic and social systems with the effect of prolonged economic upturn and steady increase in productivity. In other words, Kondratieff approach assumes trends but it also assumes certain *discontinuities* in the evolution of these trends. The cyclical pattern leads to certain

Kondratieff approach assumes trends but also certain discontinuities

shocks, as history proves: for instance, the Great Depression at the turn of 1930s, the first oil crisis in the early 1970s and of course the most recent financial crisis.

When a wave turns to a next, it usually means new technological breakthroughs. They are coupled by new value systems, social practices, and organizational cultures. However, eventually new technologies offer diminishing returns on investment. This leads to stagnation in the demand for credit with real interest approaching zero. Every major economic crisis in the past 200 years showcases this development, including the last financial crisis. Thus, what we may observe is a structural pattern that de-

finances our economies, to the extent that it assumes some sort of upheaval always taking place towards the end of an economic upturn.

This time is no different: the financial crisis has forced us to experience the end of a cycle or wave. But there is more: the point we are making throughout this book is that there is *systemic tendency* to be more exposed to extreme events because of the complexity of the system. Our ability to control human and technological systems is decreasing because of the *mismatch* between the events and control mechanisms. It is because of this tendency that we are particularly anxious to understand the nature of the next wave.

Riding the wave

The cyclical socio-economic theory of Kondratieff has been rather little used for understanding the current period of transformation and anticipating the future. Yet, anyone who is looking at the present crisis-prone economic rope-dance may agree that the world, and the world *economy* in particular, is in the state of *deep instability*, where complete chaos and danger of whole societies to step straight into abyss is looming all too near. As with previous times of economic crises, transformation brings a lot of chaotic factors into the system. Moreover, the idea of *disruptive change* occurring at the end of the cycle is seldom appealing to the economists that are more likely to cherish evolutionary and incremental economic development.

The world economy is in the state of deep instability

For us, a particularly interesting issue is how economic, technological, social, and cultural aspects of change can be analyzed and foreseen in the framework of the Kondratieff theory. In general, the theory postulates the following events in the course of one cycle:

- a) New industries emerge and they replace the old ones in the limelight. This in itself creates by a lot of chaos to the business life. We see this happening all over in the western world, as labor-intensive industries are moving to developing countries with lower salaries and operating costs.
- b) A new long boom of economic prosperity appears with the rise of the equity markets. Though this means smooth development for some industries, in some other businesses it means disruptions. The development of the Finnish forest-based industry since 1980s has been plagued with major disruptions due to rather dramatic changes in the market place.

- c) New value systems begin to dominate and they start to influence public discussion and planning. Consumers quickly adopt new values. Currently transparency, ethics, and self-control are values that are rapidly gaining ground.
- d) New corporate cultures begin to dominate. Nothing makes a corporation more vulnerable than culture that is not fit to run business in a sustainable way.
- e) New professions and skill standards appear.

Here it is assumed that recent financial crisis marks the end of the 5th Kondratieff cycle and we are entering the 6th wave. The new cycle implies new economic drivers, new social trajectories, and even new professions.

A new cycle implies new drivers, trajectories, and even professions

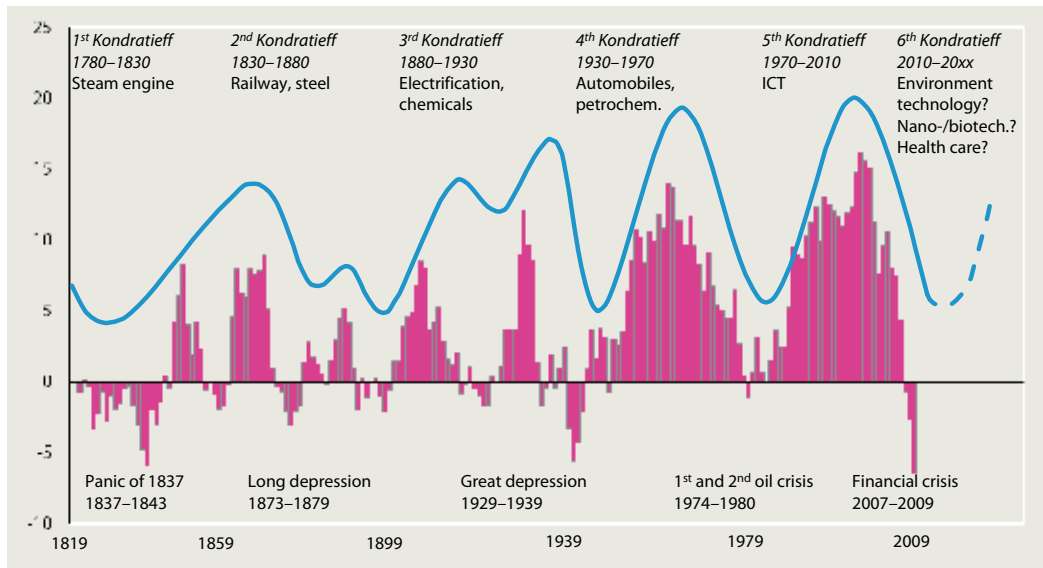
While in the previous cycle the pervasive use of information and communication technologies led to dramatic increases in labor productivity, it can be assumed that this time the drivers will emanate from environmental and bio-based technologies leading to improvements in natural resource and energy use.

As we can observe from Exhibit 6.1, the first Kondratieff wave was dominated by exploitation of *steam power*, which brought about dramatic productivity increases in the dawn of industrialization. The second wave was

Exhibit 6.1

Modern economies fluctuate in a cycle of 40–60 years

Rolling 10-year yields of the Standard & Poors 500 equity index and the Kondratieff's waves



Data source: Datastream, Allianz Global Investors Capital Market Analysis.

dominated by the spread of *railways* and the use of *steel*, both of which were critical for the spread of industrial production and distribution. With the 3rd wave, the world got *electrified* and *chemicals* started to spread across agriculture and to speed the innovation in pharmaceuticals. This wave was brought to an end with the Great Depression of the late 1920s and early 1930s.

With the 4th Kondratieff cycle came *Ford model T* and with that the mass production that fortified the spread of *petrochemicals*. Again we can observe that much of the productivity increase of this period owes to these developments. The long period of cheap oil and steady markets was brought to an end with the oil crisis of the early 1970s. At the same time, some key innovations were brought into light, particularly the microprocessor, which gave an impetus for the 5th wave. The first personal computer was constructed in the shabby garage in California, while the first wireless NMT-based telephone network was built in the Finnish archipelago. And in the years to come, these basic innovations were further developed and spread all over the world – whole new industries mushroomed to fill the demand.

The rise of *Nokia* was of course a hallmark in this information and communication technologies' path to glory. But *Nokia* was a product of its time: it perfectly surfed the 5th wave and was thus able to do its *tour de force* because it helped to increase the productivity of the economic and social system to a much higher level. As with the other drivers in the previous waves, we see again how this particular driver has solved some key problems associated with developments in the earlier waves, while creating new challenges for the forthcoming waves. The global dispersion of supply change and excess production capacity are among those topics that will be inherited from the 5th Kontratieff wave as the next wave begins to take shape. Coupled with some outcomes of the previous Kontratieff waves – entailing widespread use of cars, oil, and petrol – technologies, products, and services in the 6th wave are there again to bring solutions to the challenges created by earlier developments, while simultaneously boosting productivity to a higher level.

It is often the case that a particular driver has solved issues in the earlier wave, while creating new ones for the forthcoming wave

As excessive use of raw materials and energy fuelled the development in the previous waves, coupled with inadequate technology to restrict pollution largely caused by the use of petrochemicals, so it has by itself created agenda for the next, the 6th Kontratieff wave, which might well dominate next 40–60 years of global development. The efficiency increases will be searched from lesser use of materials, particularly the non-renewables,

such as metals and minerals and from less energy-intensive production and lifestyle. This means the quest for increased resource productivity will steer our businesses and our societies and therefore set the tone for new products and services. During the next wave, whole new industries will be emerging, some of which do not have a name today. New professions will rise as well to facilitate development (Exhibit 6.2).

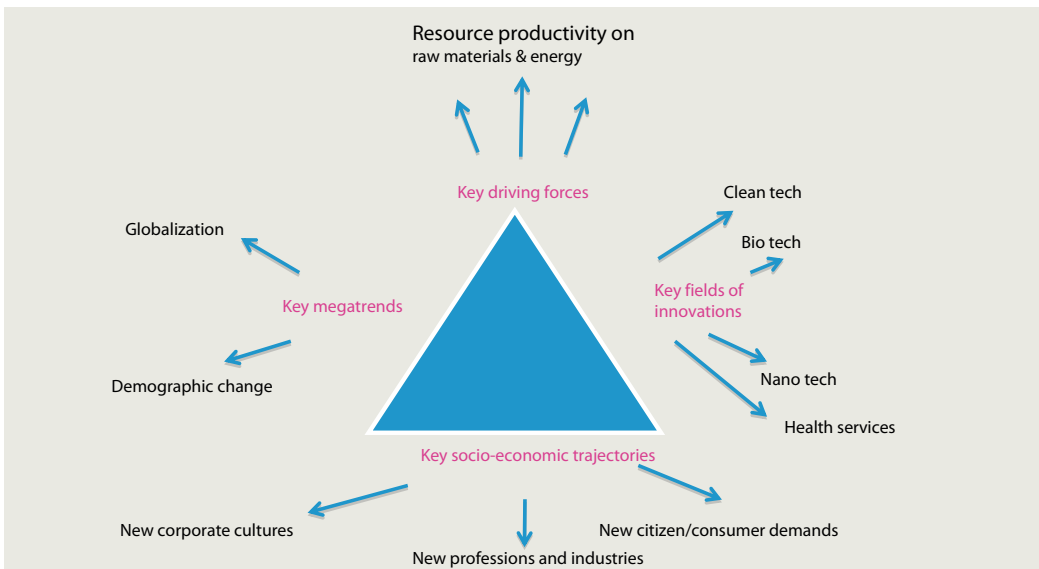
The need for better natural resource productivity is reinforced by politics

The forthcoming age of natural resource productivity and enforced scarcity will be reinforced by the political agenda: climate change; shift from fossil fuels to renewables; the over-use of critical natural resources such as forests, fishing stocks, and water; as well as the safeguarding of biodiversity and many other environmental predicaments will set the pace for national policies and thus to legislation, taxation, and agendas of political parties.

As before, a new political agenda will propel new business. But this time production will be globally distributed right from the beginning. This is exactly the novelty of this wave: the race for who are the trend-setters and benefactors for this new era is taking place on the global basis, for the first time in human history.

The real benefit in using the Kondratieff cycle framework is in anticipating the change to happen. For instance, when investment banks started to show signs of instability in the early months of 2008 (some of them even earlier), it was fundamentally easier to understand the depth of the cri-

Exhibit 6.2
The implications of the 6th wave



sis through the Kondratieff framework, through which one could easily see that this is not a crisis that passes easily. When it is evident that it is in fact a part of a pattern that repeats itself every 40–60 years, it certainly should give us a certain amount of perspective to the event.

The 2008–9 crisis turned out to be a mega-shock to societies worldwide. But at the time, when the avalanche of events followed with the downfall of *Lehman Brothers* investment bank, there were still very few who understood how fundamentally our financial system was flawed. It was corrupted by the prolonged supply of cheap money but also by relentless search for higher returns in investment banking with intolerable incentive structures. The key observation is that mega-shocks are result of human motivation and related incentive systems that set the horizon of expectation.

Mega-shocks are result of human motivation and related incentive systems

Thus, it is the social structures, in terms of mood, expectation, motivation, and intention that define the outcome. As we have seen in the case of the *Arab Spring*, shocks that suddenly shake the existing *status quo* takes place almost inevitably, as the phenomenon has gathered a sufficient amount of momentum. It seems like there are certain triggers that forces the events to become visible. But the tensions started to accumulate a long time ago. The truly explosive component of the historic chain reaction that already has taken its toll in Egypt and in Tunis started with the US invasion of Iraq in 2003. It was at that time when the first Arabic blogs appeared discussing the experiences of the Iraq war. Later particularly Egyptian forums started to discuss the implications of the prevailing suppressive power regimes all across the Arab countries.

The Arab spring could not have materialized without a new media for communication. Internet and mobile phones provided the crucial vehicles for people to join their efforts. Very close to Tahrir square in Cairo, which acted as a center for the protests, situated the spacious apartment of Mr. Ahmed Saidu. Every day during the heydays of revolution, countless messages and other forms of communication were sent via Internet to speed up and fortify protesters ambition to overcome the existing political power block. These efforts eventually led to a rather extreme political event, as a long-term dictator was forced to give up his power.

In the next few decades we are bound to see more Xevents because of a more elevated sense of justice

As we point in Chapter 2, during the next few decades we are bound to see more Xevents. This is because the elevated sense of justice – supported by education and virtual technologies on the one hand, and growing awareness of multitude of global issues with local implications on the other – will provide fu-

el for conflicts all over the world. The 6th Kondratieff wave is all about the tough decisions people and governments have to make in a world of more scarcity.

For Finland, here is an obviously strategic issue at hand: how is Finland able to surf that wave, which will sweep across regions, countries, and businesses in the decades to come? Moreover, how can Finland build its future competencies and industries to meet the demands that are rising out of this new wave?

Up until now, Finland's economic well-being has largely rested on its modern pulp-based chemical forest industry (originating from the 3rd Kontratieff wave) and electronics (the 5th wave). Now the real challenge

How well will businesses and governments anticipate and adapt to Xevents?

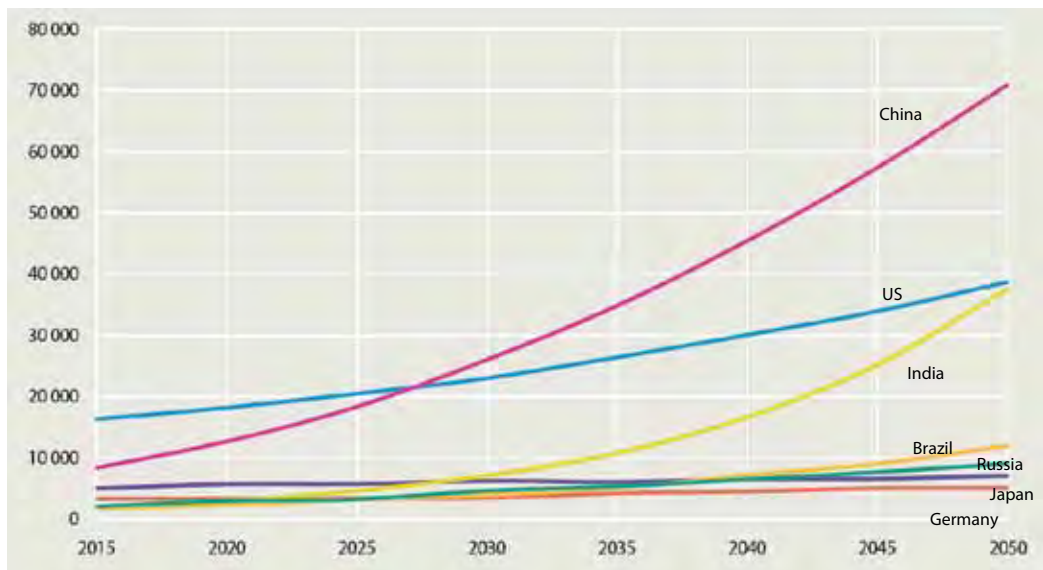
is understand what the key industries for the coming 6th wave are and how can we build Finland's competitive advantage around it. *Why?* Because new wave will bring major changes, some of them may have a long-

term character, while the others might be very sudden and abrupt. As the downswing of *Nokia* shows, those that have been riding the 5th wave, may have enormous difficulties to get on with the 6th one. It is very different to succeed in the boom market of the previous wave than to move to command the markets of the next wave. *It will be increasingly an issue of how well businesses and governments will anticipate and adapt to those changes that will occur with an accelerated pace.*

Exhibit 6.3

Globalization: The massive rise of Asia

GDP forecasts for selected economies, 2015–2050, billions of US\$



Source: Goldman Sachs.

Petrol for the 6th wave

Above we stated that the 6th Kondratieff wave will be about improving *resource productivity*. There are two key factors that are reinforcing this fundamental shift of economic, technological, and social focus. The first has to do with *globalization* of the economies. The second is has to do with *demographic change*.

