Markku Wilenius and Sofi Kurki

SURFING THE SIXTH WAVE

Exploring the next 40 years of global change

FINLAND FUTURES RESEARCH CENTRE
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SURFING THE SIXTH WAVE

Exploring the next 40 years of global change

The Interim Report of the Project
"The 6th Wave and Systemic Innovations for Finland:
Success Factors for the Years 2010–2050 (6th Wave)"

December, 2012

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Forestindustries
– Forerunner in the bioeconomy

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PREFACE & ACKNOWLEDGEMENTS

This is an interim report of the project "The 6th Wave and Systemic Innovations for Finland: Success Factors for the Years 2010–2050" (6th Wave). The report brings together our findings during the first year of our project.

We wish to thank TEKES, the Federation for Finnish Financial Services, and the Finnish Forest Industries Federation for their financial support. We would also like to thank our collaborative partners, particularly Institute for the Future in Palo Alto, California, and and X-Research Center, Vienna, for fruitful cooperation. We also thank all our interviewees and workshop participants for giving their precious time.

Thanks are due to our colleague Juho Ruotsalainen from our research centre for his cooperation, as well as to our interns, Mohammad Mehr, Sarah Moqaddam and Elizaveta Shabanova, for their help. While we are responsible for report, we acknowledge with gratitude that the concluding essay in Chapter 2, "Deconstructing the Sixth Kondratieff Wave – An Extreme View", was written by one of our collaborative partners, Dr. John L. Casti. We also feel grateful to all those people in our networks, in Finland and abroad, from face-to-face communication to social media, who have taken time to engage in a dialogue with us.

Helsinki, December 28, 2012

Markku Wilenius Sofi Kurki

“We are at the threshold of exploding ignorance…”

Professor Pentti Malaska (1934–2012)

The founder of the Finland Futures Research Centre

ABSTRACT

This is the first report published for the project *The 6th Wave and Systemic Innovations for Finland: Success Factors for Years 2010–2050* (6th WAVE). In it we present the Kondratieff long cycle theory (*K-Wave* for short) as a framework for anticipating the medium to long term future (2010–2050), with regard to current megatrends and drivers of change as well as potential game changers for the next wave of development.

The report comprises the first results of our theoretical work, based on a comprehensive literature review of previous K-wave studies, and an analysis of key technologies and societal issues we believe act as catalysts for the coming paradigm shift in economies and societies. The potential implications of these factors for Finland are explored in the context of established Finnish industries and emerging new fields, taking into account the technological and societal trends that pose challenges for the continuation of the status quo. The work goes out from the assumption that the major challenges which act as drivers for the next cycle – grave environmental problems, and the need to re-think the current welfare system in order to create a sustainable model for the future – imply that solutions will need to be systemic and able to induce significant societal transformations. While full solutions to these questions obviously lie beyond the scope of this project, our study uses the Kondratieff wave theory as a framework for understanding and identifying the potential for systemic innovation in Finland in the emerging cycle. We present our general findings in a global context, but with a special interest in looking at their implications for Finland. The Sixth Wave project is funded by Tekes, the Finnish Funding Agency for Technology and Innovation.

The Kondratieff wave theory seeks to account for the long waves of economic activity. The theory was first formulated by the Soviet economist Nikolai Kondratieff in the beginning of the 20th century. According to Kondratieff, economies follow the path of long-term dynamic cycles or waves. A long wave lasts for 40–60 years, and consists of a period of rapid economic growth, followed by stagnation or depression. Previous research and a number of economic indicators lend support to the interpretation that, since the economic crisis of 2008, we now find ourselves in the last stages of the 5th wave, about to enter the 6th wave.

According to the theory, each wave is defined by a specific set of technologies and societal practices that are unique to that wave. We know from history that the transitional period between two Kondratieff waves facilitates the entry of new types of innovations to the market, thus creating the dominant socio-technical landscape for the next Kondratieff wave. Our report examines this process and the effects of the anticipated socio-technological paradigm shift in the context of Finnish society, especially with regard to the traditional industries in Finland.

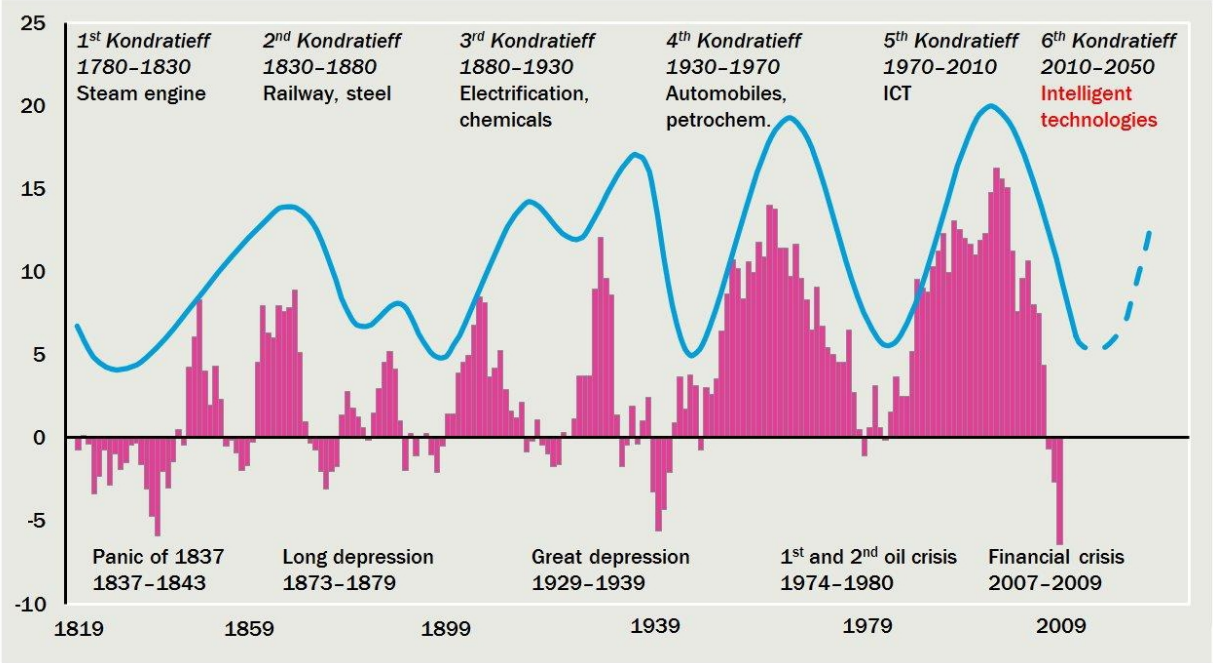

Figure 1. Modern economies fluctuate in a cycle of 40–60 years. Rolling 10-year yields of the Standard & Poors 500 equity index and the Kondratieff's waves. Source: Datastream.

As our hypothesis, we hold that megatrends in world economy, such as the permanently higher level of commodity prices as well as the mounting environmental strains, are indicative of a new Kondratieff wave that is predominantly driven by efforts to improve resource efficiency. We believe resource productivity to be the key driver for technological, economic and social change. During the next wave, our economies will be driven by environmental technologies, biotechnology, nanotechnology and healthcare. Their effect is leveraged by digitalization and the exponential rise of computational power – both legacies of the previous wave – that create circumstances for new products and services. A paradigm shift towards more efficient resource use is on the horizon, and its drivers are threefold: First, as many raw materials are becoming more rare their price tends to increase. Second, in conditions of growing competition, the level of effectiveness at which raw materials and energy are used, is becoming critical. Third, growing environmental awareness and legislation are putting pressure on companies to use less harmful substances in their production lines, and to serve their customers with less environmentally loaded products.