The raise of the leading developing countries will bring about dramatic change in the global power balance. The Asian countries, led by China and India, will grow massively. If China can maintain its rapid growth, it means that it will provide close to 20% of global GDP by 2020 (Exhibit 6.3). If this business-as-usual growth projection will take place, it means that by 2020 we shall have three equally important economic regions in the world: the USA, China, and Europe. However, this triangle will be shattered by the development after 2020s, where China will assume number one position and may by 2050 be in a situation where it holds an absolute supremacy in economic terms.

By 2050 China may have grown to define a class of its own, being almost twice as big as the United States. What is equally interesting is that by that time the size of the Indian economy may come close to that of the US. This will, of course, increase the power of Asia as a whole and give a new flavor to geopolitics. All this is to say that the global economic sphere may look drastically different by the end of the next Kondratieff wave.

But if even current trends suggest a considerably different world in a few decades, what if something that dramatically affects these trends materialize? Let us dwell on that question for a moment. We know of course that globalization is not only about the economics. As Grewal (2008) has pointed out in his book *Network Power*, the social dynamics of globalization – understood as power inherent in social relations – is turning economic wealth into social power, which will have remarkable effects as cross-border cooperation is increasingly supported by new social technologies.

Even the current trends suggest a considerably different world in a few decades. What if dramatic Xevents affect these trends?

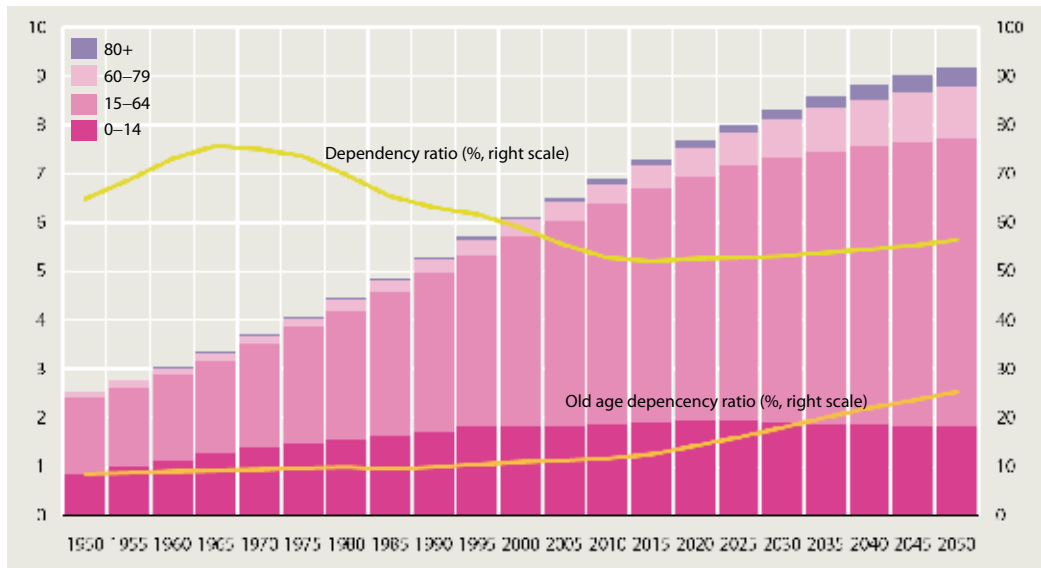
So what happens if – because of increasing network power – China will experience a revolution because of its current leaderships' negligence to political democracy? As we have already seen in the course of 2011, China has become very nervous towards its own dissidents after revolutionary tide emerged in the North African countries. Eventually China will have to face a new era, where the growing middle-class and new generation of educated and networked citizens will claim more political rights,

as they do not want to fall into the old norm of obedient top-down directed mass. This development could take the whole country into a brink of chaos with no easy solutions to re-adjust political structures and decision making. There are of course other options for a disruption induced by a political struggle. Similarly in India there is also a chance that separatist forces could abruptly activate themselves and old disputes about Kashmir could burst into flames.

Demographic change is another key trend for the 6th wave. It will shape our societies more than any other social trend. This is due to two factors. First, population growth continues at least until the latter part of the century, although the growth rate is already declining rapidly. However, the massive increase of population, projected from present 6.9 billion to 9.2 billion by 2050, will bring the capacity to produce food for the global population to its limit. Second, due to declining fertility rates and longevity, our dependency ratios are changing rapidly (Exhibit 6.4). This means that the needs of societies are rapidly changing the demand side. It is one of the key reasons for us to assume that *health industries* will be rapidly growing across industrialized countries to the extent that by 2025 they may collectively be the largest business sector in the world.

Demographic change has a devious and only partially foreseeable impact on the global economy. In the industrialized countries ageing will exacerbate the decline in the human capital base, while increased longevity will

Exhibit 6.4
Demographic change: Population growth, longevity and aging
Development of world population, billions of persons



Sources: UN Department of Economic and Social Affairs, Allianz SE.

place an enormous burden on the mostly public welfare systems. The two most populous countries on earth, China and India, are set to become the global heavyweights in education and employable skills: China within the next decade and India a bit later. As the demographic change penetrates societies, its massive impact will unfold in various ways. Occasionally, this is reflected in a country's performance, as in the case of Japan.

The industrialized world will experience great demographic changes. The baby-boomer generation will be mostly retired by 2020. Consequently, a large age group will cease contributing to the economy, while not being fully substituted by a younger generation. This means that the workforce is shrinking in many developed countries. Consequently, nations are challenged with finding a way to deal with the decline. Simultaneously – because of the rising standard of living – more matured age cohorts are healthier and wealthier. This means not only more medical care but also senior citizens more proactive role in societies.

The events that globalization and demographic change induce are not totally surprising. In some ways they are the boosters that enhance the capacity of the system, but they also bring it to the limits of its performance. This is why increasing amount of extreme events are bound to happen, as we move to the next wave.

Anyone for a mega-change?

What becomes evident from a description above is that the world in the 6th wave will become much more complex than what used to be. Complexity means that there are more alternatives but also more vulnerabilities. Societies are becoming more fragile because of new layers of technology. On the systems side, like that of healthcare or pensions, societies increasingly arrive into situation where there is a chronic systemic shortage, contributing to growing *mismatch* between the capacity and the need. Similarly, on the event side, there is growing *mismatch* between the events, like the financial crisis, and the mechanisms designed to control them. Moreover, this development is further cumulated in the social development, as we see in the case of the furiously sparked Arab Spring, where political practices of dictatorships and nepotism cannot be matched with citizens' (particularly young people's) desire for democracy. There is a potential for human induced mega-changers in the 6th wave for a number of reasons.

Growing social awareness

According to *Freedom House*, which surveys the state of democracy around the world, in the last years there has been a backlash in democratization. There are more attacks against the freedom of press. Simultane-

ously, the practices of suppression have been modified. Countries such as China, Russia, and Iran are using more sophisticated methods of manipulation and oppression, as they try to block their citizens from access to information and communication.

This development is a direct response to citizens' growing awareness of their basic human rights. As Internet creates new forums and channels for self-expression and communication, the growing anger towards the lavish life styles of political elite are nurturing furious acts.

In the Arab Spring, one more factor has a major role to play: the fact that in many of those countries over 50% of the population is under 30 years of age. This is of course the generation to whom Internet and mobile phones are in daily use. At the same time, if the circumstances are miserable and the future looks bleak, as is the case in most of countries run by dictators, they are only driving those young people to raise their voices and seek alternatives such as *Al-Qaida*, where they can find means to express their frustration.

This is a time bomb that is now ticking and will cause numerous upheavals and, indeed, Xevents. It is becoming more and more obvious that there is no way back to the kind of world where the elite could simply suppress the voices of dissident by brutal force. In the sixth wave, the inevitable rise of social awareness will cause increasing pressures and ultimately dramatic changes in the *status quo* of many governing structures.

The lack of global leadership

Currently we live – as respected economists Roubini and Bremmer (2011) have notified – in a *G-0* world, where *nobody* is really taking the lead in global affairs. At least for the time being, the G8 or G20 has no leverage to make critical decisions regarding the global system. This situation is already having consequences, in which there is a rising number of conflicts instead of cooperation. Examples are not hard to find: macro-economic coordination, the architecture of international financial regulation, and climate policy. G20 has dispersed into a state, where self-interest is the main motivation of all involved parties.

As the globe rides the 6th wave in the decades to come, it is the quality of global leadership that becomes the crucial determinant to keep us away from unpleasant surprises (or to deal with them, once they have occurred). As pointed out, the share of extreme events will rise anyhow due to several reasons, some of which are systemic in nature. It is up to each society to prepare for the heightened potential of mega-shocks.

Anticipating the unimaginable

The consequences of *systemic* extreme events are mostly addressed by taking decisive government action and by spending vast amounts of public money. Yet, the public willingness to devote resources for anticipation, planning, and preparation beforehand is negligible.

There nevertheless is a fair amount of public event consideration. The problem is that these activities are scattered and isolated. We call for a more coherent public action in event preparedness and responsiveness.

Finland's challenges with respect to events are different from the challenges of most other countries. Finnish focus should be more on having *adaptive structures* and on exploiting *opportunities* that might arise with events.

Contingency planning should be considered as a part of good governance. We propose that Finland be turned to a model for an *anticipatory society*, which constantly prepares itself for contingencies of various kinds.



Untamable complexity

The 1987–2007 period is often referred to the *Great Moderation*. With Alan Greenspan as the chief oracle, most observers worldwide were led to believe that societal fluctuations have been tamed and that sound policies would curb any unwanted deviation from the desired path.

“Minsky argues that the notion of stability of the economy is itself destabilizing.”

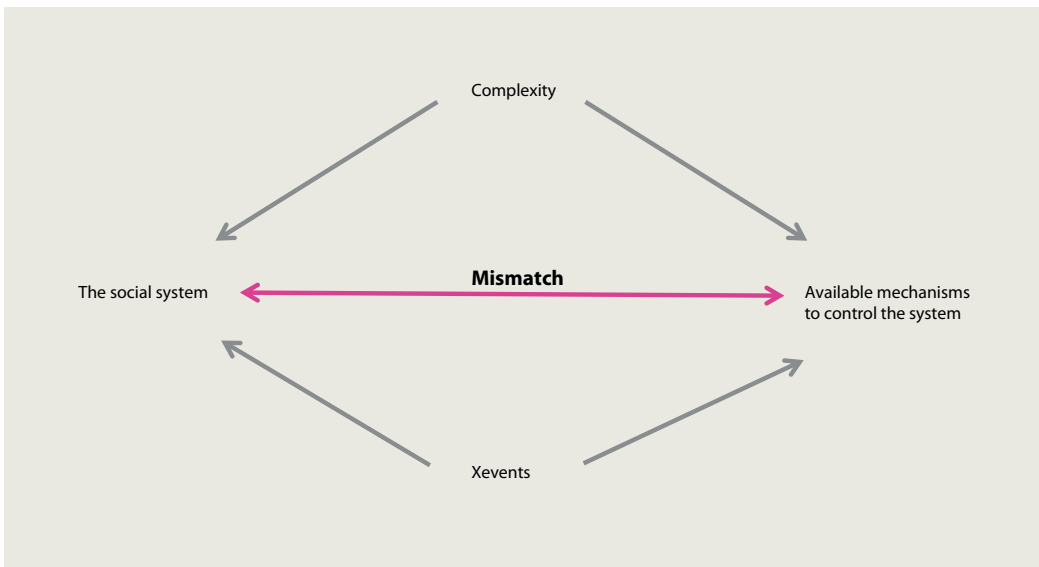
Casti (2010, p. 62)

Now it is acknowledged that the era of moderation was a *fantasy* ... but why? The short answer: increasing **complexity** – well beyond what humankind can possibly master. And even if complexity could be mastered at this point in time, in the foreseeable future it will grow at a rate that humankind cannot keep up with.

Complexity simply has to be accepted and dealt with. On occasion we have some capability to reduce complexity, but mostly the solution is to gauge related uncertainties, to reduce *a priori* exposure, and to build capacity and structures for *ex post* reactions. The challenge is that the ability to understand the system and solve its problems drops with the increase in complexity. In other words, we are increasingly challenged by the very nature of human built systems. Be it financial stability efforts, climate change negotiations, or international trade disputes, we are encountered by the fact that growing complexity causes a *mismatch* between the system and our ability to control it (Exhibit 7.1).

Exhibit 7.1

There is a mismatch between the system’s complexity and its control mechanisms



From forecasting to foresight

We often like to reduce complexity – and uncertainty – by *forecasting*. However, forecasting in the strong sense of the word is simply *not* possible in a complex environment. Any model that pretends to know *exactly* what will happen in the future is doomed to failure. We are simply not able to act as fortune-tellers, even if we would love to do it. This is particularly true if we wish to predict longer-term changes. However, this is not to say we should not investigate what may happen in the future, e.g., to produce different future scenarios.

Thus, instead forecasting, we should talk about *foresight*, which means projecting various scenarios about the future with the understanding that we will never capture the future in all relevant aspects. For instance, while it would be ridiculous to assume any definite description of Finland in 2030, it is certainly worthwhile to build various projections of Finland in 20 years time. What will *really* happen depends on contingencies in the operational environment and on the abilities to face them.

Neither forecasting nor foresight is possible without *errors*. Not accounting for these errors is costly both in terms of direct *harm* and in terms of *missed opportunities* (Makridakis & Taleb, 2009). We should perhaps rather talk about the *anticipation of possible future contingencies*. Inaccuracy is a fact – strategies need to be robust to surprises of various sorts.

Much of current *forecasting/foresight* activity that is supposedly about the future is actually about the *past* – linear extrapolations of historical data do *not* inform us on what lies ahead. Surely a trend may well continue into the future, but the point is to understand what drives it and what might cause disruptions and discontinuities.

“To understand the future to the point of being able to predict it, you need to incorporate elements from this future itself. If you know about the discovery you are about to make in the future, then you have almost made it.”

Taleb (2007, p. 172)

For instance, even if demographic trends, such as longevity, are to some extent predictable, we have not seen any longer predictions that actually capture correctly the longevity trend. This is because longevity development is actually dependent on number of other determinants, e.g., on advances in health care, available gene pool, as well as nutritional and exercise habits.

The above facts call for an explanation and an understanding of possible future dynamics, not for a forecast *per se*. Most trends and even surprises can be anticipated in the sense that conditions exist to recognize their possibility and to gauge their likelihood.

"I try to always be balanced in my assessment – as much as possible – with an objective assessment of risks, of the volatilities, of the upsides, thinking about scenarios and assigning probabilities."

Nouriel Roubini (Scott, 2011)

When anticipating the future, we should not forget the **human** dimension. The humankind influences (e.g., global warming) and often even completely determines (e.g., stock market valuations) future patterns of interest. As for the causes, initial reactions, and ultimate impacts of an event (extreme or not), understanding *animal spirits* and *social moods* – spiced with various degrees of herding and strategic behavior (including attempts to “buy low and sell high”) as well as weaker and stronger networks and inter-links – are crucial.

A call for societal action

Self-interested individuals dedicate considerable resources to insurance and games of chance as well as prepare otherwise for the possibility of *personal* extreme events. They spend virtually no time or resources to consider *systemic* extreme events. And they shouldn't.

If the society is simply an aggregation of its individual members, it too ignores extreme events at the relevant level of aggregation *before* they actually happen. Well, the society should do better.

In Chapter 4 we have argued that *per se* modern societies do *not* promote consideration for extreme events. They rather *nurture* internal extreme events and are quite *exposed* to external ones. *It is quite possible that all members of the society ignore systemic Xevents* If anything, Xevents are likely to become both large in magnitude and more prevalent. Even if they are next to impossible to anticipate and preparing for them is challenging, it would be foolish for any society not to make an attempt.

History suggests that the consequences of *systemic* extreme events are mostly addressed by taking decisive government action and by spending vast amounts of public money. Yet the public willingness to pay for anticipation, planning, and preparation *beforehand* is negligible.

With an Xevent the society is caught off guard in a desperate search for “shovel ready” solutions rather than appropriate ones. One of the main points in preparing for Xevents is to *avoid* emergency measures and to be able to stick to sound long-term policies.

It is the case that most governments – particularly the Finnish one – **are** already doing a fair amount of Xevents consideration and preparation. The problem is that these activities are scattered and isolated. But sys-

temic Xevents do not respect administrative boundaries. They should be more effort to look beyond various domains and consider the national society as a whole from this perspective.

While we call for government action in Xevent preparedness and responsiveness, we acknowledge that such considerations are not easily built into bureaucratic bodies and their decision making. A bit of force might help: perhaps there should be mandatory consideration of probabilistic and fundamental uncertainties in all public planning that concerns the future.

Resilience

For Comfort, Boin, and Demchak (2010, p. 9) “*Resilience is the capacity of a social system (e.g., an organization, city, or society) to proactively adapt to and recover from disturbances that are perceived within the system to fall outside the range of normal and expected disturbances.*” This is certainly in line with its Latin origin *resilio* – ‘to jump back’. This resilience is largely about preventing regime changes as well as about restoring and maintaining the *status quo*.

Latin origin of resilience is resilio – to jump back

Our understanding of resilience is explicitly *symmetric*. For us **resilience** is the capacity to absorb and recover from negative extreme events as well as to nurture and benefit from positive ones. Our interpretation is more about agility and adaptability; we wish to induce a shift to a new regime rather than to prevent it. We also want to consider explicitly three phases: *before*, *during*, and *after* the fact.

For us resilience is the capacity to absorb/recover from negative Xevents and to nurture/benefit from positive ones

Before

In the **before** phase the over-arching goal is to embed the consideration of uncertainties into all planning for the future. There should be an understanding of possible dynamics over a range of scenarios as well as ways to gauge stress signals.

Institutions, infrastructures, and resources for the *during* and *after* phases should be built up. In this context one needs to recognize what are the critical infrastructures. According to the US commission on Critical Infrastructure Protection there are eight: telecommunications, electrical power systems, gas and oil storage and transportation, banking and finance, transportation, water supply systems, emergency services (medical, police, fire, and rescue), and – last but not least – continuity of government. Besides infrastructures, one may want to consider supplies – including food, shelter, bodily integrity, as well as respect of private and public property.

During

The **during** phase is about the immediate first-line of response. It is about preserving systems and values that sustain and support life and business as well as about jumping to any emerging opportunities. Immediate response depends on communication, coordination, and improvisation in a situation where relevant institutions, infrastructures and personnel may not be accessible or operational. While the government often has a central coordinating role, an optimal response

“It is not the strongest of the species that survives, nor the most intelligent, but rather the one most adaptable to change.”

Attributed to Charles Darwin

is invariably a combination of public and private effort.

The very first line of response is often an individual’s entrepreneurial action – s/he needs to be able and willing react as well as be equipped with necessary means and information. What is the ability of a random individual reasonably react to a contingency induced by an Xevent? Does s/he have the means and courage? Is s/he afterwards rewarded for good and held accountable for bad behavior?

After

The **after** phase is about converging to a new equilibrium, where the society’s capabilities and resources are exploited to the fullest. In the after phase a normal competitive, dynamic, and entrepreneurial market economy should in fact serve the society’s interests quite adequately – at least as long as supporting institutions have been adjusted to reflect the new internal and external realities.

Exhibit 7.2

New national skills?

Floating

The unpredictable world requires fast, almost instantaneous adaptation. This is not possible if structures are rigid. One needs a networked structure that is floating on the top of the sea of the global economy. Each member of the network has a different role, and these roles are shifting between fast accelerations and decelerations. If the volatility is as high as the *Game Changers* team anticipates, the role shifting within organizations is not sufficient, we have also to flexibly change the roles between public and private organizations.

Surfing

With rapid market entries/exits and ups/downs, the key to national prosperity is to identify the fast wave of temporal growth at its early stage and then “surf” on it. Simultaneously we have to keep in mind that each of the waves will sooner or later brake, and then we have to be able to release the resources for the next ride. It is essential that those who take the risk of a surfing attempt, will not be punished when the short burst of growth is over.

Before/During/After

Above we have implicitly referred to an one-off Xevent. As the size and complexity of the system increases, the number of both internal and external Xevents it is exposed to increases. Eventually many before/during/after phases are ongoing simultaneously. In order to succeed in such a situation, resilience has to be an in-built feature of the society. Detailed *a priori* planning and rigorous control would not be feasible. Some kind of a loose guerrilla network with co-operative but reasonably self-sufficient cells might be a good societal structure.

Resilience trade-offs

At the societal level resilience refers to collective action. It needs to be motivated and attended to at the societal level. Resilience does not come about costlessly and effortlessly. It involves difficult trade-offs, which are obvious when employing our symmetric interpretation. Resilience should not come at the cost of accountability, flexibility, and oversight; it should not hinder responsiveness or hold back the society from reaching “its full potential” in normal times.

What to do? The obvious

A network without any redundancy breaks down immediately with a hiccup in one of its nodes – the chain is truly as strong as its weakest link. There are several obvious things to do to avoid a break down.

One can choose not to depend on a network. Internal local provision naturally offers shelter from external shocks, while it also necessitates consideration of internal ones. Mammoth organizations are often quite inefficient and – if they have a hierarchical nature – also vulnerable for any disruptions. If and when reliance on external partners is desired or necessary, one can consider having a number of *unrelated* networks for the same purpose. Since its logistical nightmares in the 1990s, for instance *Nokia* has implemented “second sourcing” for core inputs among its corporate policies. Also in the case of networks, agility, diversity, and flexibility promote resilience.

“It is very important now to think the extreme; you have to have buffers.”

*Hans-Paul Bürkner, Boston Consulting Group
(Economist, 2 April 2011)*

There are several forms of *insurance* one may want to consider. For a fee a formal insurance contract can cover losses in case of an event – provided that the contract is enforceable and the counterparty is alive and liquid after the event (strong conditions as far as Xevents are concerned, not least because of often extensive *force-majeure* clauses).

But “insurance” may take other forms. General, multi-purpose, and interchangeable infrastructures, resources, and expertise serve as insurance – they can be deployed elsewhere if necessary and in any case they should

“Mother Nature is the best risk manager of all. That’s partly because she loves redundancy. Evolution has given us spare parts – we have two lungs and two kidneys, for instance – that allow us to survive.”

Taleb, Goldstein, and Spitznagel (2009)

have higher liquidation values and better alternative uses. Spare capacity and stockholding can also serve as insurance.

As for economic crises, their roots are often in leveraging returns with excessive debt (in particular when denominated in foreign currency). Interesting enough, most governments – including the Finnish one – subsidize leverage, e.g., by making mortgage interests tax deductible. Not carrying debt, being self-sufficient, and “saving for the rainy day” (preferably in gold bullion under one’s direct physical control) also serves as insurance.

As far as Xevents are concerned, alertness for stress signals and being “quick on the feet” can hardly be overemphasized.

What to do? The not so obvious

Especially for a well-managed small-open economy – such as Finland – most systemic Xevents have their roots abroad. The world undeniably needs new *multilateralism* in many domains, especially when it comes to Xevents. The failed attempt to curb global warming is an example of a colossal failure in this respect. However, the immediate aftermath of the 2008–9 may be considered a sign of hope – while explicit cross-national coordination was perhaps somewhat weak, major economies of the world did act quite decisively, rapidly, and in concert. With these efforts, a complete melt down of the global financial system was avoided (for now, at least – the underlying issues remain and have perhaps even been aggravated). It seems redundant to say that in today’s world no national policy is made in isolation from other domestic or foreign policies, but this simple truth is all too often forgotten.

Since systemic Xevents often involve a jump in public spending, *countercyclical policies* offer advantages. The difficulty is that they require considerable self-discipline. By definition these policies include cutting spending and saving in normal times – in the absence of an immediate treat or opportunity –, which is more easily said than done under prevailing political realities. On this note – and also more generally – *automatic stabilizers* and *force-majeure* exceptions in public spending ought to be considered.

We have touched upon (public) infrastructures and institutions above. It is often forgotten that the labor market is a crucial parameter influencing the ultimate impact of an extreme event. Upon considering the cost of climate policies, Guivarch et al. (2011) find that when “*labour market rigidities are accounted for, mitigation costs increase dramatically*”. Labor market policies should *not* protect existing jobs and job descriptions but rather *individuals* – there is indeed a great deal to be learned from the Danish-style flexicurity.

In the course of the *Game Changers* project we have run several Xevent exercises. The greatest difficult we faced was to challenge our mental frames – thoughts that do not easily fit to what’s already in our heads tend to get ignored. One solution to the problem is to run a number of parallel processes that consciously contradict.

Finland and the build-up of an anticipatory society

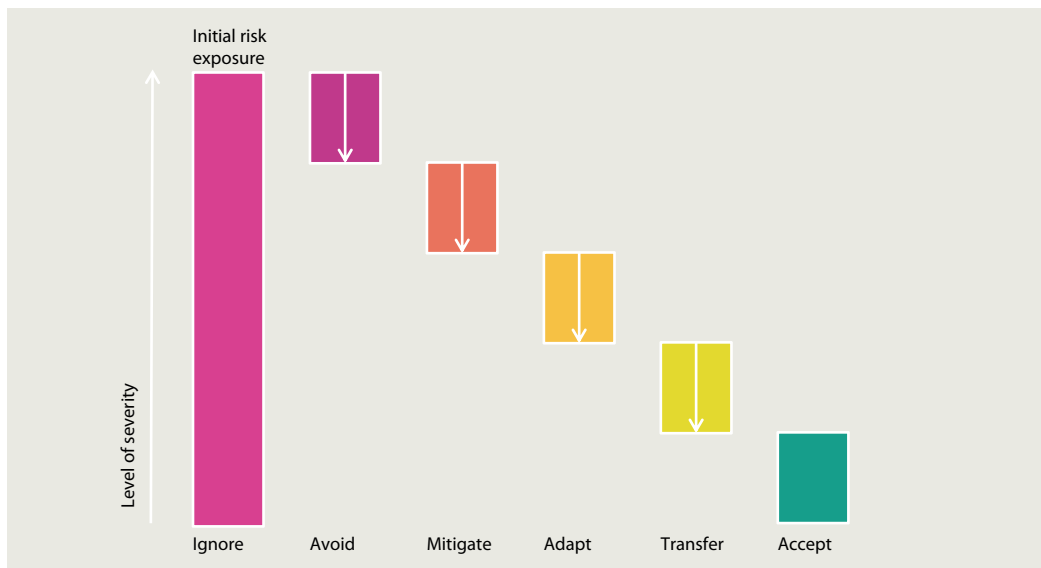
There is a limit to how much the society should invest in *active* defenses/offenses with respect to Xevents. The emphasis is perhaps more on “in-formational procedures”: the society needs a broad-based holistic view of Xevent anticipation and preparation.

Extreme events test individuals’ and organizations’ abilities for knowledge capture, validation, creation, and deployment. While these abilities

Exhibit 7.3

Preparation reduces exposure to adverse effects of Xevents

Generic risk response strategies



Source: WEF (2011, p. 48).

may well be more than satisfactory in normal times, they need special attention to be adequate as far as Xevents are concerned. Completely Xevent-free society is infeasible, but some protection is (nearly) cost-free and/or comes as a by-product. Contingency planning should be considered as a part of good governance. Meaningful Xevent preparedness and responsiveness is difficult but possible to achieve. The reward is a considerable reduction in risk exposure (Exhibit 7.3).

A society's ability to react on an Xevent crucially depends on its institutions and infrastructures as well as on the coordination and cooperation among its members. In these respects Finland compares favorably to virtually all other countries in the world.

Finland is nevertheless more exposed to Xevents than many other countries. The country's industrial structure is lopsided, still quite heavily focused on highly cyclical investment goods, and dominated by large companies. Finland is open and deeply engaged in global networks. The domestic market is not only small but sometimes also underdeveloped. While static efficiency is high, societal structures are quite rigid – for instance, persistent long-term unemployed suggest that dynamic efficiency leaves something to be desired.

Finland's challenges with respect to Xevents are different from the challenges of most other countries in the world. Relative to the other countries, Finland's focus should be more on having *adaptive structures* and on exploitation of *opportunities* that might arise with Xevents.

What we propose is to make Finland a model for an *anticipatory society*, i.e., a society that constantly prepares itself for contingencies of various kinds. There are several ways to build such a capacity. First, there should

Finland could be a model for an anticipatory society, that constantly prepares itself for contingencies of various kinds

be a continuous exercise involving experts from various fields and sectors (public administration, politics, business, non-governmental organizations, academia/research), where Xevent scenarios are considered. Second, Finland should re-think its current economic strategies in the light of nurturing more resilience. Third, and perhaps most importantly, Finland should educate its citizens to prepare for future contingencies.

Louis Pasteur said that "Chance favors only the prepared mind." We whole-heartedly agree. And we encourage preparing sooner rather than later.

The Game Changers project

Summary of the project results

Edited by John Casti and Leena Ilmola

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Appendix

1. Executive summary of conclusions

Leena Ilmola, John Casti

Decisions have to be made every day even if we cannot provide decision-makers with information that might decrease uncertainties. The sustainable way to solve this problem is to apply *planning tools designed for uncertainty*. We have found some *principles that increase resilience* of the systems, both in corporate and public sector operations.

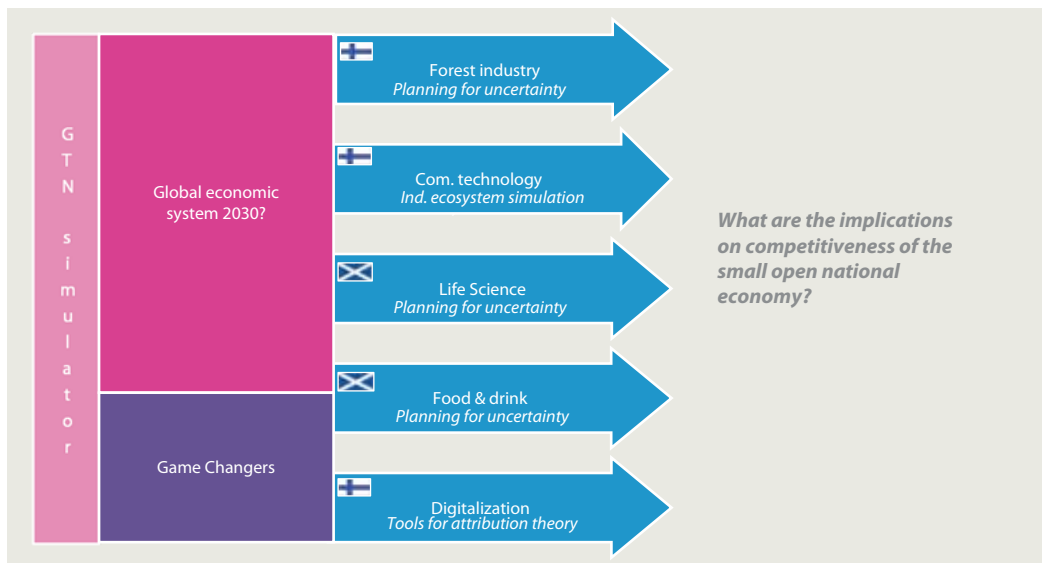
Resilience – immediate adaptation

We have divided our attack on questions arising in an uncertain environment into two challenges; how to understand both adaptation and growth. The reaction to emerging changes appears to be so fast that it requires equally quick reactions, almost “automatic” systems. There is no time for analysis and traditional decision making.

The results of the Game Changers project indicate that one of the major keys to development of resilient systems lies in structure. When we cannot predict the future and we do not have resources to manipulate it, we have to be prepared for surprises. The resilient portfolio consists of diverse businesses or sectors that are not sensitive to the same game changers.

Exhibit A.1

The Game Changers Project – Overview



When an external shock will destroy one of the sectors, it simultaneously generates opportunities for some of the other industries/businesses in that sector. A resilient ecosystem consists of large and small companies (a network of small companies is the most resilient structure). The low value-added companies are essential to the structure because they balance the ecosystem as whole.

Volatility is increasing nowadays. The periods of fast growth are followed by sudden deep recessions. Different phases require different actions. Corporations should have two different strategies, one for the growth, another for the recession during which industries are restructured. The requirement for the public sector is even more difficult. If the national economy consists of networks of small and medium size companies, it is essential that some part of the management of the cyclical global environment is a public responsibility. Both the regulation and the guiding principles of the public sector should be different in different phases of the economic cycle. When production requires resources we should be able to import labor and university students, and retired people should be able to work without losing their pension benefits. When production resources are released in recession markets, there should be multiple ways to fund the development investments. For example, additional adult education or different kinds of experiments are impossible when all the resources are needed for production.