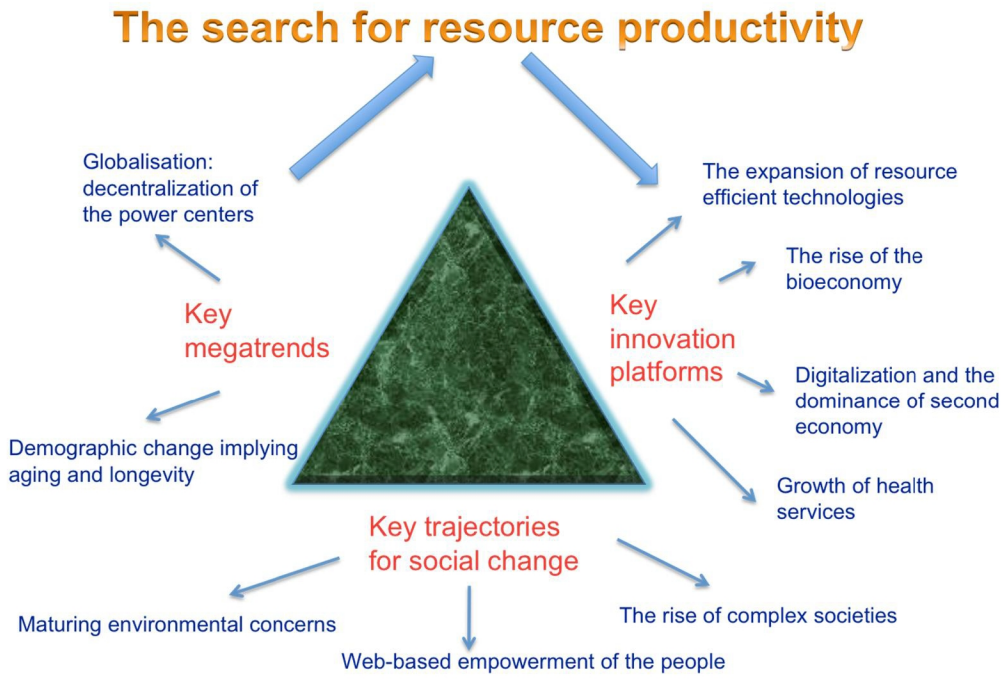

Figure 2. Key drivers for the 6th wave (2010–2050).

The key drivers for the 6th wave are what we were assigned to investigate in our project. The above diagramme shows roughly where we are directing our attention. As the project proceeds, this framework will develop as well.

The project is conducted in partnership with Forestindustries and the Federation of Finnish Financial Services, and this report includes an in-depth look at the challenges and future potential in those fields. We will continue our work by adapting the results presented here to participatory futures processes with the aforementioned organisations in order to explore further the possibilities we see on the horizon.

1. OUR HISTORICAL TRANSFORMATION: TOWARDS NEW BUSINESS, SOCIETY AND CULTURE

Future can never really be known, but it always exists through our perception. Some eminent scholars say our future will be defined by scarcity, while others believe we are headed towards a world of abundance. Still others may point to the increasing fragility of the emerging system that may be at the brink of the collapse at any given time while some others, again, point out that we are just at the doorstep of greatest period of evolution ever experienced by human mind[1],

However we may interpretate the situation we stand in right now, there seems to be no denying that never before in the history of humanity have we faced circumstances of a similar degree of challenge as today: The development of the world has reached a point where humanity has no other choice but to align itself with the biosphere. Climate change, soil depletion, scarcity of water and energy, enormous waste problem, death of ocean fisheries, deforestation of tropical forests and loss of biodiversity, are but a few of the pressing environmental concerns that have made increasingly clear the gap between the exploitation of natural resources and their availability, especially for the future. The growth rate of world population, although declining, will increase global population by an added two billion, to reach an estimated peak of 9 billion by 2050. At the same time, millions of people the world over are being lifted out of poverty to a higher standard of living. These factors combined seem to lead to a Malthusian conclusion that once we have all had our piece of an already overeaten pie, there will be too little left to sustain humanity on Earth. In the end, the same processes that have provided unprecedented prosperity to humanity during the past two hundred years are now threatening us with the fate that normally faces an unusually successful species in nature: extinction.

Ultimately, the challenge we are facing is an ethical one. The values and concerns of the people have already shifted, and revolve increasingly around the issue of a more harmonious relationship with nature. In time, hopefully, the preferences of consumers will shift towards products and services in which these concerns are taken into account. Slowly but surely, the innovation capacity of the world will focus on the question of how energy and material resources can be utilized ten times more efficiently than at present. In this report we concern ourselves with understanding when and how this shift could happen.

What we need in order to start unraveling the knot of vicious problems we seem to be stuck in at present, is a completely new paradigm in organizing our economy and production. Moreover, the paradigm

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[1] See Randers, Jörg (2012): 2052: Global Forecast for the Nect 40 Years. Chelesea Green Publishing. White River Junction; Diamandis, Peter H. & Kotler, Steven (2012): Abundance. Free Press. York. Casti, John (2012): Collaåse of Everything. HarperCollins, New York. Costa, Rebecca D. (2010): The Watchman's Rattle. A Radical New Theory of Collapse. Vanguard Preasee, Philadelphia. Kurzweil, Ray (2012): How to Create a Mind. The Secret of Human Thought Revealed. Viking, London.

shift would need to happen very soon: there are already visible signs of the biosphere drawing close to systemic tipping points after which certain processes become irreversible.

Postulating a revolutionary paradigm shift as the only way to survival may feel like small consolation. There is a wealth of research showing that even individual behaviour change in order to prepare for the future is not easily achieved, even when the benefits of doing so are obvious to everyone. The ongoing global climate negotiations suggest that such changes might be even less attainable collectively. Yet, there are quite a few historical precedents of revolutionary change going through entire societies in a matter of just a few decades. Indeed, not only has such change happened before, it seems to be following a temporal pattern.

A theory of such structural socio-technical cycles was developed by the Russian economist Nikolai Kondratieff in the 1930s. According to him, modern economies fluctuate in cycles of 40–60 years (known as Kondratieff waves), always starting with technological innovations that penetrate economic and social systems, effecting a prolonged economic upturn and steady increase in productivity. This development is coupled with *new value systems, social practices* and *organizational cultures*. However, at a certain point, the new technology networks begin to offer diminishing returns on investment. This results in stagnation of credit demand with the real interest rate dropping to zero, before the cycle begins again. This pattern is demonstrated by every major economic crisis in the past 200 years, the last financial crisis included. There is therefore an observable structural pattern that defines our economies, illustrated in Fig. 1.

Kondratieff waves can be understood as regime shifts in the world economy. As these waves are historically repeating patterns (for more on the theory and the cycles, see Chapter 2), we can assume with some certainty that they will occur again in the future. It is our conviction that the deep economic recession of 2008 was the turning point when the fifth Kondratieff wave reached its end, and a new phase of global socio-economics is now underway. In it, we will see new drivers beginning to dominate the scene, similar to those of basic ICT technologies, oil, electricity or automobiles in the past waves. As the waves are a result of complex interactions between politics, technology, and economy, it must of course be noted here that a new period of growth after the stagnation is by no means a given fact. History has witnessed periods of prolonged stagnation, and good arguments have been presented also for the view that those factors that so far have generated the waves may have changed to such a degree that the mechanism no longer works[2].

Nevertheless, at this point it seems clear that there are huge new opportunities on the technological front. In their landmark book *Abundance*, Peter Diamandis and Steven Kottler set out to make a case for a future that will overshadow everything we have seen in the past in terms of human well-being[3]. They see our societies sliding into a world of plenty, supported by a staggering rise of innovations based on new technologies. As a result, we will have a novel planetary nervous system, a prelude to an Internet of Things:

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[2] Tuomi, Ilkka (2009): The Future of Semiconductor Intellectual Property Architectural Blocks in Europe. JRC Scientific and Technical Reports. EUR 23962 EN.

[3] Diamandis, Peter H. & Kottler, Steven (2012): Abundance. The Future is Better than You Think. Free Press, New York.

in the future, every "thing" will have its own IP address which then helps to track any device, be it at the end of the earth, and get connected.

Diamandis and Kottler also envision that our harshest predicaments, such as climate change and raw material and energy scarcity, will be tackled successfully with measures that the increase in computational power has provided for technological development. This is because the seeds of new technologies that will bring us closer to sustainability are already here: we only need to nurture them and see them growing towards 2050.

Major technological changes often go hand in hand with societal paradigmatic changes. Paradigmatic changes alter the fundamental logic, structures and values the systems are based on. The challenges our current socio-economic system is facing, and the solutions provided to solve them, can be expected to form a completely new paradigm in which old divisions between industries may not be relevant anymore. Different industry sectors will merge with one another and with social spheres, especially with people's leisure time and everyday living. This is part of the general paradigm shift in society's power relations away from the top-down and towards the bottom-up.

In this change, a lot can and needs to depend on human innovativeness. The whole new wave of innovations – some technological, some political - is needed to solve some of our key resource problems: We are indeed moving into an era where totally new layers of technological innovation are needed. Some will be novel, yet age-old approaches, such as biomimicry (promoting the transfer of ideas, designs and strategies from biology to sustainable human design), whole system design, industrial ecology, green nanotechnology, new energy technologies and so forth. In all this human-engendered progress, radical resource productivity will be the key theme as we are bound to look for radically smarter solutions for our infrastructure and urban design.

The next wave, now truly global for the first time in human history, will eventually be about raising the level of awareness concerning key human predicaments and then searching for and implementing measures that can really make a difference: new smart and decentralized power grids, new welfare models that stand up to scrutiny. This is a massive learning challenge for societies, to wake up and notice they are in great trouble unless attitudes and policies change.

Our firm belief is that in this emerging 6th wave, the next big race to which the major thrust of our technological development, economic growth, social cohesion, and even our cultural and spiritual activities, will be devoted, has to do with making our systems more intelligent. A lot of this intelligence has to come from understanding how we can use our natural resources more efficiently. As social and individual awareness concerning the limits of our fragile planet grows, new innovations are bound to build a technological and social infrastructure that helps us live more meaningful lives.

OUR NOMADIC FUTURE

A Blogpost by Markku Wilenius (April 24, 2012)

Perhaps the most ingenious travel writer of all time – and an astute anthropologist - Bruce Chatwin, tried all his life to create a compelling theory of nomadism to what he called "the Anatomy of Restlessness". His point was that the rapid move of humanity from open fields to cities has bred in us a terrible pain of staying still, while our genetic system and therefore our mental models are still tuned to the time we moved constantly from one place to another looking for new pastures or searching for new hunting grounds. This is why we who are tied to life in cities, who have fixed flats as our homes and routines that confine us to relatively small circles, have every now and then a curious feeling of living in a prison and – subsequently – feel ourselves restless without really knowing why. Chatwin himself certainly felt this urge to walk and let his spirit free by roaming around the world. Although Chatwin never actually completed his thesis before his premature death in 1989, he wrestled with this idea in one way or another in nearly all his writings. Nowhere is this plainer than in the brilliant collection of essays entitled suggestively "What am I doing here".

What does this have to do with the future? Everything

The current decade marks the first full decade when more people live in cities than in rural areas. From Chatwin's viewpoint, we are putting ourselves under increasing constraints. The cities of tomorrow will have people on a massive scale, and unless we can ensure that this innate restlessness is somehow handled by urban design, we are headed straight into trouble. In practice, it will entail green open spaces (Chatwin thought that people in the countryside are less prone to the restlessness due to the availability of open spaces) and logistic design that caters to people's willingness to move about (bicycle and walking lanes, etc.) and thus make them feel that they are – even on a small scale – "on the road".

We also know that, as living standards rise, people tend to invest more and more of their money into travelling, which satisfies their appetite for new experiences. Because this ancient call for seeing new places is caused by our nomadic instinct that is ingrained into our genes, it is not likely to wither away in the near or the far future.

This may even have some practical implications. For Finland, it may well be a great opportunity as we should in the future see an increasing share of the inflow of people and money being connected with attractive infrastructures for "nomadic tourism", providing advanced services for people looking for travel experiences. Here, we certainly have not used but fraction of our true capacity.

Eventually, we should not limit ourselves to physical movement. Our innate hunger for new inventions and innovations can also be interpreted as an expression of the same nomadic instinct. Nowhere is this more visible than in little children and their endless willingness to play: playing also soothes the craving for movement. Furthermore: look how children can best be calmed down: by taking them for a ride that involves movement, a variation of the archetypal experience of being carried on the mother's back in times of nomadic culture.

The search for new experience and discoveries can thus be traced back to their logical origin. In my experience, the things people most regret for not doing in their lives quite often have to do with not following their instincts to move and explore new things.

And it is no accident that I happen to write this in San Francisco, far away from my hometown of Helsinki back in Finland.

As always, human intention is what will lead the way. Information revolution has taken place in two ways: First, scientific evidence abounds that the present industrial model of development will not take us to the kind of future we want. Second, we have today novel channels for networking. There are over 6 billion mobile phones in the world. A whole new digitalized space has been created, and the number of active Facebook users has hit the magical one billion mark.

Moreover, we see new technologies, such as nano- and biotechnologies, taking the stage. Nanoparticles are used everywhere, from helping to filter fresh water to providing self-cleaning windows. Biomaterials will

eliminate the excessive use of non-renewable materials in many fields, such as the construction, insulation and packaging industries, as new products based on natural wovens will begin to substitute existing products. In terms of price and industrial scale, new renewable energy technologies are fast approaching market entry.

There are thus two fundamental factors at work here: first, needs arising from the observed limitations of existing ways of producing and consuming, and second, a new awareness concerning the innovative ways in which we can make society smarter and more human through the use of various technologies. Today we are in a situation in which new breakthroughs are taking us onto a new level in the interaction between humanity and technology. Futurist Ray Kurzweil, who with an astonishing rate of success has forecast the rise of a new high-tech paradigm, recently pointed out how the operations of the human mind and brain can be tracked and this knowledge brought into vastly intelligent human machines[4]. Not only are we seeing the birth of new superintelligence through the application of our know-how to technology, we are also witnessing totally new possibilities to extend the powers of our own mind.

In backcasting, after a hundred years from now, the 6th wave will appear to us as a phase when a new kind of awareness took shape in our societies. In the present, we need to look ahead to make sure we will not miss this opportunity to make the change happen.

The role of financial services in the 6th wave

On March 14, 2012, Greg Smith, a Goldman Sachs executive, published an op-ed article[5] claiming that the culture of his company has, since the dawn of the financial crisis, shifted away from a customer-centric and into a kind of predatory culture, in which the interest of traders, i.e. of the company, come first (making money), and in which customer needs come last. In a book published later that year, Smith tells in a nutshell the story of the financial rollercoaster that the Western world has experienced in the course of the last decade[6]. Needless to say, its roots go back much further, to the 1930s and the Great Depression.

Smith points out that it was actually the culture of integrity that had helped Goldman Sachs stand out among peers and become the world's most powerful investment bank. In those days, it was the culture of humility, respect for the facts and the principle of not taking advantage of the customer in any dealings. In other words, the earlier GS promoted the ethics of integrity and transparency. Smith noted that all of this eroded as people in the company began to protect their own earnings at any price because of the crisis.