During the boom, the private sector is willing to pay for services. So the public sector should use this opportunity (why not to sell the knowledge that is needed in the fast growing markets?). We should also have a system in which the private companies struggling with the recession are able to develop tools for the next growth period through public support.

Resiliency involves new challenges, along with a knowledge base. The most primitive way top management tries to adapt to the reduced size of their market is by adjusting their resources through layoffs or dismissals. Corporations ought to focus on multi-skill, multi-role staff, people who are able to shift from one task to another without any additional investments in training.

The minimum requirement for the today's decision making is to give at least some minimal consideration to the choices we are making today. Would investment in a huge production unit, which may be reasonable in the growth market, also be reasonable if we had a 100% recycling requirements and the price of transportation was tenfold? Or is it wise to collect all the businesses under one brand, when a failure within one area destroys the value of the brand for all the corporations.

Timing seems to be of the essence; when should we give up supporting the traditional industrial structure and shift our attention to the new ecosystems? Transition will not be easy. But from the game changers' perspective, earlier is always better than later.

Using a metaphor of the "ocean" of the global economic system, automatic adaptation represents floating capabilities, but it is not ambitious enough to survive...

Resilience – agility for growth

The Game Changers project found that many drivers lead to a situation in which the western economies are losing their foothold and their relative position will be weaker. But there are players, companies and countries that are able to counteract this trend. Finland and Scotland seem to be two of those. But this requires intelligent tools, as well as good timing.

Let us turn back to the metaphor of an ocean. Growth is possible if we are able to surf on the periodic waves of growth. The prerequisite for seizing the quickly appearing – and suddenly disappearing – growth options of the global market place is good timing. Those that are able either to enact the growth phenomena or detect it at very early phase is going to have an opportunity for premium pricing. We claim that this capability is essential to the national economy, and that the Finnish Statistical Centre should be re-named The Finnish Scanning Centre.

The Game Changers results show that those ecosystems that consist of small companies and that cooperate within areas where innovation requirements are very high seem to be able to generate both growth and still maintain their resilience. This suggests that the public sector should favor industries in which the bankruptcy rate is 20%! This requires that government create a regulatory environment that is beneficial for small companies (the safest domain for open- source contracting). The public sector should also invest in a platform that provides SMEs with the same access to the supercomputing, virtual production or risk funding, that the strong players have.

Analysis of the trade structure shows that in order to grow, we should increase exclusivity of our products and services, along with diversity of the export structure. When we take the resource and speed constraints into consideration, this means that we need to be fast in generating unique combinations of existing products with novel technologies or solutions. A prerequisite for this is the right kind of educational system; we need to invest in basic education so that our competence base is wide enough. The Life Sciences study showed us that we have to establish a new system for hybrid knowledge, unique combinations of knowledge that are hard to copy.

Every surfing expedition ends in a crash. The growth trends of the future have a strong temporal nature. When we identify a growth trend we must already be preparing for its end. The best portfolio for a corporation is a combination of smallish “wave-like” businesses and scalable mega businesses. This will be a challenge for corporate leadership. The same phenomena generate tension in the national economy. If our economies consist of resilient networks of SMEs, this means many business failures. We need to establish an insurance that will compensate the risk, reallocate the released resources, and again speed up integration of the experienced entrepreneur and his ideas into the ecosystem.

Tools for planning for uncertainty

The primary objective of the Xevents initiative in IIASA is to develop tools and methodology for understanding and dealing with uncertainty, especially extreme-event uncertainty, i.e., “unknown unknowns”. The Game Changers project provided opportunities for experimenting and piloting a number of such tools. The tools are presented in the Chapter 11 of this report.

The first fact to note is that we have to accept our limitations. We are used to trend based planning. Now we must accept uncertainty. But this does not mean we cannot anticipate the future. BUT at all times we have to remind ourselves that the future will not evolve according to our script.

How instead of what. The Game Changers project started with scenario planning (a description of the process is found in Chapter 3). The Game Changers scenarios describe what is typical for the behavior of the global economic system. Some of the drivers were rather controversial by their nature. Yet, they are the drivers of many similar behaviors in different scenarios. The new element in the futures outlined in the scenarios is the dynamics of the environment.

There are four ways to go beyond trends and megatrends.

1. Invite diverse outside experts to the process. Web-based methods make it easy to increase the diversity of participants.
2. Challenge the basic assumptions of existing strategies with game changers (*What if the price of energy is only 1/10 of the current price? What if western economies fall into a 15-year stagnation?*).
3. Use a systematic process to study uncertainties.
4. Target to concrete actions, instead of abstract elaborations.

One of the keys to success in the world of uncertainties is early detection of signs of change; i.e., efficient scanning. This is the challenge that looks to be unsolved right now, so it offers a huge potential for differentiation.

2. Game Changers

Leena Ilmola, John Casti

Background

The goal of this initiative is to identify drivers having a major impact on the transformation of the global economic environment. These “game changers” serve as external shocks that will be used to analyze the resilience/rigidity of the different activities within the Game Changers project. By a *game changer* we mean a driver that has a very low likelihood of taking place but has a high potential impact on the global economic system. By *economic system*, we mean the subsystem of the overall human system that includes not only economic activity, but also the financial and technology systems, as well. Here the human system consists of the economic system, along with political, social, military, and all other systems and values the global society.

Research question

What are the game changers that may trigger a major transformation in the global economic system 2030?

Research methods

The questions to be addressed start with identification of the game changers. By definition, these are events/trends that are complete surprises, which mean there is no statistical database to draw upon for estimating the likelihood of their occurrence. Consequently, our methodology had to follow a non-mathematical course.

The theoretical framework used in this study has been social constructionist (Berger-Luckmann 1968, Luhman 1999) and cognitive processing theories (Hodgkinson 1999). Our perception of reality is based on the institutionalized concepts that emerge from social interaction. These concepts are not explicit, but form a set of basic assumptions that guide our thinking and actions. In this study, the objective was to identify the existing basic assumptions and then to try and present alternative ways of perceiving the events and the logic that leads to them.

Data and analysis

The material we analyzed came from two sources: the basic assumptions governing the global economic system were studied by analyzing the economics literature (materials from the

Economist and *Business Week* magazines, *Financial Times* and several books that examined both the 1991 recession in Scandinavia and early comments on the 2008 financial crash). The second source of potential game changers was a list of drivers of the change in the global economic system produced at an April 2010 expert workshop at IIASA. The list of basic assumptions driving game changers consisted of those drivers that appear to have a major impact on the structure of the economic system.

Results

Game Changers have been divided into three groups; low likelihood–high impact drivers that are *exogenous* to the human system, *endogenous* drivers that emerge from the overall human system, and finally those that emerge within the economic system itself.

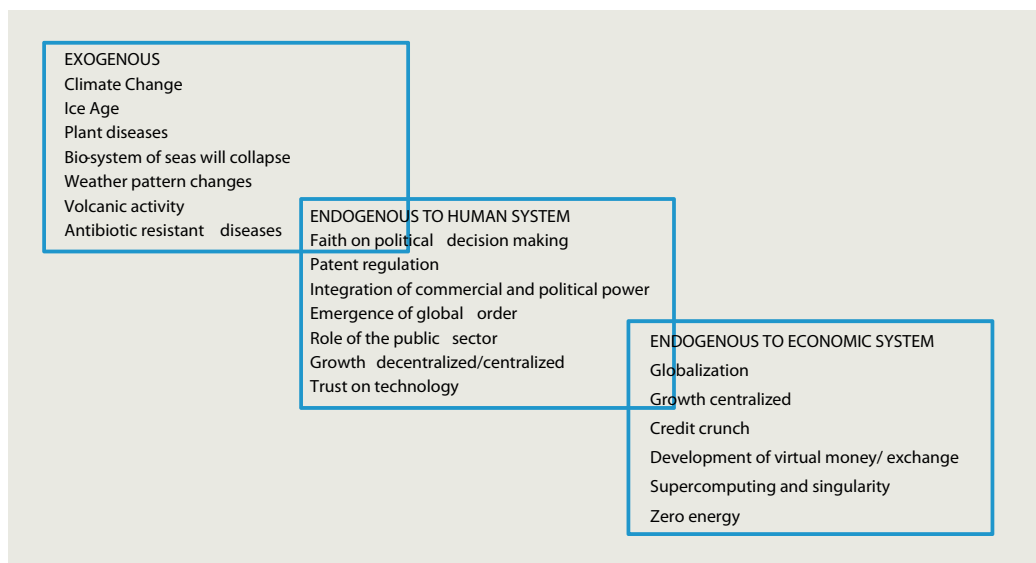
Implications

Analysis of the game changers and their impact on the Finnish national economy, especially on our case study fields – global forest industry, communications technology ecosystem, food and drink, life science and digitalization – show that some of the sectors are very sensitive to the game changers. Sensitivity to game changers increases if the sector is highly centralized (a few large companies), the GVA is high (such as Scottish whisky) and the competitive advantage is dependent on growth of the global market. Resilient sectors are those that consist of a network of small companies having also low value-added production.

Exhibit A.2

The categorization of game changers

They are either exogenous, endogenous to the human system and/or endogenous to the economic system



Technology driven fields, such as life science and communications technology, are benefiting from most of the external shocks arising from the game changers. The more turbulent the operating environment, the higher the demand is for life science and communications technology (digitalization) solutions. The only game changer that may harm technology-intensive fields is total failure of technology.

3. Global Economic System 2030 – scenarios

Leena Ilmola

Background

At the end of 2009, when the substance of the collaboration with IIASA's X Events project and the group of Finnish organizations was discussed, it seemed that the global economic system was in a period of major change. The participants in the discussion chose the global economic system to be the focus of the study. The challenge for the project (named later the Game Changers project) was to look for alternative, non-obvious futures driven by low likelihood-high impact drivers.

Research question

What are the possibilities for unlikely, but plausible behaviors of the global economic system in 2030?

Research methods used

The research method employed was the qualitative scenario procedure. Initially, we applied five different methods and processed the outcomes using traditional thematic scenario building. The nature of the research question led us to recognition of the impact of cognitive constraints. Our solution here was to apply network analysis and instead of focusing on what happens to shift the emphasis to description of the potential structures that the global economic system might assume. These structures define the typical behavior to be expected from the system.

Data and analysis

At the April 2010 workshop, a group of 24 experts produced a list of 96 potential drivers of change. These drivers were clustered together using the PESTE (political, economic, social, technology, environment) classification. The GC team analyzed clusters and in a deductive group process identified 8 leading themes. The group responsible for qualitative scenarios then produced two alternative structures (by applying network theory) for the outcome of the themes. This phase of the analysis revealed that totally different structures may produce similar behavior; the outcome of the study was to identify three distinctively different behavior patterns for the global economic system by 2030 (Please see Exhibit A.3)

Three different economic systems in 2030

Stable & turbulent

Stable and turbulent behavior is driven by a hierarchical structure. The economy is relatively stable as long as the prevailing power structure is strong. Until the shock of power structure collapses causes huge turbulence, in which there are no rules at all and the most aggressive actors are dealing the wealth among themselves, the system continues to function well. *Example: The rise and fall of the Soviet Union.* The long stable periods are favorable for investment-intensive technology development and large-scale production, but both nations and corporations have to be prepared for the era of turbulence and maintain their asset flexibility and ability to react quickly to changing circumstances.

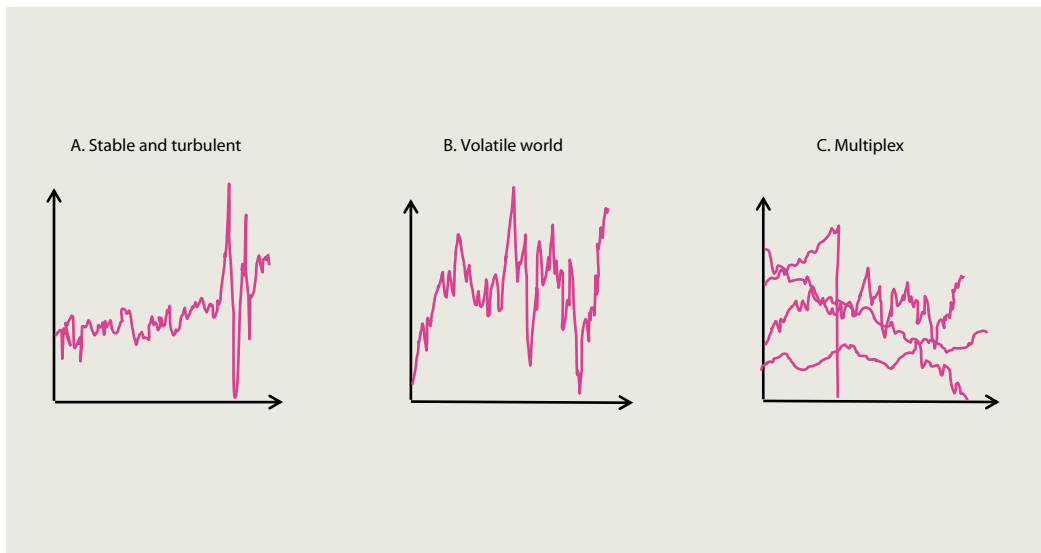
This future is possible if:

Most of the game changers driving an economy are those consistent with a hierarchical structure, in which the decision-making power and wealth is accumulating at the top level of the hierarchy. Drivers supporting hierarchical structure are strong patent regulation and a strong role of the public sector. We have two alternative options:

1. *New World Order*, where global organizations (UN, GTO, ISO) have considerable power and both the rules and the resource allocation take place at a global level. The prerequisite for the emerging of the New World Order is a fast climate change causing severe shortages of food and water. If the market driven financial system collapses at the same time, increasing collaboration among countries will also follow.
2. *World of blocs*, in which there are a few competing blocs that are defined by intertwined political and commercial power. These blocs develop their own rules and technologies, as well as allocate resources within the bloc. The prerequisites for the formation of authoritarian blocs are integration of political and commercial power, a clash of cultures and a relative weakening of the western economy and value system.

Exhibit A.3

Three alternate behavioral patterns of the global economic system in 2030



Volatile world

Another option for the global economic system is an unpredictable and very volatile structure. In this world, we will have relatively short, rapid periods of growth where all available resources are used for production. But these do not last very long; small changes in external or internal conditions (such as beliefs on the part of speculators) may cause a major shift in the behavior of countries and thus also in the global trade flows. The recession that follows is as steep and rapid as the growth was fast. *Example: commodity futures market.*

If the global economic system is volatile it requires flexible resourcing. In order to benefit during periods of growth, we have to be able to multiply the resources involved with different kinds of production and have a capability for distributing the economic outputs worldwide. During recessionary periods production resources are freed up for another kind of use; development, maintenance and restructuring. Those who have resources will restructure the markets and acquire the best skills.

This future is possible if:

Development of a world with multiple power centers is possible if the global economy has a long period of growth, one that facilitates technology development. Super computers are the backbone of this new knowledge economy. Such a globalized world is market driven, with the relative power of political decision-makers smaller than in the world of 2011. Drivers supporting a dispersed structure are reliance on open-source development, resource scarcity (that enables increasing speculation) and loss of religious and political ideologies. We have two very different options:

1. *Globalized world* of multiple power centers, in which resources are flowing free within the network. The majority of production is virtual, and there are no shared rules (no overall legislation) but some shared procedures are emerging.
2. *Broken world* is the outcome of failure in climate change mitigation. Increased resource scarcity forces nations to optimize their own growth/survival. Global division of roles is impossible, which leads to collaboration with neighbors as the political system loses its power.

Multiplex

There is not only one dominating structure within this global system, but the economy consists of several subsystems, domains with different structures and different behavioral patterns. In addition to the domains of volatility, stable and turbulent, there are virtual spaces showing highly discontinuous behavior, old markets with steady but declining volumes, and all possible options in between. This world is systemic and full of surprises. A disruption in one of the domains will cascade throughout the system, but we do not understand this complexity well enough to predict its consequences. *Example: Difficult to find...*

The global winners in this market are those that have the skill to operate in all of the different domains. The most sustainable economies/corporations build portfolios consisting of diverse sectors/businesses having different features. If an external shock harms one of the businesses, it may be beneficial to others.

This world is possible if:

The development of the global economy is asymmetric. Either global cartels of companies or national protectionist policies or ideological reasons create isolated domains able to build and maintain their individual structure.

4. Global Trade Network Simulator

Ugur Bilge

This module of the Game Changers Project focuses on the simulation of global trade network with a special emphasis on Finland's trade in the global network. GTNS mainly focuses on understanding and generating insights about changing trade patterns between countries, (imports and exports) and their impact on GDP growth rates.

GDP growth rate is probably the most important measure used in determining and comparing the welfare of nations, and trade is an important part of this measure.

GDP = Exports – Imports + Consumption + Investment + Government Spending

It is not a surprise that in the first Game Changing Project meeting, GDP growth rate appeared in several sessions as a major concern for game changers in the future success or failure of the economy.

Research question

The network nature of the global trade makes it difficult to model with conventional tools, particularly since we saw several times in recent history globalization has made crises more contagious. This is why we decided to develop the Global Trade Network Simulator with Agent Based Simulation philosophy as the most suitable technology. Our objective was to enable policy makers to run what-if scenarios into the next 20 or 30 years of Finland's trade with its major trading partners, explore the impact of changes in global economy and trade patterns on the Finnish GDP growth.

Research methods used

Agent Based Simulation is a bottom-up modelling technique involving a number of autonomous agents each equipped with their own data and connections, following a number of simple rules. This setup can lead to 'emergent patterns'. Visualisations and statistical analyses of the emergent behaviour provide insights into the problem. Although simulation results cannot be used to forecast the future, they can be used to find boundaries of confidence in forecasts when certain event combinations occur.

The network sometimes causing unexpected results. GTNS can run randomly generated combinations of GDP shocks and presents results of these probable events; it can run ABM scenarios where country agents adopt simple strategies for increasing exports to some countries while reducing trade with others and it can also run a combination of what-if and ABM rules.

Data and analysis

We used public domain data sources from the web such as World Bank, IMF, OECD, and CIA World Fact Book archive, as well as Finnish data on Finland's sector based exports. GTNS provides several network analysis measures such as identification of cliques, most significant countries and trade links.

By far the most useful feature of the simulator is the what-if scenario analysis driven by user defined narrative scenarios, resulting in an analysis of results on Finland's sector exports.

Results

GTNS is an interactive tool, driven by scenarios about the possible future changes in global trade patterns, such as trade wars, changes in GDP growth involving one or more country in the simulation. To give an example of the GTNS use, the following steps take place:

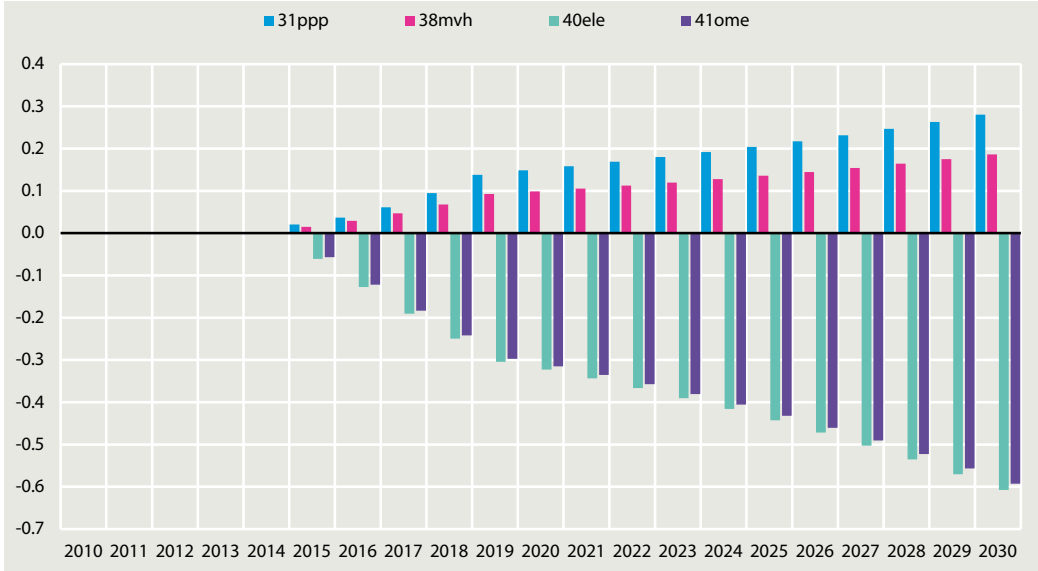
1. Expert/analyst defines a narrative what if scenario, e.g.,
Between 2015 and 2020 China's trade with the rest of the world goes down by 10% a year. During this period Germany increases its imports from the Euro zone by 2% a year and increases exports to USA, Japan and UK by 2% a year.
2. Narrative scenario is translated to the language of the simulator:

2015	5	CHI	IMPORT	-10	World
2015	5	CHI	EXPORT	-10	World
2015	5	GER	IMPORT	2	Euro
2015	5	GER	EXPORT	2	USA
2015	5	GER	EXPORT	2	UK
2015	5	GER	EXPORT	2	JAP
3. GTNS runs the what-if scenario, and calculates Imports, Exports, GDP growth rates (as a result of changes in trade) for all countries in the simulation. The network and agent based nature of the simulator enables it to spread crises or increases in trade via the trade links. For Finland the sector exports are also calculated, and all results are shown as differences from the baseline scenario which assumes Finland will grow with an average 1.69% with a continued export and import growth (average of the past 8 years).
4. Interpretation of the results is facilitated by the graphics user interface which displays and highlights results as differences from the baseline. (Please see Exhibit A.4).
This scenario has a number of unexpected consequences for Finland. In summary Finland's growth is affected very little but some sectors do well, others do badly.
Positive Sectors: paper products (31ppp), motor vehicles and parts (38mvh).
Negative Sectors: electronic equipment (40ele), machinery and equipment NEC (41ome).

Exhibit A.4

China–Germany Scenario

Export Performance of Finnish Sectors between 2010–2030, difference from baseline (bn USD)



5. Global forest industry - printing papers

Olli Lehtonen

Background

An event or change in the circumstances of one country can spread many other countries and create massive turbulence, spinning the whole system toward completely unforeseen outcomes (Kotler & Caslione 2009). This change in the operational environment rises the strong need for predict future in order to reduce, or ideally eliminate, its inherent uncertainty (Makridakis & Taleb 2009). Instead of companies seeking to maximize their returns in the face of high uncertainty, they might instead make decisions that minimize risk so that if the worst happens, the companies will still survive (Kotler & Caslione 2009).

The need to innovate and redefine business models is especially urgent in the mature printing paper industry, with its constant mill closures and persistent profitability problems. This study concentrates on investigating how printing paper industry can get sustained competitive advantage. Uncertainty in environment makes sustained competitive advantage valuable, and the question is that how to create resilient sustained competitive advantage, and moreover which kinds of resiliency are essential for gaining sustained competitive advantage to printing paper industry.

Model to resilient competitive advantage

Printing paper companies are forced to adapt to new environmental situation and transform their strategic orientation in order to sustain the competitive advantage and to gain better profitability. Our approach to build sustained competitive advantage is related to the fact that coping with the increased uncertainty by developing more accurate forecasts of the future is a tedious and problematic path at best (Raynor, 2007), which emphasize the need to build advantage on resilient factors.

The need for sustained competitive advantage is obvious in the complex and turbulent operating environment of the printing paper industry. "Sticking to a single strategy often turns out to be problematic when competitive environment change" (Lau 1996, 12). To overcome this vulnerability, we have used scenario planning method called "*space of uncertainty*" to correspond how resilient sustained competitive advantage can be built in turbulent environment. The space of uncertainty has 5 steps as shown in Figure 1: 1) scanning uncertainties, 2) create scenarios for each of the uncertainties, 3) generate actions that create success in scenarios, 4) evaluate each action on each uncertainty, and 5) run robust portfolio analysis.

The outcome of the model is resilient sustained competitive advantage which is based on actions that are valid in different environments and ensure the capability to operate in many different uncertainties. These actions are the core of the industry strategy.

Data

The data for the model is based on 50 expert's views. The key uncertainties were analyzed with Delphi method where participants constituted "cross-disciplined" the group of forest industry stakeholders and experts. Data collection was made with 4 web-questionnaires.

Results: key actions creating the resilient sustained competitive advantage

Next we will shortly present the most resilient actions in these environments which are the results from the "space of uncertainty".

Differentiation from bulk production and specialization in less price sensitive segments is often used to decline competitiveness and improve profitability. According to our results this action would also give the highest resilience for printing paper production. At the moment printing paper industry is integrating into the *biorefining*. This action seems to be valid also in terms of resilience because it enables production of new high value-added products. Small production units close to the *deinked pulp* and large markets and organizing of a *recycled paper collection* and a *sorting company* for the company's own use would increase the resilience of the printing paper production. Being there where the markets and raw-materials are is an essential prerequisite to survive in the turbulent world. Results show that the most resilient lines of production are related to the *erasable printing paper technology* and integrating the paper company into the digital age by changing focus on *printable high-tech products* such as printable electronic components (such as integrated circuits) and solar panels.

Conclusions

The uncertainty of the future can be a threat to some firms but it also provides opportunity for those firms that have the higher degrees of resilience in turbulent environment. A central prerequisite for success in dynamic fast-changing environment is going to be the ability to build adaptive capacity with resilient strategies. For printing paper production, this will currently mean investments to the biorefining and recycled paper production in the metropolis. Thus, we can argue that the resilience is related to the resource-oriented advantage. Our methodological approach, "space of uncertainty", seems to be a valuable tool in strategic planning. The understanding about "space of uncertainty" allows to select the least vulnerable option of adaptability along with the company can build resilience based on operational, strategic and structural sustainability. Thereby, the paper industry can prepare itself for the future.

Comments by Markku Tykkyläinen

Taking into account financial and temporal resources, the applied methods gave good results which can be assessed as well as they can be received from the future development which is based on human choices and decisions which are not very predictable. The most valuable part of the results, and the novel part of the model, is the filtering of the most resilient business strategy from the set of proposed measures. The method itself could be strengthened by increasing the quality of data provided for selecting the most resilient business strategies. Now there is a risk that data provide relatively conventional starting points for screening. The method is feasible and represents a business assessment model for assisting to select an appropriate long-term business and investment strategy. It would be useful to assess the results of this exercise after a certain period of time.

6. Innovation strategies and ICT ecosystem

Peter Klimek

Background

A country's economic performance is deeply related to the types of products it exports. The national economy can be thought of as a collection of firms accumulating wealth by upgrading the products they produce and export. Each of these products requires a certain set of inputs and productive factors (e.g. physical and human capital, labor, skills, infrastructure ...). If a national economy is efficient in producing a certain type of product (as measured e.g. by a high RCA in this product category), the required inputs are available. Consider two products P and Q. If a large number of countries exporting P also export Q, and those who are not exporting P (or Q) also lack Q (P) in their export catalogue, there is reason to assume they need a common input (Hidalgo et al, 2007). These common sets of inputs and production factors can be viewed as 'economic building blocks' (Hidalgo and Hausmann, 2009). By looking at the development of e.g. Finland's export structure one can infer which kind of building blocks are present and how they develop over time. It was shown that economic growth is directly related to (i) how diverse a countries exports are (how many product categories) and (ii) how exclusive (how many other countries export in these categories).

A part of the Game Changers project is to shed light on to which kind of technological developments may drive the economic system in 2030 and how a small national economy can be prepared today to be competitive in this environment. By a thorough understanding of which building blocks are currently available and how close they are (in terms of common production inputs) to potential future building blocks, one may infer to which extent investments in certain production areas are likely to pay off.

Of course there is no way to exactly predict which of the future scenarios produced by the Game Changers project will be realized to which extent. But there are some characteristics that will be required from a national economy irrespective of the actual scenarios. One key finding of this sub-project is the need to diversify. This is due to one immediate and one less immediate reason. First, an increase in product diversity means less exposure to individual market risks ("don't put all your eggs in one basket!" or "What if Nokia leaves Finland?"). Secondly, an increased stock of innovations increases market adaptability in a rapidly changing environment (resilience) and decreases time-to-market of new products. High product diversity is also indicative of future economic growth (Hidalgo and Hausmann, 2009). We have confirmed and elaborated these findings for the Finnish ICT sector by building an agent-based model of a production eco-system (Thurner et al., 2010) focusing on different

innovation strategies leading to new goods or production methods. In particular we study how public stimuli on process or product innovations impact the sector's economic growth and product diversity.

Results

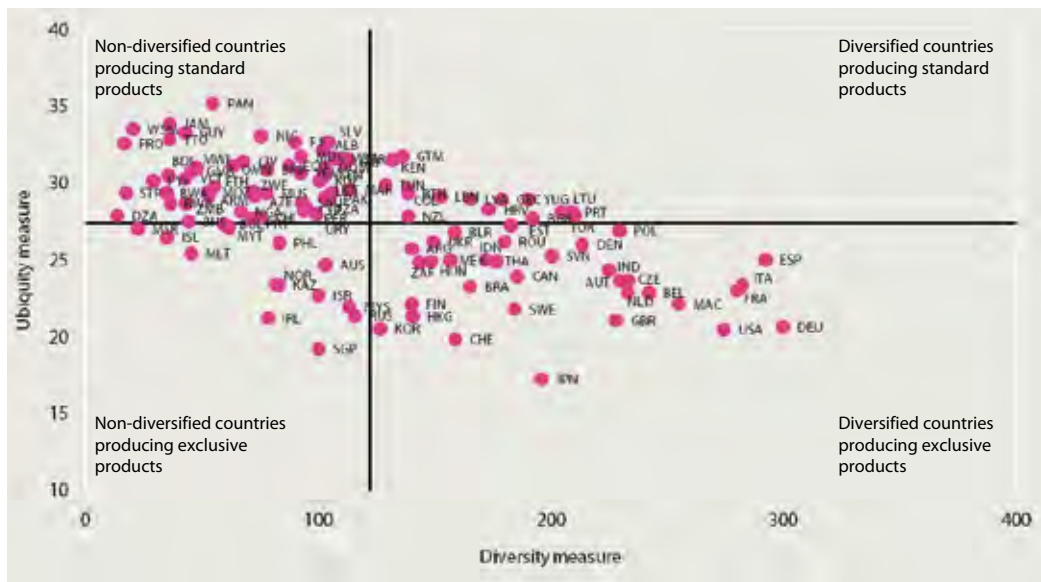
Exhibit A.5 compares product diversity and ubiquity of several countries with data aggregated over the years 2005–2010. Diversity and ubiquity indicators were constructed using the method by Hidalgo and Hausmann (2009) with UN COM Trade data. Countries with high economic growth tend to lie in the bottom right quadrant, indicating high diversity and low ubiquity (exclusive goods requiring many and/or complex inputs). Finland, for example, possesses a relatively high product exclusivity value, close to the USA or Germany, but an average diversity value.

The Finnish ICT sector can be viewed as an industrial eco-system dominated by a single leader firm. Together with the comparably average diversification in the product portfolio this raises the issue of resilience and adaptability to changing environments. What if the leader firm re-allocates its production or goes bankrupt? What if a Game Changer turns market demand upside down and requires a different type of products, production methods or, for instance, distribution systems? These questions can be quantitatively studied using an agent-based model. They are especially suited to study problems where a large number

Exhibit A.5

Comparison of product diversity and ubiquity across several countries

Countries with high economic growth typically have high diversity and low ubiquity



of heterogeneous agents are involved. In the model companies act as agents who buy certain inputs and transform them into more complex output products with added value. This output can then serve as input to a yet more complex product or be sold on the market. As model input served stylized statistical data about the Finnish ICT sector (in terms of company size distribution and bilateral business ties).