The story is symptomatic of today's economic downturn. The mood of the markets and people alike, have suffered a serious blow and future seems gloomy for most people. As students of socionomics know, social mood has a certain anticipatory power, foretelling what will actually happen in the market place[7].

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4 Kurzweil, Ray (2012): How to Create A Mind. The Secret of Human Thought Revealed. Viking, New York

5 Smith, Greg (2012): Why I Am Leaving Goldman Sachs. The New York Times, 14.3.2012.

6 Smith, Greg (2012): Why I Left Goldman Sachs. Grand Central Publishing, New York

7 Casti, John (2010): Mood Matters From Rising Skirt Lengths to the Collapse of World Powers. Copernicus Books, New York, 2010.

Most assessment regarding the future options for European economy in particular do not see much light at the end of the tunnel.[8]

We really do seem to be at the bottom of the curve. But, relying on our basic framework, it is a curve, not an endless downhill slide. We therefore assume that the recent crisis, with its near collapse of the whole financial system, marks the end of the 5th Kontratieff cycle and that we are now entering the 6th wave. The new wave implies new economic drivers, new social trajectories and even new professions. While in the previous cycle the pervasive use of information and communication technologies led to dramatic increase in labour productivity, it can be assumed that this time around the drivers will emerge from environmental and bio/nano-based technologies prompted by an incredibly fast rate of digitalization that will in all probability lead to productivity gains in the use of natural resources and energy.

The financial system itself experienced massive growth in the course of the 5th cycle. In just 35 years, it nearly quadrupled its size, as shown in the figure below:

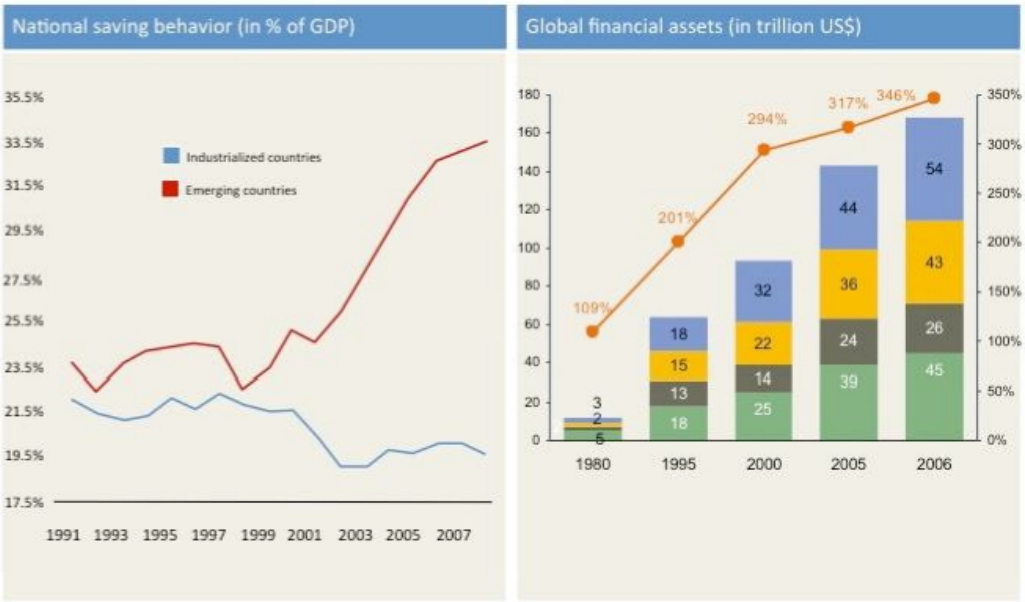

Figure 3. Transformation of global financial system: two key indicators. Source: McKinsey Global Institute.

This was essentially the road to the global financial crisis, but it involved much more than just a financial or a banking crisis. It involved a massive change in the culture of some of the world's most powerful financial institution and individuals, a change that put pressure on the market to liberalize it to the fullest extent possible. Some people, such as Alan Greenspan, the then chairman of the FED, thought that professional financial experts could regulate themselves without any excesses[9].

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8 See IMF: Latest Financial Stability Board Report

9 See a revealing documentary movie "Inside Job" by Charles Ferguson

As we now know, Greenspan's vision of self-regulating financial experts did not work. In their persuasive book "Animal Spirits", George Akerlof and Robert Schiller point out how the current financial turmoil, now continuing as a public debt crisis, was at its core a result of the failure of public policies that allowed "animal spirits" to raid the room with devastating results[10]. The term was originally coined by John Maynard Keynes in the aftermath of Great Depression in the 1930s[11]. The severity of the last crisis (according to the wave theory, some kind of crisis was nearly inevitable) was thus basically caused by two factors: the greedy behavior of bankers and developers, and the inability of regulatory bodies to intervene effectively. What is more, it was a very strong belief system, one in which everybody was too busy to reflect upon what was actually going on. In the end, most of the beliefs on which the entire financial economy was based, turned out to be false:

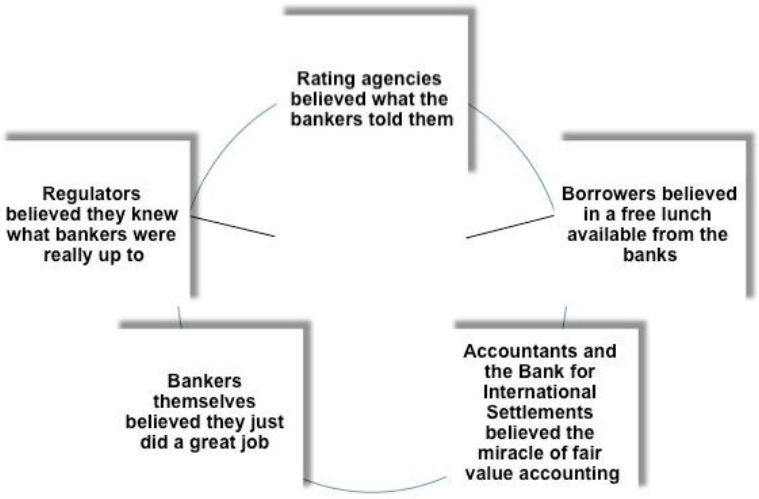

Figure 4. Operating belief-system before global financial crisis.

Financial services are like the blood circulation system: they are absolutely necessary, but only because they function as an enabler. Financial services have grown into the biggest business sector in the world, with a surplus amount of innovation some of which has proved to be devastating to our entire economy. When the financial system hit the wall in 2008, it was brought there for numerous motivational reasons: greed for excessive bonuses, greed for pay packets, overwhelming arrogance, sheer mental brutality, as well as massive amounts of self-confidence and attendant lack of humility. As a result, the investment bank system went through a major wipe-out after the crash, and new regulatory architecture has been gradually been put in place.

We believe that in the 6th wave the financial sector will resume its core role as the blood circulation system of the economy. To achieve this, it must focus on three types of targets: First, it needs to get back to

[10] Akerlof, George A. & Schiller, Robert J. (2009): Animal Spirits. How Human Psychology Drives the Economy, and Why it Matters for Global Capitalism. Princeton University Press, Princeton.