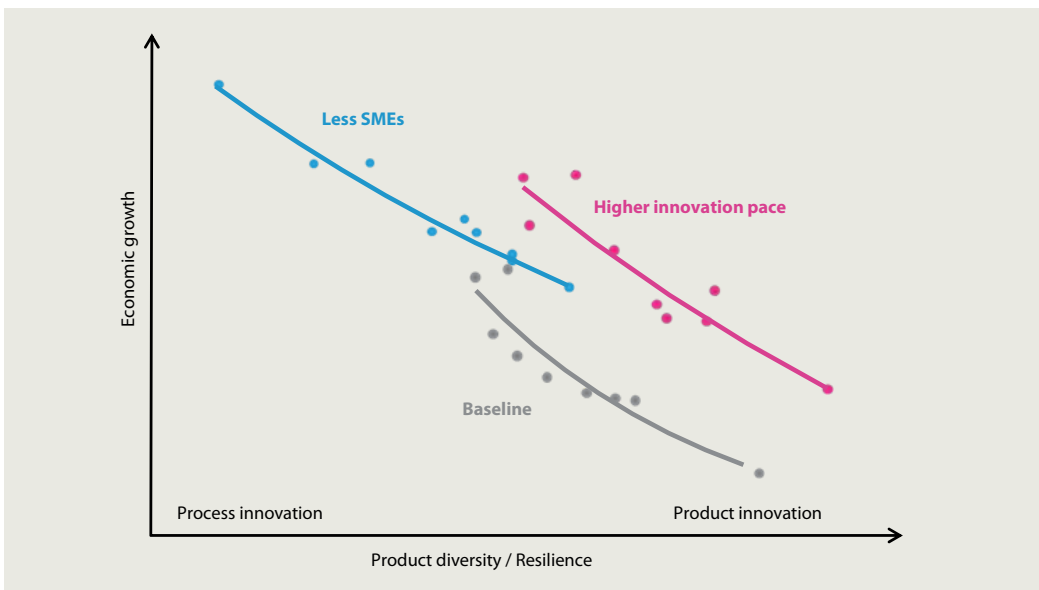
The public sector is modeled as an agent putting incentives on different stages of the R&D and innovation process. In the simplest and instructive scenario it allocates a certain budget to product innovations (that is research leading to the introduction of novel products in the market) and a budget to process innovations (leading to more efficient production methods for already existing goods). Product innovations translate into entrepreneurial activities, whereas process innovation is the outcome of applied research. Assuming that the overall budget is fixed, it is studied how the sector's growth and product diversity change under different mixes of product and process innovation strategies.

The resilience of the sector was studied by simulating external (e.g. financial) shocks. Here one assumes that as result of this shock a certain fraction of companies goes bankrupt. Since the system consequently loses some outputs and production methods, this initial event may trigger a cascade of bankruptcies of other companies. Our measure of resilience is how large these cascades are (smaller cascade size, higher resilience). We also study a scenario where the dominance of the leader firm grows and the number of SMEs declines. In another sce-

Exhibit A.6

Resilience/growth tradeoff

Three scenarios are studied. (i) Baseline scenario (blue), (ii) a scenario with decreasing SMEs (red) and (iii) increased innovation demand (green). For each curve the leftmost point corresponds to pure process innovations, by going to the right we increase product innovations.



nario the pace of innovation drastically increases, that is the market requires innovative products at an increasing rate. The results are summarized in Exhibit A.6.

This shows that increased product innovations lead to a higher diversity of output products and to higher resilience scores. On the other hand, process innovations lead to higher short-term economic growth but higher vulnerability to large external shocks. A decreasing number of SMEs amplifies these developments, leading to even higher growth at the expense of less resilience. An increased pace of innovations offers potential for higher economic growth. In the latter scenario there are more possibilities for companies to become monopolists for a short time.

7. Digitalization

Leena Ilmola, Ruggero Rossi

Background

This case study addresses the digitalization of printed communications. The domain of the case study is important to the initiating partners of the Game Changers project due the structure of the Finnish export industries. Digitalization has been a prerequisite for the modern communications technology industry. At the same time, a large part of the Finnish economy is still based on forestry and paper manufacturing. Evolution of digitalization in communications will change dramatically the consumption level of paper in books, magazines and newspapers printing.

In addition to the country specific importance, the case also has some generic value since it represents an ongoing cascade of innovations that is changing the global market, as well as society's structure and behavior patterns.

Research question

The preliminary research question addressed is:

- *What kinds of value networks are required for digitalization to replace print communication?*

The phenomenon under investigation is large, so we will use one of the recent well known digitalization processes, emergence of the e-book, as a focal point for describing the nature of the overall process. Thus, we narrow the research question to

- *What types features are needed for the emergence of the e-book in the publishing value network?*

Research methods used

The theoretical framework employed in this study is the theory of the Agents, Artifact Space and Generative Relationships developed by professors David A. Lane and Robert R. Maxfield (Lane & Maxfield, 2005). This choice is motivated by the nature of the research questions. We are regarding a value network as a social system, and unlike the traditional innovation literature, Lane and Maxfield see innovation as a set of processes through which changes in the structure of the agent-artifact space are realized. The second framework we use is the theory of social mood and its operationalization developed by our team in previous research projects (Casti, 2010).

Data and analysis

The study is qualitative, with data collected about the development of the e-book having been collected from four media sources (each of them representing one group of agents in the value network); *Wired*, *Business Week*, *Publishers Weekly* and *The New York Times*. We have analyzed over 30 000 mentions of the e-book in 2000, 2003, 2006 and 2009. In order to test some of the hypothesis in detail, we looked at the published e-book material in *Publishers Weekly* for the years 2001, 2002, 2004, 2005, 2007, 2008 and 2010. We made use of a text miner tool developed by Data-Rangers Oy for the analysis.

Results

Our goal was to better understand an environment as an ecosystem, in which a technological innovation reaches the mass market. Lane and Maxfield define the prerequisites for emergence of innovation into three elements: shared perception of an opportunity (aligned direction of the value network), collaboration capability (directedness) and supporting structures (scaffolding).

The agent structure of the market was already established in 2000, but there was a prominent shift in the roles of the agents. The first initiators were software vendors, such as Microsoft and Adobe, while the actors that brought the business to the market were device producers like Sony and Apple.

Our study does not show a linear correlation between development of the sale of e-books and the aligned perception of the business, but something that is more interesting. It seems that all three approaches used – aligned perception of the opportunity, directedness and the measure of the social mood – are directing our attention to the same fact.

Each of these different measures indicate that there has been a period of low social mood, hesitation and disagreement just before the invention turned out to be a successful innovation (i.e., developed into a commercially viable product). This conclusion is strongly supported by the social mood theory that claims periods of negative social mood are the domains of invention, and when the social mood turns positive the market is ready for true investment (launch of solution, marketing investments) in the innovation.

According to agent attribution theory, scaffolding structures are necessary for the ecosystem to negotiate about the collaboration by offering both the forums and the ways to negotiate for a shared understanding of the business. In this study, we use price as an indicator of the scaffolding structures. This is because the media we analyzed does not provide us with sufficient data on other scaffolding elements (such as standards, legislation), and it seems that for identification of potential business models and earning logics the price is “a hook” by where different business potential considerations can be anchored.

Development of the price perception radically changed from 2000 till 2009. In 2000 the proposed price for an e-book was *“double or triple of the price of the hard cover, because it provides the reader with additional value”* or *“we can offer new e-books with the unit price of \$4,25 due the low production costs”* or *“for free, for marketing purposes”*. During the “crisis” of the e-book concept in 2006, some of the players standardized the pricing up to \$7,99 per book, but that was not accepted among the ecosystem and the players forced the major publishers to push the price to \$9,99 by the end of 2009.

Conclusions

One case study can present only limited conclusions about the entire process of digitalization, and its generative power is low. But everything we have studied supports the theoretical claims of the Agent Attribution and Social Mood theories. The potential value is high for use of this framework and qualitative data for anticipation of the tipping points of the life cycle of innovation.

8. Food and Drink case study

JUUSO Liesio

Background

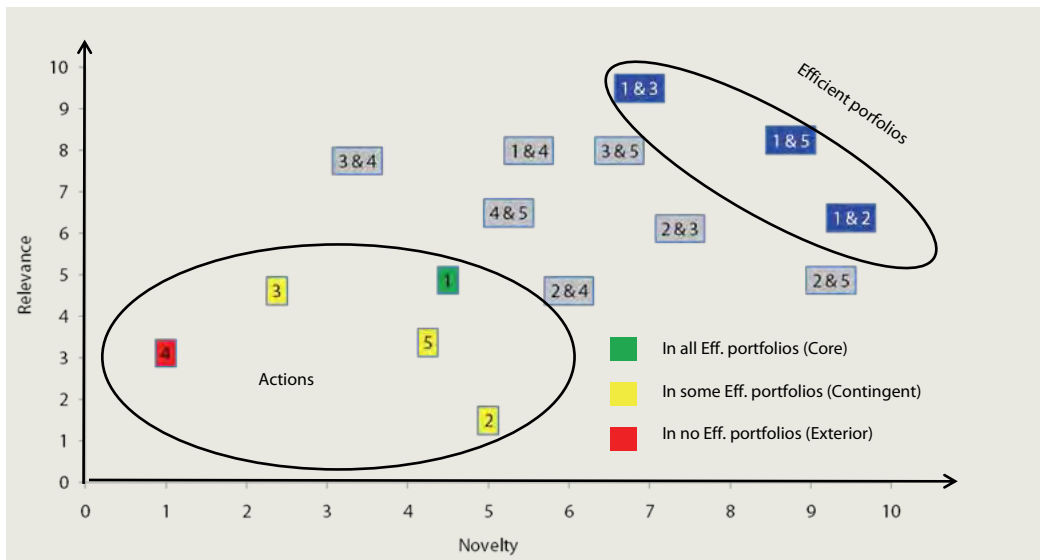
Scotland's Food and Drink key sector accounts for a significant part of Scotland's economy and reflects the contribution of all areas of Scotland. Scotland offers distinct advantages to the sector in terms of the quality of raw materials, high animal welfare standards and production systems and real strengths in crop, animal husbandry and human nutrition research. Scottish Food and Drink products have a strong international reputation and brands, especially at the luxury end of the market (e.g., whisky, salmon, seafood and Scotch Beef).

Objectives

The objectives of this case study are to gain insight on i) the types of unlikely future events and drivers that would have a significant impact (i.e., Game Changers, GCs) on the competitive advantage of the Food and Drink sector and its subsectors, and ii) actions or interventions that would help to build more resilient competitive advantage for the sector.

Exhibit A.7

Efficient portfolios of two actions when the environments' likelihoods are not restricted



Methodological motivation

Planning and foresight processes that set out to produce insight on the most likely possible futures to support organization's policy or strategy formation usually focus on the analysis trends and megatrends. Hence, such processes may not recognize very unlikely events or they are intentionally filtered out to produce internally coherent future scenarios. However, the relevance of an uncertain future event depends roughly on i) the likelihood of the event, ii) the impact of the event, and iii) the actions that could be taken now to prepare for or benefit from the event. Game Changers compensate for the low likelihood by having a potentially major impact; however, it is not self-evident what types of preparatory actions could be taken or whether such actions would be feasible in view of the more probable futures. Hence, to gain insight on the relevance of Game Changers requires also identification and analysis of the possible preparatory actions.

Process

In this case study the following seven-step process was carried out to address both the aspects of identifying Game Changers and creation of actions:

1. Web-questionnaire to collect ideas for GCs, and comment ideas of other respondents.
2. Identification of most significant GCs from the questionnaire to describe the GC environments.
3. Workshop to i) elaborate the GC environments and the potential impacts on the sector and its subsectors, and ii) create ideas for concrete actions or interventions that would help to build competitive advantage in each of the GC environments.
4. Analysis and combination of the action ideas from all GC environments.
5. Web-questionnaire to assess the actions' usefulness in building competitive advantage in each GC environment.
6. Identification of action portfolios that help build resilient competitive advantage.
7. Workshop to elaborate the implications of the portfolio analysis for action planning.

In Step 6, Robust Portfolio Modeling (RPM¹) was used to identify the efficient action portfolios. When there are no statements on the relative likelihoods of environments an action portfolio is efficient, if no other portfolio containing an equal number of actions is more useful in all the environments (see Exhibit A.6). Thus, seeking to select actions so that they would optimally help to build competitive advantage across the GC environments always leads to one of the efficient portfolios.

Results

Based on the results from the first questionnaire 10 GC environments were identified:

1. **“Healthy food only”**: Markets for unhealthy food and drink products diminish due to consumer preferences, production regulation or taxation...

2. **“Basic needs”**: The share of income that consumers globally can afford to spend on Food and Drink decreases due to global economic depression (c.f. like in the 1930s)...
3. **“Rise of the consumer society in Asia”**: In China and India middle Class grows considerably and their consumer spending power exceed that of Europe and the US combined...
4. **“Local food only”**: Environmental regulation, high energy prices, trade wars or consumers preferring local food make it infeasible to transport products to foreign markets...
5. **“Sustainability through new technology”**: Technological change significantly increases the yield and quality of production, without damaging reputation for sustainable, ethical production...
6. **“Sustainability through revolution in consumption”**: Sustainability is achieved through transformational change of consumption habits in western countries (grain to humans not animals)...
7. **“Ruined reputation”**: Scotland’s reputation as a ‘Land of Food & Drink’ is ruined because of a health scare. Food and drink sales and, in particular, exports suffer massively...
8. **“Decreased natural wealth”**: Scotland’s reputation as a ‘Land of Food & Drink’ is ruined because of a health scare. Food and drink sales and, in particular, exports suffer massively...
9. **“Increased natural wealth”**: Effects of climate change substantially decrease the advantages that Scottish land and sea offers for the Food and Drink sector...
10. **“Liberalisation”**: Scotland’s Food and Drink sector opens up to market forces. Subsidies, such as the single farm payment, are eliminated, EU Common Agricultural Policy collapses and tariff barriers are removed...

The researchers carried out some preliminary analysis on the impacts of these Game Changers on the different subsector. The chart in Exhibit A.8 was used in the first workshop to help the participant think about which subsectors would be negatively affected and which ones would be in a position to benefit from the GCs. For instance, a future where demand for healthy food and drink products is dominating the market could be driven by consumer preferences, change in taxation or even UK or European level regulation. Even though the fruit and vegetables subsector could potentially benefit from such a future, this could have a huge negative impact on the sector overall, since distilled alcohol drinks delivers some half of the sector’s total Gross Value Added.

In the first workshop the most relevant Game Changers were perceived to be the rise of the consumer society in Asia, new technology helping sustainability, ruined reputation and increasing demand for only healthy or local food. The action generation work resulted in a list of some 120 ideas. In addition to concrete actions to be taken now or in the very near future, the list also included features of the GC environments, capabilities that would be needed in the environment and also responsive actions, to be taken if after an event (“e.g., Food health scare”) happens. Some of the environments drew out a ‘protectionist’ tendency in some ac-

tion ideas and responsive actions of bilateral trade agreements with other countries. Other common themes were building flexibility by thinking new ways of using the end- and by-products of the sector (e.g. bio-fuels), and investments into research and innovation to build knowledge base that would allow changing production if demand changes. After the workshop, analysis of all the material carried out by the researchers in cooperation with some of the experts resulted in a final list of 19 actions ideas (see Exhibit A.9 left axis for the actions' titles).

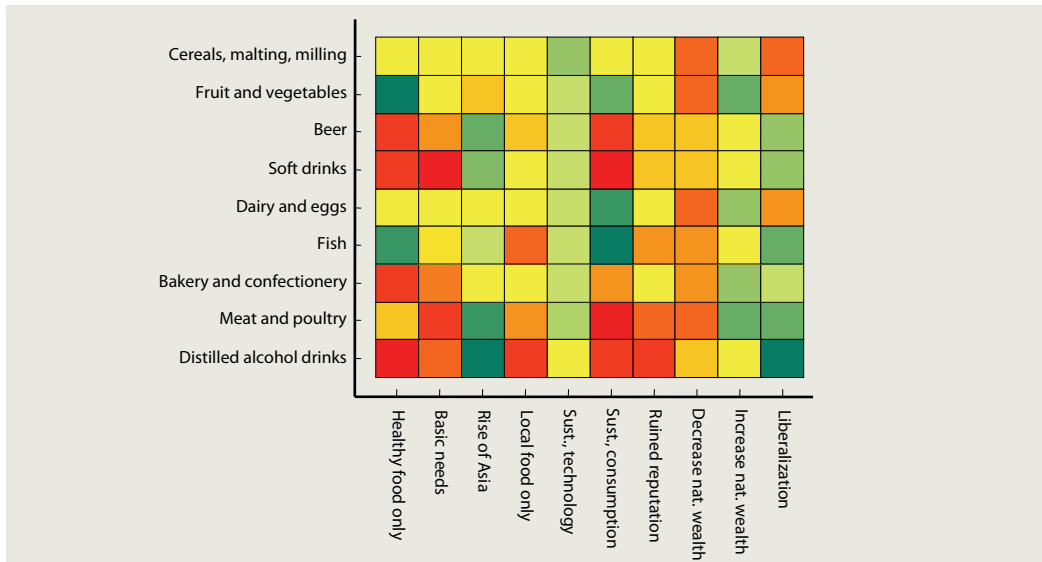
In the second questionnaire the experts were asked to assess how useful each of the 19 actions – if taken now – would be in improving the competitive advantage in each of the 10 GC environments. The assessments were given on a scale from 0 (not useful at all) to 7 (very useful). Based on the assessments and the qualitative statements on the environments' likelihoods from the first workshop, efficient portfolios of all sizes up to 19 actions were computed (see Exhibit A.9). Overall the results seem to indicate that the premium products and scale of businesses (actions 1. and 4.), which are key priorities of the current strategy, are useful in building competitive advantage in the GC environments. Also investments into crop, soil and animal research (action 8.) and active scanning of new foreign markets (action 13.) build resilience by helping to create a more diverse set of products and markets for these products.

In the second workshop, the experts worked in three small groups to build an action portfolio from the 19 actions. As background material each group was given description of the

Exhibit A.8

Effect of Game Changers on sectors

Bright red and green mark the opposite extremes of a scale continuum that assesses the impact of Game Changers on particular sectors. Red colors signify negative impacts, while green colors signify positive impacts.



actions and the environments, and the chart of Exhibit A.9 that shows the composition of efficient action portfolios. The selected portfolios are marked with crosses in Exhibit A.9. Overall the experts felt comfortable to follow the portfolio analysis recommendations, i.e., selecting actions that are green and thus included in most efficient portfolios. However, the fact that the analysis did not give a single ‘optimal’ portfolio or strict priority order for the actions, stimulated thinking and discussion on synergy effects among the actions. For instance, supporting business growth helps to increase research activity and exports, as large companies are in a better position to fund R&D and to access foreign markets.

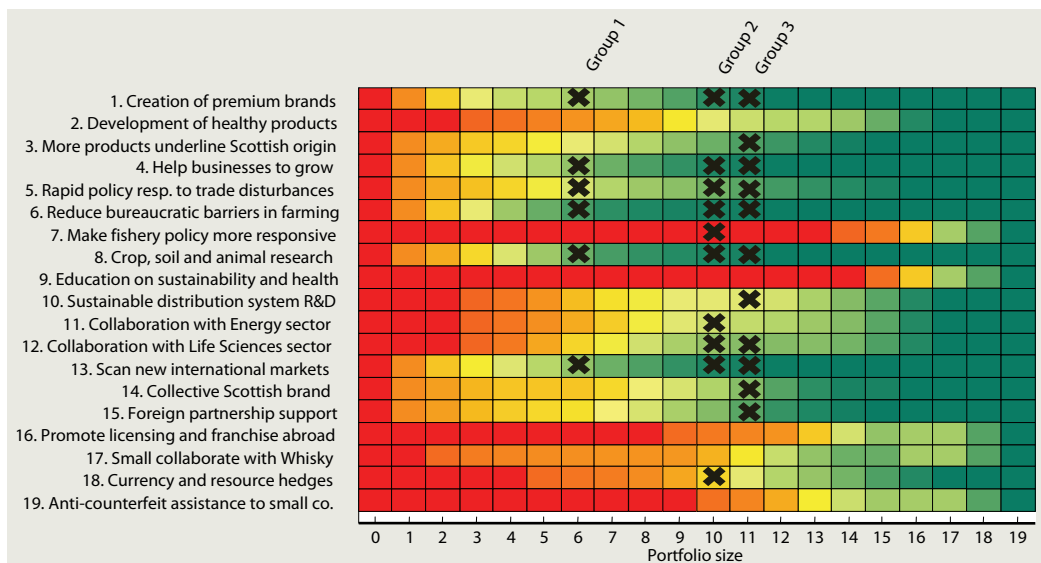
Conclusions

In the closing discussion the experts felt that the process was useful in helping to think about the unlikely futures. Furthermore, the process was able to produce novel ideas for actions, especially in how the public sector can help businesses to access foreign markets. At the same time, the results seem validate the key priorities in the current strategy (e.g., creating premium products and helping businesses to grow), in the sense that activities that support these priorities, also help build competitive advantage in the less likely futures.

Exhibit A.9

Composition of the efficient action portfolios

Colors indicate the share of efficient portfolios in which an action is included (dark red: not included in any; dark green: included in all)



For instance, the action “1. Creation of premium brands” is included in all efficient portfolios, when 10 or more out of the 19 actions are selected. In turn, selection of action “7. Make fishery policy more responsive” can only be defended if 16 of more actions are selected.

9. Life Sciences

Juuso Liesio, Leena Ilmola

Background

Life Sciences sector includes pharmaceutical products and services, manufacture of medical and surgical equipment and appliances, and research and experimental development on natural sciences and engineering. Based on 2006 and 2008 data the sector employed almost 31,500 people in 620 organizations and the turnover was estimated at over £3 billion, with gross value added (GVA) at over £1.3 billion. Furthermore, the sector has strong growth potential globally, due to ageing population and the demand for improved quality of life. Scotland is globally recognized as one of the top research in the area and Scotland's universities account for 12 per cent of UK research staff and funds, which is higher than Scotland's share of the UK population. The challenge is commercialization of this know-how. However, only a small number (4–6 %) of companies are high in growth (20% in 3 years). In the October 2010 workshop Scottish Life Sciences decision makers defined that the focus of the case study should be in attractiveness. In order to increase growth opportunities it is essential to identify new means for increasing attractiveness of Scotland as an environment for the existing companies, for new start-ups and a location for the new investments of the large global companies.

Objectives

The set of research questions for the case study are

- What are the most relevant Game Changers that would decrease/increase the attractiveness of Scotland?
- What kind of industry and public sector driven actions should be in place in case a Game Changer realizes? How to build attractiveness that is resilient with regard to Game Changers? How to take an advantage on opportunities provided by Game Changers?
- Which set of actions are beneficial across the futures in which Game Changers happen?

Methodological motivation

The case study is one of the pilots of the planning tools for uncertainty. The reference group of this study put a special emphasis on the pragmatic nature of approach; so the ambition of the method is to produce resilient strategies that generate growth potential to the Scottish Life Sciences sector.

Process

In this case study the following seven step process was carried out to address both the aspects of identifying Game Changers (GCs) and creation of actions (same process presented in the Chapter 7):

1. Web-questionnaire to collect ideas for GCs and comment ideas provided by other respondents.
 - a. For this phase we had some 80 respondents that produced some 60 uncertainties.
2. Analysis and identification of most significant GCs from the questionnaire to describe the GC environments.
3. Workshop to i) elaborate the GC environments and the potential impacts on the different fields of the LS sector and its current strategy (that was under construction) and ii) create ideas for concrete actions or interventions that would help to build competitive advantage for the Scottish Life Sciences in each of the GC environments.
 - a. Workshop produced almost 100 action ideas.
4. Analysis and combination the action ideas from all GC environments.
 - a. Action items were clustered into 23 strategies.
5. Web-questionnaire to assess the actions' usefulness in building competitive advantage in each GC environment.
6. Identification action combinations (i.e., portfolios) that help build resilient competitive advantage.
7. Workshop to elaborate the implications of the portfolio analysis results for action planning processes.

Results

Based on the results from the first questionnaire 5 GC environments were identified:

1. Development of patent regulation

Strong IPR: Patent regulation is very strong. Large corporations gather IPR, mainly by acquiring innovative start-ups. New products require high investment inputs. Large corporations set the rules of the global market, while others operate as subcontractors. Markets are divided among few brands, prices are pretty stable and the market behavior of agents is easy to predict.

Weak IPR: Open source rules. Plenty of small players, some coalitions. Technology emerges all around, but there are not so many strong investors. No standards, but a position as a dominating technology is gained by fast development. Products are highly diversified; plenty of small and radical innovations are competing for attention. Players are entering/exiting the market with high frequency. Local customers.

2. The role of regulation

Strong outside regulation: Global/EU level regulation is strong, same rules for all of the players in the homogenous market. Acceptance of authorities for the new innovations requires time and money. Large corporations are the strongest players. Lobbying and collaboration with public sector is essential. Global segment specific products, global brands.

We set our own rules: Country level regulation generates small markets that differ from each other. Local companies/agents are strongest players. Technology customized according to the market needs. Less investment in technology, because the market potential is limited.

3. Perception on technology

Trust: Technology solves both resource scarcity, aging and health problems. Consumers believe in technology. Large players are technology companies that invest heavily in innovation. Technology investments are increasingly attractive. Technology intensive concepts for niche needs.

Mistrust: Mobile phones cause cancer; shared opinion of technology is that it has failed. Also internet is perceived as unreliable. Players of this market are traditional companies, alternative health is strong, quality of life is important. No investors Small, low-tech innovations emerge.

4. Market structure

New Life Science powers: India, China and Brazil are investing heavily in LS, in their new large corporations (funded/supported by governments). Fierce competition, political decision makers support with subsidies. Few dominating investment intensive technologies emerge.

Global brands: Other players are subcontractors to the few leading companies. No local markets if there is no protectionism.

Multiplayer market: Plenty of small innovative LS companies all over the world. Technology development for small customer segments. Plenty of VC money. Different approaches, local products, radically different technologies applied. Low and high tech side by side. Dynamic structure, something is happening all the time. The consolidation of new networks but also new start-ups and specialization going on.

5. Climate change

Catastrophes: Climate change is not managed, plenty of small crises all over the world. Fulfillment of basic needs is the first priority; food, clean water, vaccinations for sick people. Resources used for clean-up of catastrophes. Governments and governmental health care are the leading agents. “War environment”. Focus on existing technologies, low tech drugs etc. Not possible to develop radically new innovative products.

Relative Benefits: Governments invest in mitigation of climate change. CC related technologies attract investors. Scotland benefits from the climate change; water is the number one LS asset. New radical technologies emerge. Environmental and life science technology closely linked. LS plays major role in solving CC related social, economical, health problems etc.

The Game Changer research team used the game changer environments as a testing ground and analyzed the potential usefulness of the elements of the Life Sciences strategy. The analysis implied that strategy elements that are based on collaboration were very useful in 7 out of 10 game Changer environments. Direct investment subsidies for the large foreign companies did not seem to provide any competitive advantage (richer countries will have higher subsidies to offer). The project team also analyzed different branding options for the Scottish Life Sciences. The most useful branding option seems to be to brand Scotland as a home for fast innovation.

In the first workshop the experts worked in small groups. Each group was given one uncertainty axis (e.g., Perception on technology). Each group then i) elaborated the global environment for the Life Science sector in two extremes of this uncertainty, ii) identified capabilities that would make Scotland's Life Science sector successful in this type of an

environment and created ideas for actions that would help to build such capabilities. Also some work was done to see how the action ideas created link to the key priorities set out in the current sector strategy process. After the workshop, the researchers formed 16 strategy elements based on the action and capability ideas created in the workshop and also based on additional interviews of Life Science experts from both public and private sectors. The **strategy elements** include:

1. NICHE FOCUS. Small, agile companies focus on niche but highly profitable segments working with and for small client groups and developing specialized services for them
2. NETWORKED OPERATIONS. Develop cooperatives of small Life Science companies able to quickly build new partnerships when needed and to share expertise and resources.
3. COMBINATIONS. Improving and innovating by combining new technology with old products to reduce development costs and risks
4. LARGE COLLABORATION. Focus on collaboration with big companies. Strategic level role in fostering 'real' grounded relationships around critical costs and procurement. Use Scotland's national health records as an asset.
5. CLIMATE CHANGE SPECIALIST. Support sector wide specialization in understanding the opportunities and threats of climate change for life science companies and the sector as a whole.
6. SELF FUNDING. Reduce dependency on venture capital funding by developing smaller scale solutions and products that can be funded from existing revenue streams.
7. RADICAL INNOVATION. Collaborate actively with global networks of companies and experts. Brand Scotland as the most innovative and stimulating environment for Life Science start-ups.
8. NHS COLLABORATION. Invest in strategic collaboration with the National Health Service and develop specific solutions for clinical trials. Market this approach to other countries.
9. HARD TO COPY. Integrate the core of your product with tailored customer specific services to make the solution harder for competitors to copy.
10. INFLUENCE EU MARKET, Lobby for favorable EU regulation and build a position and role as a specialized Life Science expert within the European market.
11. SPECIALISED PARTNER. Identify few specialized positions in the global Life Science network, where Scotland can be the leading provider of solutions and products and partner with large global companies. Select the positions from different parts of the network to reduce risks.
12. PIONEER SCOTLAND. Establish strong regulatory support and systems for fast experiments and the fast adoption of new concepts.
13. OPEN SOURCE SCOTLAND. Make Scotland a home for safe, open source domain that is used globally by developing flexible and easy to apply legislation.
14. PRICE AND QUALITY. Compete on both price and quality. Brand Scotland as a fast and cost effective partner in development processes.

10. Game Changers: Web scanning

Manfred Lex, John Casti

Background

The goal of this activity is to scan the Internet periodically to identify trends in sentiment that may serve as early-warning signs of game-changing events. In the absence of adequate data, a sentiment analysis is not meaningful and predictions are of little value. So the goal of this activity is to use the internet as an essentially inexhaustible source of data.

Research

The basic question is: How often are particular words used to suggest the sentiment (positive or negative) of given phrases.

Approach

Search engines are one way to address this question, but the *page rank* scheme of engine's like Google is unpredictable. So the results may give many hits, but they may also be out of date and not reflect the context of the search. *Subject-focused search engines* use context analysis to assess the relevance of a website for a given subject. They search for URLs that are preselected for high affinity to the subject in order to identify a high quality, highly relevant collection of pages for a given subject.

Methods used

Since classical web-mining and crawling led to poor data quality results, we chose a different approach. First, the web was scanned by a search engine for the given phrase in order to identify potential sources of data. This led mostly to sources from libraries or local search engines from newspapers, since the information obtained from such sources has already been classified by a human. After identifying the sources (ProQuest library, New York Times Magazine, Tele Read, Publishers Weekly, Business Week, for example), our goal was to get at the articles behind the phrase.

Data and analysis

Acquisition

When the source is known, the data behind the URLs is revealed by using *Deixo screen scraping*. But this yields the text only when the article is buried in garbage (advertisement,

abstracts, tables etc.). Thus, we produced a macro in Excel to extract the written text with only with the header and date stamp. The text may also be split into phrases and sentences.

Analysis

Data analysis was done with a text-mining tool *DR-Miner*, which can import Excel files using their preformatted structure with headers and date fields.

Results

Example: Data for “Intellectual Property Rights”

Of course, what we are mostly interested in is the trend, positive or negative. Our concern is to find how legislation is moving toward greater or lesser control of IP.

Example: Data for “United States Government”

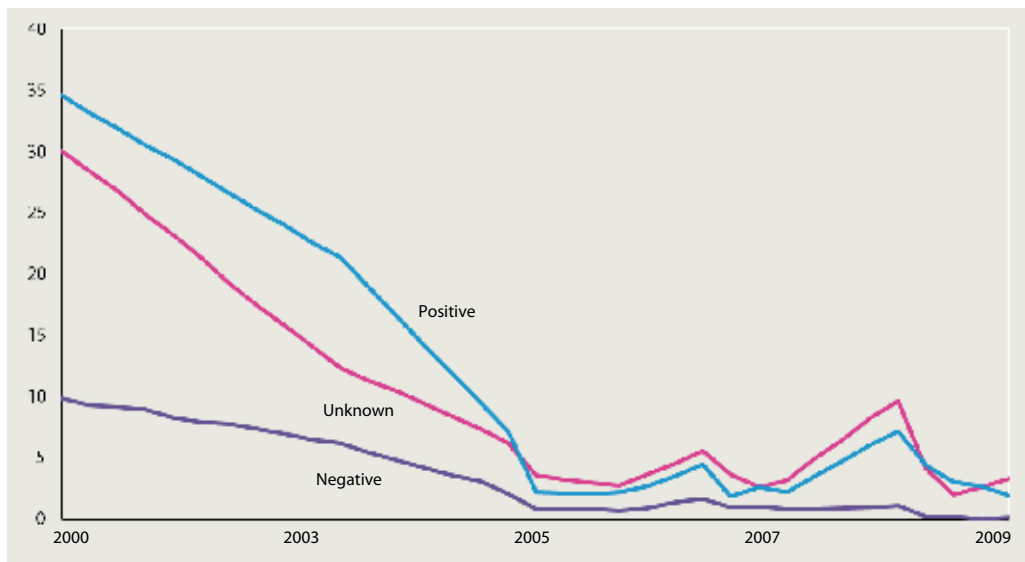
To show what a commercial tool can produce, here is a query with a temporal analytics engine (see Exhibit A.12). The possibility to see a bit into the future is the main point of interest here. We do this by analyzing the data containing mention of future occurrences. For example, “Apple said according to a spokesman they are planning to...” and other phrases of this sort.