[11] See insurmountable description of the events by Lewis, Michael (2010): The Big Short: Inside the Doomsday Machine. W.W.Norton & Company Ltd., New York.

the basics, the real needs of customers, and abandon the old product-oriented service model. When will we see financial (insurance) companies offer lifelong partnerships that would involve an understanding of the various phases in individuals' lives and build that into the programme? Second, the culture of the financial services sector needs to be more flexible and agile. The sector is known for its old-fashioned and stiff cultural code that hardly fits circumstances in the next wave. Third, the entire sector needs to enter fully into digitalized services, which is really about building networks with stakeholders. New kinds of public-private partnerships must be formed in which new mixtures of public and private funding will provide the necessary support for critical services. Digital services also need to be developed in which financial services play a major role. In general, there is a place for greater strategic alliances between different industry sectors, and the role of the financial sector as a middleman in this regulated field needs to be strengthened.

All in all, the key principle of the financial sector – and this goes for the entire economy – should be how to establish partnerships that create genuine win-win situations through the formation of more sustainable welfare than we have seen up until now.[12]

[12] Finanssialan kyvykkyydet 2020 (2012): Luotaus tulevaisuuteen [Financial Sector: Key Competencies Towards 2020]. Finanssialan keskusliitto. With English resume.

2. OBSERVING THE PATTERNS: LONG CYCLES IN SOCIO-ECONOMIC ACTIVITY

Cyclicity in economic activity refers to fluctuation patterns of apparent regularity that investigators of economic time series have noted in their data. Typically a cycle consists of a period of rapid economic growth, followed by stagnation or depression. Cycles of varying length have been identified by researchers and named after their discoverer: the shortest cycle lasts about 40–49 months and is called a Kitchin cycle. A so-called Juglar cycle, also referred to as the regular business cycle, last from 3 to 7 years. The Kuznets cycle is estimated to be about 15–25 years, and the Kondratieff cycle lasts 40–60 years. And finally, there is even a hypothesized "grand supercycle" of over 70 years.

There tends to be more evidence, and thus credibility, in short-term economic cyclicity: for instance the term "business cycle", which is an often used term for the Juglar Cycle, has entered common parlance and is nowadays considered a routine way to assess the state of the economy. The longer waves, especially the Kondratieff cycle, are more enigmatic. Due to their length and the available reliable economic statistics, they are more difficult to observe than shorter cycles. Despite numerous attempts to pin down the long waves using exact econometric analysis and models, at this point they remain an inductive generalization, most apparent by visual examination of various time series of economic data (although the same also applies to a large degree to waves of shorter length, such as the regular business cycle).[13]

Economists and other social scientists have been trying to understand the long run dynamics of economies at least since Mr. Hyde Clarke published his article titled *Physical Economy. A Preliminary inquiry into the physical laws governing the periods of famines and panics* in 1847 (reprinted in 1999).[14] In it, he noted a periodicity of about 54 years in economic activity, and after considering plausible causes for this fluctuation, attributed them to long-term climatological changes. His final conclusion was that the phenomenon related to the Saros period, which is triple the time of the solar eclipse. In his article, Clarke made references to a few of his contemporaries, who had also been studying the phenomenon. Although these beginnings in a scientific sense can be noted as mere curiosities, they signalled the start of a research programme that gained full speed in the beginning of the 20th century.[15]

The research on the long wave began for real when a Marxist economist, Jacob Van Gelderen, started studying the phenomenon of long waves of 50–60 years in 1913. Although lesser known than his more influential successors, Van Gelderen in his seminal work laid down the foundations for much of the later work on the topic and discussed several key themes that were later rediscovered by many authors investi-

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13 Louçã, F. & Reijnders, J. (1999): Foreword. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

14 Clarke, Hyde (1847, reprinted in 1999): Physical Economy. A Preliminary inquiry into the physical laws governing the periods of famines and panics. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

15 Ibid.

gating the long waves. Among the significant contributions Van Gelderen made were, for instance, his suggestion that a long period of rising prices is driven by the rapid growth in one or several leading sectors. He also tried to understand other important features of the process, such as periods of over- and underinvestment of capital, periodic scarcity and abundance of basic resources, credit expansion and contraction, etc. (Ayres 1990). Van Gelderen published his work only in Dutch, making his work largely unavailable to the international economist community of his time. Despite poor communication capability between different authors, at the turn of the century there was a surge of interest in the idea of long waves determining the fate of economies. Besides Nikolai Kondratieff, important figures in this early 20th century discussion about the long waves were Joseph Schumpeter and Simon Kuznets, whose ideas have since figured predominantly in the K-waves literature.[16]

The Kondratieff wave theory

The Kondratieff wave (or cycle) is a 40–60 year fluctuation in the economy that is named after Nikolai Kondratieff, the most thorough of the early long-wave scholars. What Kondratieff did in his research was to subject the hypothesis of the long waves of economic activity to rigorous and systematic examination. As noted earlier, the main difference between Kondratieff's work and those who had been examining long waves before him was that Kondratieff took advantage of the latest and most sophisticated methods of statistical analysis available at the time. In his empirical analysis, Kondratieff used several key indicators[17] of economic activity, such as commodity prices, work wages, foreign trade turnovers, raw material production and consumption rates, and private bank savings, in his analysis.[18]

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16 Ibid.

17 Kondratieff, N. (1928/1984): 'The Long Wave Cycle' and 'The Theses of N.D. Kondratieff's Paper: Long Cycles in Economic Conditions' in The Long Wave Cycle, New York: Richardson & Snyder, translated by Guy Daniels, p. 25–99 and 101–5, 137–8. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

18 Kondratieff's article 'The Long Wave Cycle' mentions the following data sets: Consumption rates indices of commodity prices in England, France and United States 1780-1920; quotations of the French rente 1820–1920; quotations of English consols 1815–1920; Annual wages of agricultural workers in England 1789–1896; Weekly wages of workers in English cotton industry 1806–1906; Foreign trade turnover of France 1830–1920; Foreign trade turnover of England 1800–1925; Coal production in England 1855–1912; Consumption of mineral fuel in France 1830–1910; production of lead in England 1857–1918; Production of pig iron in England 1845–1925; Private savings banks in France (liabilities towards depositors in millions of francs) 1838–1910. Kondratieff believed the phenomenon of the long waves to be inherently tied to the rise of industrial capitalism, and for this reason he took only data starting after the industrial revolution. After him, other authors have claimed to identify the same pattern from much earlier time.

The previous waves and their key drivers

There is no official concensus about the timing of the waves: different authors rely on slightly different chronologies, and there are differences between individual industrial countries. In the following we adopt a rough chronology, where each wave is defined by a key technology or a socio-technical ”revolution”.

The first Kondratieff wave (1780–1830) was dominated by the invention of the steam engine, which signalled a dramatic increase in productivity in the early days of industrialization. The second cycle (1830–1880) was dominated by the proliferation of railways and steel – both were crucial to the spread and distribution of industrial production. The third wave (1880–1930) saw the electrification of the world and the spread of chemicals in agriculture, speeding up innovation also in medicine. This wave came to an end with the Great Depression at the turn of the 1920s and 30s.

The fourth Kondratieff cycle (1930–1970) saw the advent of the T-Model Ford and the entire auto industry, strengthened by the growth of the petrochemical industry. Most of the increase in productivity in this period derived from this development. The long period of cheap oil and stable economy collapsed with the oil crisis of the early 1970s. At the same time, however, certain key innovations saw daylight, such as the microprocessor, which ushered in the fifth wave (1970–2010). The first microcomputer was built in a garage in California, and a little later the first wireless NMT telephone network was set up in the Finnish archipelago. In the years that followed, these basic innovations were developed and refined and distributed around the globe, creating entire branches of new industry.

The rise of Nokia was emblematic of the age of ICT. But we must understand that it was a child of its age. Nokia went surfing on the fifth Kondratieff wave and showed its power, because the wave increased the productivity of the economic and social system. Once again we see how a specific innovation solved certain key questions relating to the development of the previous waves, simultaneously creating challenges for future waves. The global redistribution of production capacity and excess supply are among the factors inherited from the fifth Kondratieff wave, just when the new wave begins to develop its own characteristic drivers. Together with the consequences of the preceding waves – the massive distribution of cars, oil, technology and services – they provide solutions to the challenges of the previous phase, while also raising economic productivity to an even higher level.

In the previous wave, the excessive use of energy and materials, coupled with insufficient technology, launched a development which was unable to prevent petrochemical pollution. This alone defined an agenda for the sixth Kondratieff wave, which will set the tone of global development for the next 40–60 years. The increase in productivity must be found from a decreasing use of non-renewable resources such as metals and minerals, and from lower energy intensity. The search for better resource productivity will steer both businesses and societies, defining new products and services.

NIKOLAI KONDRATIEFF – THE MAN WHO FORMULATED THE THEORY OF THE LONG WAVE

Nikolai Kondratieff was the key figure in defining a research programme to uncover the mysteries of the long waves. Nikolai Dmitriyevich Kondratieff's (1892–1938) name has become synonymous with the long wave theory mainly because he was able to present a complete monograph on the topic that far exceeded the analysis of his contemporaries, and he was also first to employ methods of modern statistical analysis to the subject.

Kondratieff was a Russian economist, a member of the Socialist-Revolutionary Party, and a former student of Mikhail Tugan-Baranovsky, also one of the central pioneers of the long wave theory. In the economic policy of early Soviet Union, Kondratieff was a proponent of the New Economic Policy (NEP), which promoted small free market enterprises. After receiving his degree in economics, Kondratieff was appointed as Deputy Minister of Supply in the last Kerensky government, which lasted only a few days, and after that he moved back to the academy to found the Institute of Conjuncture in Moscow in 1920. The Institute grew rapidly into a prestigious research institute of its time, and it was there where Kondratieff started to investigate the idea that capitalist economies develop in long cycles of about 50 years, characterized by a succession of waves of expansion and decline. In his work, Kondratieff analyzed the patterns of economic growth, their relation to changes in economic structures and institutional frameworks, and placed his findings into a coherent vision of social evolution. He published his first work on the long wave theory in 1922. His theory enjoyed international success for a short period in the beginning of the 20th century. However, Keynesianism's triumph in the aftermath of the Great Depression of the 1930s drew attention away from the K-wave theory.

In Soviet Russia, Kondratieff's theory of capitalism as a continuous, self-regenerating system was even more controversial than within capitalist discussions: Marx had in his writings argued that capitalism was on the verge of imminent collapse, and the economic problems visible at his time were signs of this, not just an overpass before the next growth wave. In the revolutionary phase of Soviet history many communist writers were intrigued by the long wave theories, but as the regime moved to a more dogmatic phase, especially under the leadership of Stalin, these theories were increasingly perceived as unorthodox, and consequently even Kondratieff fell into disfavour. His leadership of the Institute of Conjuncture was discontinued in 1928, and two years later he was arrested, accused of being a "kulak-professor" and a member of a "Peasants' Labour Party" (allegedly a fictional party invented by Soviet secret police NKVD). Kondratieff was sentenced to an eight-year prison sentence that, despite ruining his health, allowed him to continue and even plan publishing his research during his time in prison. In 1938 he was subjected to a second trial, where he was condemned to ten more years in prison, which would be served without the right to communicate with the external world. However, Kondratieff never returned to jail but was executed by firing squad directly after receiving his new sentence. Kondratieff was 46 years old at the time of his execution.

The Kondratieff's theory of long waves challenged the foundational assumptions about economics in his day, and continues to stir discussion and provide theoretical underpinnings for understanding the systemic nature of large transformations in society.

The impact of the K-wave theory after Kondratieff

Despite the initial successes in the beginning of the 20th century, the theory of the long wave never really hit the mainstream of economic theory. There are a number of influential economists who don't believe in the presence of any economic cycles, and even within the K-waves literature authors sponsor views of varying certainty about the cyclicity involved in the phenomenon. Their use of language often conveys their approach to the issue: talking about cycles carries a stronger sense of regularity in the phenomenon, whereas

talking about waves or fluctuations gives more room for the inherent uncertainty about their causes and temporal regularity. The Kondratieff wave theory has remained on the fringes of economics mainly for two reasons: there is a lack of convincing theory of the underlying cause(s) of the waves, and because the timing of the waves remains ambiguous, in part due to a lack of consensus about an appropriate analysis method.

A commonly held, although a rather general, insight among the K-wave scholars about the origin of the waves seems to be that they result from the interplay between the structure of the economy and the decision-making of individuals and organizations. Jay Forrester applied a systems dynamic model to the waves in his 1976 article *Business structure, economic cycles, and national policy*. With it, he argued that he was able to individually identify and analyze the short (three to seven year) business cycles, the longer (15 to 25 year) Kuznets cycles, and very long (45–60 year) Kondratieff waves.[19]

Forrester specifies his generational framework of the waves by identifying five factors: 1) movement of people between sectors, 2) the long timespan to change the production capacity of the capital sectors, 3) the way capital sectors provide their own input capital as a factor of production, 4) the need to develop excess capacity to catch up on deferred demand, and 5) the psychological and speculative forces of expectations that can cause overexpansion in the capital sectors.[20]

A more recent development in the analysis for long waves has been the application of spectral analysis to reveal cycles of varying length.[21] Still, due to the lack of reliable data over a long enough time period for making inferences about such long cycles, from a purely econometric perspective, the theory builds on too much speculation to be regarded as a serious way to explain the economy.

As discussed earlier, the main argument for the K-wave theory is still the apparent regularity of a visual pattern in economic (and other) time series. Consequently, a key problem in legitimating this theory has been a lack of a convincing theory that would explain the phenomenon.

Regarding the cause of the waves, two fundamental positions have been defended in the literature. The first argues that the mechanism is located outside the economics, and thus behind the cyclicity lies an *exogenous force* that also gives expression to the economic trends. The second position interprets the cycles or pulsations as something produced by the economy as a "living organism". In this case the mechanism that

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19 Forrester, Jay (1976): Business structure, economic cycles, and national policy. Futures, 8(4), June 1976, pages 195–214. Forrester, Jay (1981): Innovation and economic change. Futures, 13(4) August 1981, p. 323–331.

20 Forrester, Jay (1977): Growth Cycles. De Economist, 125(4), p. 525–543. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

Forrester, Jay (1979): An Alternative Approach to Economic Policy: Macro Behavior From Microstructure. Economic Issues of The Eighties. N. Kamreny, and R. Day. eds. Baltimore: Johns Hopkins University Press.

Forrester, Jay (1981): Innovation and Economic Change. Futures 13/1981, p. 323–331.

21 van Ewick, Casper (1982): 'A Spectral Analysis of the Kondratieff-Cycle'. Kyclos, 35, Fasc. 3, pages 468–99. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

Korotayev, Andrey V. & Tsirel, Sergey V. (2010): A Spectral Analysis of World GDP Dynamics: Kondratieff Waves, Kuznets Swings, Juglar and Kitchin Cycles in Global Economic Development, and the 2008–2009 Economic Crisis. Structure and Dynamics, 4(1).

generates the pulsations is integrally a part of the economic system, and is thus an *endogenous force* accounting for the waves (in the latter approach the mechanism itself may be either exogenous or endogenous).