Time scales and noise reduction in web scans

The question of how often to “mine” the web for information about trends regarding a given topic is a tricky one. Basically, the frequency of web scans has to match the natural timescale of the phenomenon under study. If these two time scales are out of balance, the scans

Exhibit A.11

Example: Data for “United Nations”



will have little chance of shedding any useful light as to whether what may appear to be an emerging trend is real, an artifact of the data-mining process itself, or simply just a random fluctuation. For example, if the topic of interest is the trend in Intellectual Property Rights (IPR) toward more open-source innovation as opposed to more proprietary control, it's reasonable to assume that the actual unfolding of a genuine trend in this domain will take at least several months for the trend to reveal itself, if not a year or more. This means that mining the web daily, or even weekly, for indications of which way the wind is blowing on this theme is much too frequently. Probably a better time step for gathering data is monthly. And even if you were to mine more frequently than this it would be a good idea to average the data in some fashion, so as to smooth out statistical fluctuations that are inevitably present in high-frequency sampling.

The take-home message, then, is that the timescale of the data mining should match the natural unfolding time of the phenomenon in order to obtain information that is likely to reveal the emergence of an emerging trend that could be taken seriously.

Exhibit A.12

Quotation of “United States Government” in the last 12 Months

(red – negative, green – positive sentiment)



11. Planning for uncertainty handbook

Leena Ilmola

Background

Game Changers project is a part of the Xevents Initiative that has a strong methodological focus. The aim of the project is to understand the nature of uncertainty and surprise in different systems. The Game Changers project shares this ambition, our aim has been to produce pragmatic tools for planning in the environment where uncertainty is dominating.

Research objectives

To develop, pilot and document planning tools for uncertainty.

Research methods used

The starting point of tools has been uncertainty, but their theoretical background varies. The theoretical framework has been tested either in one case study or in several different case studies with a different lay out. The project was conducted in 13 months, so that we have mainly used an existing framework that has been applied with specific additional features customized to deal with uncertainty.

How to use these tools?

If your challenge is to

- Identify the key uncertainties of your organizations operating environment
 - >>> use Uncertainty Delphi
- Conduct a foresight study within the field where there are plenty of uncertainties
 - >>> use Structural Scenarios
- To test the shock sensitivity of your existing strategy/structure
 - >>> use basic assumptions testing
- Create a resilient strategy when you know that the environment is changing but the direction is unclear
 - >>> use Space of Uncertainty

Results

Uncertainty Delphi

Uncertainty focused Delphi has been developed for scanning for potentially disruptive drivers of the operating environment. This is a major difference to the traditional Delphi study that focuses on looking for a consensus of the expert panel about future developments.

Principle

The web-based scan collects all the potential drivers of the operating environment from the group of experts. The megatrends and trends are reported but the focus of the analysis is on uncertainties, those drivers with low probability but high impact.

Process step-by-step

(Note: in this process we have used a web-survey.)

1. Invite a diverse group of experts with a different background to participate.
2. Ask respondents to describe as many potential drivers of change as possible with an open question such as “*What may change our industry by 2020?*”
3. Ask respondents to assess the probability of the set of drivers (that you have chosen from the drivers produced in the step 2, or all of the drivers produced) and also the potential impact of the drivers.
4. Analyze the report; the report will show a set of drivers that are highly probable and their impact is great (megatrends or trends), but also list of drivers with low probability and high impact, these are the game changers that represent uncertainty.

How to use the results?

The task described above can be used as a first step for the rest of the tools presented in this report: You can use the results either as a part of a foresight exercise (both megatrends and trends) but also for “What if...” considerations as a part of the strategy process. The value of the “What if” approach is that it reveals the resilience requirements; which parts of your organizations new/current strategy is resilient if the environment where you operate changes.

Structural Scenarios

Structural scenarios have been developed for the foresight exercise in which we try to generate ideas about the future for the environment that we know our cognitive constraints are prominent; we know very little about the drivers that may shape the environment.

Principle

The idea is to generate as many different structures as possible based on the key drivers of uncertainty. When the potential behaviors of these structures are analyzed, the outcome is that very different drivers shape similar structures, and different structures lead to similar type of behavior. In our Game Changers scenario building, we started with 97 drivers of change, designed 16 different structures that led to three different behavior scenarios for the global economic system.

Process step-by-step

1. List the potential drivers of the future, assess them and choose those that have low probability and potentially high impact to the processing.
2. Divide these drivers into five categories, political, economical social, technological and environmental (PESTE). Identify the key themes these drivers produce if they are active.
3. Describe the thematic scenario. Who are the key actors, what kind of transactions and connections are typical between these actors.
4. Describe two or three alternative structures for this thematic scenario. Who are the central actors that are using power in this scenario, who has the majority of contacts, who is collaborating with whom?
5. Group similar structures together and define a typical behavior for each of the different structure types. Use network topology as a thinking tool (attached).
6. Write behavior scenarios (3–5). Define what kind of organizations will succeed in the environment defined by the scenario.

How to use the results?

These scenarios are based on uncertainty, so they represent “what if...” considerations and are complementary to those scenarios driven by more probable megatrends and trends. If your aim is to increase resilience, these scenarios can provide you with a sufficient perception about futures. In other cases, it is essential to compose also the megatrend and trend driven images of the future.

Game Changer stress test of the existing strategy

The current strategy of the organization is based on the situation of the operating environment and uses the existing strengths and capabilities as a starting point. In most of the organizations, megatrends-based foresight exercise has been included in the strategy process. If, for some reason, there is a lot of uncertainty about the trend behavior or there are some potentially important, but still low probability, developments on the horizon the sensitivity assessment is needed.

Principle

The basic assumptions of the current strategy are identified and then challenged by the key uncertainties of the operating environment. The usefulness of the existing strategy is assessed in different environments derived by key uncertainties.

Process step-by-step

1. Define key assumptions that the strategy is built on; is the economy expected to grow, what is the growth rate? What are the assumptions behind the customer/user behavior? How will the global market develop? Etc.
2. Use the global economic system scenarios (page 17) or game changers (see page 11) to challenge these basic assumptions. Articulate alternative assumptions or re-modify existing assumptions and compose a description of the market, where these remodified assumptions are shaping the competition.

3. Test the feasibility/usefulness of the different parts of your strategy in these alternative markets.

Please note that you can also use the Uncertainty Delphi for the steps 1–2.

How to use the results?

The outcome of the sensitivity assessment may produce new aspects to take into consideration when resourcing of the implementation of the current strategy is elaborated. It can also reveal some aspects that may require more attention in the next strategy round.

Space of Uncertainty Portfolio

Planning for “unknown unknowns” is in principle a challenge to the imagination; we have to systematically extend our understanding by pushing the borders of our existing thinking outward from our current perception of what is relevant, what is logical, what is causal.

Principles

We apply four design principles in our SoU method. In order to define the borders of uncertainty, we focus on extremes; low probability events/drivers and descriptions of environments defined by the extreme ends of uncertainties. We process a large number of options, which is why we transform qualitative descriptions to quantitative ones. The method is web-based and participatory.

The ultimate goal of long-term planning is to support decision making in the short-term. Thus it is important to create and evaluate options and incorporate these into our planning such ways that we can prepare for/or benefit from the extreme events.

Process step-by-step

1. The process begins by scanning uncertainties and defining the *key* uncertainties. We have developed a web-questionnaire tool for this purpose. First, we ask participants to share their ideas about the uncertainties with us. Second, participants assess their own ideas and a list of potential uncertainties is derived from our Global Economic System 2030 scenarios.
2. We then take a closer look at the 6–10 Key Uncertainties. Participants in the process describe the extreme ends of each of the uncertainties. In these theoretical descriptions all the operating environment is defined by the uncertainty. This task can be either web-facilitated or conducted in a workshop.
3. Now we analyze the specific features of this environment and define what agent(s) will succeed in this type of environment. What sorts of capabilities are needed and what is typical for the operations of the most successful player/agent in this environment. Now we turn the focus on the organization itself. What are the development actions that should be initiated in order to create the required capabilities? The list of development actions is the input for the next phase. This task can be either web-aided or conducted in a workshop.
4. The developments actions are assessed with regard to (context dependent) multiple criteria on a qualitative or a quantitative scale. The main criteria measure how an ac-

tion contributes to building success in each of the extreme environments. Other criteria may measure, for instance, current feasibility of an action idea, fit to the existing capabilities, the investment required or value for existing operations. Depending on the context, some of these assessments can be carried out by analysts. For instance, action ideas that seem to be valid under many different extreme futures should receive a high assessment in all these futures. Additional items for assessment can be obtained by a web-questionnaire or in a workshop.

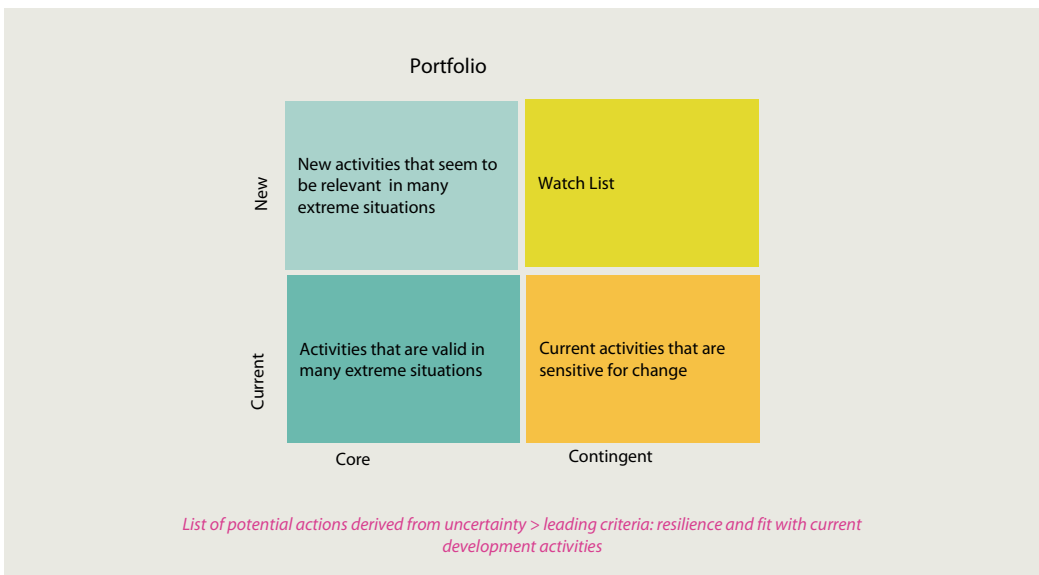
5. The RPM method is used to identify those portfolios that i) satisfy the relevant constraints (e.g., the feasibility or fit with current strategy, limited number of actions that can be pursued) and ii) optimally help to build success across the possible extreme futures, i.e., builds resilience (confer Exhibit A.13).

Since there is incomplete information on the model parameters (futures' likelihoods, actions benefits, or importance of the assessment criteria) there are usually multiple efficient portfolios. However, we can often identify i) core actions that are included in all efficient portfolios (help build success in all extreme futures) and should therefore be pursued and ii) contingent actions that are included only in some extreme futures and iii) actions that are not included in an efficient portfolios.

How to use results?

The process does not produce a strategy, but it provides valuable input to the strategy process; concrete ideas of actions that produce resilience in uncertain environment. The actions portfolio is a long list of actions derived from the environment; some of them are even totally controversial. The strategy process makes choices and potentially takes into consideration those actions that are potentially relevant.

Exhibit A.13
Portfolio matrix for mapping and categorizing development activities



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Endnotes

Chapter 1

- ¹ http://en.wikipedia.org/wiki/Jacobellis_v._Ohio. Visited: 4 May 2011.
- ² There is a separate but related discussion on the properties of the distribution. For instance, distributions that relate to the financial markets often have “fat tails”, i.e., extreme positive and negative events are more likely than what the normal distribution would seem to suggest. Many distributions are also asymmetric or skewed, in which case the probabilities of extreme positive and negative outcomes that are equidistant from the mean differ.
- ³ Admittedly this does not really solve the problems in defining what an event is.
- ⁴ We are sometimes unable to maintain this symmetry in our treatment of the topic.
- ⁵ Exact timing and details are certainly unpredictable.
- ⁶ The US Department of Defense, News Briefing, 12 February 2002. News Transcript at <http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=2636>. Visited: 5 May 2011. See also: <http://www.youtube.com/watch?v=GiPe1OiKQuk>. Visited: 5 May 2011. Rumsfeld has used the same riddle in a number of other occasions.
- ⁷ Rumsfeld’s riddle is in fact so illuminating that we discussed it in some length in our original project proposal.
- ⁸ <http://www.telegraph.co.uk/news/uknews/theroyalfamily/3386353/The-Queen-asks-why-no-one-saw-the-credit-crunch-coming.html>. Visited: 10 May 2011.
- ⁹ <http://media.ft.com/cms/3e3b6ca8-7a08-11de-b86f-00144feabdc0.pdf>. Visited: 9 May 2011.
- ¹⁰ We are aware that many central bankers, and much of the related academic literature at least since the early 1990s, reduce the mission of the central bank to maintaining price stability, i.e., to targeting inflation within a narrow band.
- ¹¹ Not to mention issues with the applicable discount rate and utility/welfare criteria (Weitzman, 2010).
- ¹² What is unacceptable is ultimately a normative choice.

Chapter 2

- ¹ Multinational companies manage global production networks at a fine resolution. Not only major units but increasingly also individual tasks or job assignments seek their globally optimal geographical locations (Baldwin, 2006; Grossman & Rossi-Hansberg, 2008). Even in the absence of extreme events, this brings about more turbulence at the local level.

Chapter 3

- ¹ <http://www.nytimes.com/2011/01/22/world/africa/22sidi.html>. Visited 30 May 2011.

Chapter 4

- ¹ The welfare theorem states that when the economists' conditions for a competitive market are fulfilled (strictly speaking they cannot possibly be fulfilled in a real-world situation), this is indeed true (Varian, 1992). Some necessary conditions for the market to be "competitive" and the welfare theorem to hold – in a strict sense – include the following: There should be no seller or buyer with significant market power. The market should be liquid with a large number and volume of demand and supply at all times. There should also be a market for everything and all relevant aspects should be reflected in the market price. There should *not* be, for example, any externalities, i.e., one should not be able to enjoy the vista of the neighbor's garden without paying for it or have to suffer with the smell of sulfate from a near-by pulp mill without compensation. The information among market participants should be symmetric.
- ² The insulation relates to the structure of our wage contracts, to the availability of unemployment insurance and other social safety nets, and to the limited liability nature of our financial commitments (note that this applies to both assets and liabilities – with personal bankruptcy or a downright escape to Brazilian jungle one can always "clean the slate").

Chapter 5

- ¹ http://en.wikipedia.org/wiki/predictions_of_hurricane_risk_for_New_Orleans. Visited: 6 June 2011.

Chapter 6

- ¹ <http://www.alvintoffler.net/>. Visited: 6 June 2011.

Appendix

- ¹ Liesiö, J., Mild, P., Salo, A., (2008). Robust Portfolio Modeling with Incomplete Cost Information and Project Interdependencies, *European Journal of Operational Research*, Vol. 190, pp. 679–695.

Extreme Events

This book serves as the final report of the *Game Changers* project, which was established towards the end of 2009 as a part of the *Extreme Events in Human Society* initiative at IIASA, *International Institute for Applied Systems Analysis* (Laxenburg, Austria).

A *specific extreme event* (Xevent) is unlikely but it potentially has significant societal impacts. However, due to the range of possible Xevents and their transmission via global links, the effects of *some* Xevent touch upon Finland quite frequently. We argue that Xevents should be one of the central concerns of decision makers in all sectors.

A completely Xevent-free society is infeasible, but some protection is nearly cost-free and comes as a by-product. Contingency planning should be considered as a part of good governance. We propose that Finland be turned to a model for an *anticipatory* society, which constantly prepares for contingencies of various kinds.

Louis Pasteur said that *Chance favors only the prepared mind*. We wholeheartedly agree. And we encourage preparing sooner rather than later.

For further information and additional material, please visit Xevents.fi.

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