Schumpeterian framework of technological innovation as the cause of the timing and phases of the long wave

One of the most popular explanations to the existence of the K-waves has been that of looking at the clusters of technological innovation. This causal hypothesis comes originally from Joseph Schumpeter, whose main question was how innovation and technology influence economic growth. In his early work Schumpeter approached this by investigating the long-term economic growth patterns and their relationship to innovation. The Schumpeterian framework became thus based on the idea that temporal clusters of major innovations create new opportunities that in turn accelerate economic growth.[22] Later, many of the interesting K-wave theories have built on this by trying to explain historical growth patterns by changes in key areas, such as communications, energy, production, or transport technologies.

To complement Schumpeter's original theory, Gerhard Mensch has added the idea that the reason major innovations occur during recessions relates to investment behaviour: Mensch argues that during prosperity investors tend to invest in less risky ventures, and in stagnation or recession fewer low-risk investment opportunities are available. Together the Schumpeter-Mensch theory of technological innovation as the key to the waves has inspired the main body of literature related to the Kondratieff waves.

Robert U. Ayres examined critically the Schumpeter-Mensch hypotheses in his massive article, published in two parts in the Technological Forecasting and Social Change journal.[23] While remaining supportive of the general idea that the timing of the waves is dependent on technological developments, Ayres nevertheless came to the conclusion that clustering of innovation can be best explained by the dynamics of technological opportunity: technological breakthroughs on one hand push back the limits of existing technology, and on the other hand offer possibilities for "convergence" or "fusion" of developments in different fields. Interestingly Ayres suggests – relying on historical evidence – that an important innovation contributes economically quite little to the next upswing of the wave, but instead the effect lags on to the subsequent ones. For example, from Ayres' description of the previous waves one can find a combination of continuation of a previous technology and an innovation that brings it to the next level and spurs radical innovation in other areas: the first wave (1780–1830) according to Ayres was driven by an incremental innovation in iron-making (an old technology): changing the fuel from charcoal to coal, and that in turn led to

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[22] Schumpeter, Joseph A. (1939): 'Time series and their normal' in Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process, Volume I, Chapter V, New York: McGraw-Hill Book Company, Inc., 193–219, 1051. In Louçã, F. & Reijnders, J. (eds.) The Foundations of Long Wave Theory. Models and Methodology. Volume I. Cheltenham, UK: Edward Elgar.

[23] Ayres, Robert U. (1990a): Technological Transformations and Long Waves. Part I. Technological Forecasting and Social Change 37, p. 1–37.

Ayres, Robert U. (1990b): Technological Transformations and Long Waves. Part II. Technological Forecasting and Social Change 36, p. 111–137.

inventing the first steam engine, building of the first canals and mechanization of cotton spinning. The second wave (1830–1880) took steam power to transportation (railway and steam boat) and the textile industry, while the same period also saw a radical improvement in technologies of steel production. The third wave (1880–1930) continued with steel as a substitution for iron as an engineering material, but saw also the beginning of electrification and petroleum industry. As the development of the internal combustion engine was also done in the third wave, ingredients for the automobile were ready for the next wave. These basic developments allowed for a new set of technological combinations that produced a number of spinoffs in the form of new industries. One such significant offspring of petroleum industry was the innovation of coal tar based dyes that could be used to replace vegetable dyes. Mainly due to the increase in demand for dyes in the growing textile industry, chemical industry grew rapidly.

Ayres also notes that in the 4th wave, very few of the technologies contributing to economic growth were new, *only the ways the technologies were used had advanced.*

Ayres' point relates to an earlier contribution to the Schumpeter-Mensch thesis by Freeman[24], who also suggested that the rapid growth period of the long wave is not necessarily driven by innovations occurring in the immediately preceding depression or recession. In fact, there seems to be many cases where the rapid growth has been driven to an extent by the diffusion of important technologies that were tentatively introduced much earlier, but had not been able to surface to the mainstream before. In the innovation diffusion/adaptation thinking, much more emphasis falls on what happens after the basic innovation phase: incremental work on the basic idea, adapting the innovation to new purposes, and adoption. It is commonly assumed that this interactive dynamic holds at least in part a key to understanding the generation and decline of the long wave.

The main apparent problem with the theories of Schumpeter and Mensch is that they do not offer a sufficient explanation for the downswing that ends each period of prosperity. Therefore, increasingly, the waves are being perceived as something more than technology or economics.

Technological infrastructures, entrenchment, and lock-in as causes of the long-wave

Of the neo-Schumpeterian thinkers, especially Carlota Perez has advocated a theory where economic history can be best understood as a succession of separate techno-economic paradigms, where long-term growth is driven by a key general-purpose technology. The "slowness" of the long-waves comes from the inertia that the new disruptive technology first faces with the previous techno-economic paradigm, and the powers and interests that relate to it. Only gradually, through conflict and the realization of a new competitive ad-

[24] Freeman, Chris (1993): Technical change and future trends in the world economy. Futures, 25(6) July/August 1993, p. 622.

vantage, an alignment of the new technology and corresponding societal institutions forms the new socio-technical paradigm of the new wave.[25]

The theme of technology paradigms and their entrenchment is the topic of an academic discussion around the possibility of transitions. A significant school of thought that explicitly distances itself from the long wave theory, but touches upon the same issues of socio-technical transitions in a historical context, comes from the Netherlands, where scholars Frank Geels, Johan Grin, Jan Rotmans, Johan Schot, and Derk Loorbach under the Sustainability to Transitions Research Network (STRN) have set out to understand how systemic transitions and innovation happen, and how they can be influenced. As theirs is an approach that focuses on generating systemic transitions to sustainability in response to the grand challenges of our time, they are not as interested in the kinds of "natural" change processes developing over time as implied by the K-waves theory. Nevertheless, assuming that also the key technologies of a K-wave emerge by way of a complex interaction of policy, business interest, and social demand, the two approaches cannot be thought of as mutually exclusive. The STRN combine perspectives of complex systems analysis, socio-technical change, and governance, to build a framework upon which to stage various experiments, and conduct action research to gain more insight into the processes by which societal transformations take off. Although very much a work in progress, the approach is an important contribution to understanding the dynamics of socio-technical paradigm shifts, and as such provides important insights to areas that are not very well covered within the K-wave framework. [26]

Especially intuitive is the multi-level perspective (MLP) model by Geels (2002). It builds on Fernand Braudel's notion of three levels of historical time: Events, Conjunctures, and Structures. In the MLP these levels are elaborated with notions from science and technology studies, sociology, and evolutionary economics to produce a nested hierarchy, where, on the highest level of structuration of activities in local level (corresponding to the Structures in Braudel's model) is the (socio-technical) Landscape: a broad exogenous environment that is beyond the direct influence of the levels under it.

On the middle level (in place of Conjunctures in Braudel's model) is the Regime, a set of cognitive routines and sociological rules that act as stabilizing forces in the existing socio-technical paradigm. The regime is held in place by a stable network of artifacts, regulations, markets, infrastructures etc. As a force of stabilization, it is also a source for counterproductive stagnation in the form of lock-in which prevents radical renewal of the regime. In the lowest level of structuration is the Niche, entrepreneurial action and innovation, and thus generation of novelties in the system.[27]

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[25] Perez, Carlota (1983): Structural change and the assimilation of new technologies in the economic and social system', Futures, 15(4) 1983, p. 371.

Perez, Carlota (1983): Towards a Comprehensive Theory of Long Waves. In Long Waves, Depression and Innovation, Bianchi et al. eds. Proceedings of Sienna Conference, 1983.

[26] Kemp, R. – Schot, J. & Hoogma, R. (1998): Regime shifts to sustainability through processes of niche formation. The approach of strategic niche management. Technology Analysis and Strategic Management, 10 (2), p. 175–195.

[27] Grin, John – Rotmans, Jan & Schott, Johan (2010): Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Routledge Studies in Sustainability Transitions.

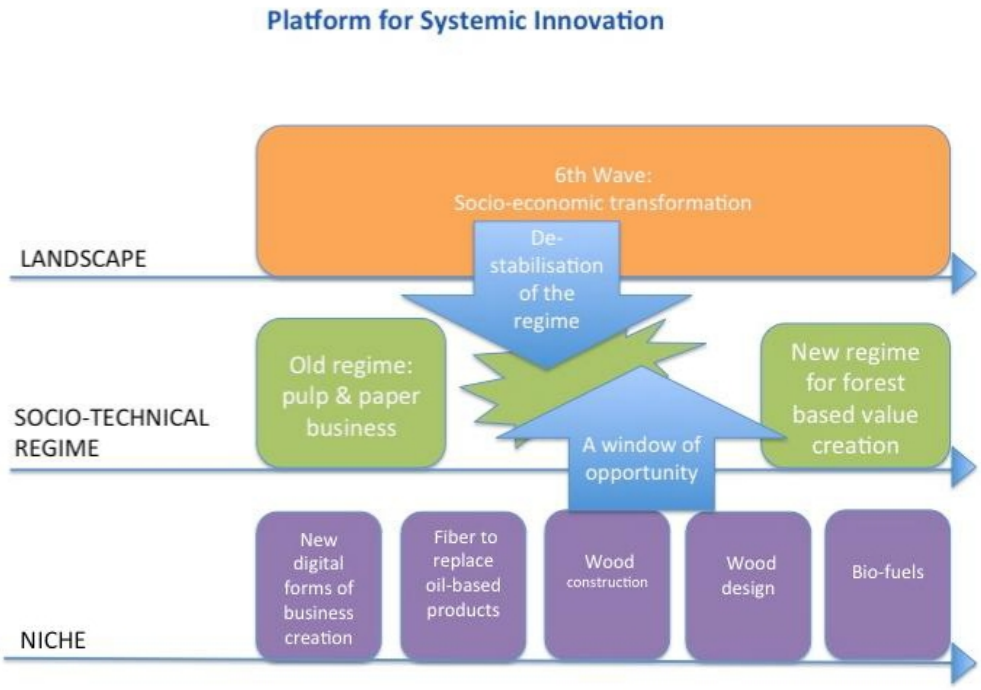

Figure 5. MLP model as an illustration for the transformation process between different K-waves (with the forest industry as an example).[28]

In Figure 5 we adapt the systemic transformation framework to the K-wave theory, by placing the coming sixth wave as the evolving landscape, where the rapid changes cause pressure and destabilization on the regime and create a window of opportunity for the niche innovation to break into mainstream and enter the regime. Although the MLP model is not designed to accommodate the K-wave paradigm, it helps to understand how a shift from a previous wave would unfold with regards to the technology path dependency and potential entrenchement.

The apparently accelerating pace of technology development has also inspired questioning of the dynamics of the K-waves: can they really be expected to continue unfolding at the same interval, or according to the same logic in a world where developments in other aspects seems radically faster than in previous times. Ilkka Tuomi, a Finnish societal theorist, argues, relying in part on the work of Hagel, Brown, and Davison[29] that the elements that according to the Schumpeter/Perez model make up the long waves, most importantly the institutionalization of new societal processes as a response to a new disruptive technology pervading the society, are no longer in place to generate the next wave. In this view, the exponential pace of technological development has led to a situation where the institutionalization processes simply cannot keep up with new technology. As a result, the system becomes characterized by constant reconfiguration

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[28] Adapted from Geels, Frank W. (2002): From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research Policy Volume 33, Issues 6–7, September 2004, p. 897–920.

[29] Hagel, J. – Brown, J.S. & Davison, L. (2008): Shaping strategy in a world of constant disruption. Harvard Business Review (October 2008), p. 81–89.

instead of a succession of societal waves each defined by a specific key technology aligned with a set of corresponding organizational, legal and production processes. This state of "constant disruption", then, becomes the essence of the new economy. Whereas Hagel et al. see the exponential growth of semiconductor-based technologies as the core reason for the continuous disruption in societies, Tuomi anticipates the end of Moore's law[30], but at the same time maintains that continuous disruption will find other sources and will no longer be tied to improvements in computing hardware. Although sceptical of the idea of the next wave, Tuomi believes assuming wide adoption of ICT to be key to understanding future sources of innovation and growth. Furthermore, Tuomi thinks that this development will lead to a shift of focus from basic technological innovation to harnessing opportunities offered by the technologies, with much more emphasis on downstream innovation processes. He also sees this transition as having a profound effect on societal processes. These could even be of the same magnitude as we might expect in a transition within the framework of the wave paradigm. Still, Tuomi's point is that we cannot rely on the same kinds of models to work in technology foresight or in policy planning as in the world of slower technological development.[31]

Alternatives and spinoffs of the K-wave theory in understanding societal change

Most of the work on the long waves and long-term patterns has been focused on looking at economic indicators. However, there are interesting observations that back up the lacking economical data by bringing up long wave -like behaviour in fields that are distant from the sphere of economics and belong more to collective psychological behaviour.

In 1986, Cesare Marchetti, at the time researcher at IIASA (International Institute for Applied Systems Analysis) published an article in the journal Futures, which was a part of a larger research programme investigating cyclicity in human activity. Marchetti argued that as cycles cannot rightly be described as a repetition, *déjà vu,* but still the emergence of new things seems to follow a somewhat cyclical pattern, a new term "pulsations" was more adequate in describing the phenomenon. Marchetti extended his analysis from the sphere of economics to encompass different kinds of societal activities and measured a variety of non-monetary physical indicators to examine whether or not the same kinds of long-wave pulsations as in economics could be found in other areas. He discovered a clear pattern of pulsed behavior of 55 years, from a period of at least 200 years, in infrastructure building, innovation, and even violence, and claimed the identified patterns could be mathematically formulated to allow quantitative forecasting based on them. Marchetti suggested an interpretation where the economic cycles would be just one instance in the sphere of social activities that gives rise to and reflects cyclicity. The root cause of cyclicity, or pulsations, then, would be the networked nature of social information trading that follows basic biological patterns. In Marchetti's framework "*an automobile is the trans-*

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[30] See chapter 4 for an in-depth discussion of Moore's law.

[31] Tuomi, Ilkka (2009): The Future of Semiconductor Intellectual Property Architectural Blocks in Europe. JRC Scientific and Technical Reports. EUR 23962 EN.

codification of a conceptual structure in the same way that an animal is the transcodification of a DNA structure", and following this logic, Marchetti did find even automobile population growth to mimic the growth patterns of animal populations.[32]

More recently, Peter Turchin, professor at the University of Connecticut, US, in the Department of Ecology and Evolutionary Biology as well as in the Department of Mathematics, together with two colleagues, Sergey Nefedov of the Institute of History and Archaeology in Yekaterinburg, Russia, and Andrey Korotayev of the Russian State University for the Humanities in Moscow, have continued in Marchetti's footsteps by developing a field they call Cliodynamics (after Clio, the Greek muse of history), which aims at applying the same mathematical models and simulations previously used in population ecology to understanding historical developments.[33]

Essentially, cliodynamics is based on analyzing four basic variables: population numbers, social structure, state strength and political instability, measured in different ways (social structure, for example, includes health inequality and wealth inequality, and both are measured using proxies that capture an essential aspect of the variable, such as life expectancy in social structure, and largest wealth to median wage ratio in wealth inequality). These different measurements are then plotted and examined for historical patterns emerging over time. An example of their findings using this method is that corruption tends to increase and political cooperation unravel right before a violent or in other ways unstable social period. The analytical tools allow the researchers to see the order of the changes, thus helping to find correlations between factors and providing potential explanations for historical events.

An interesting result from the perspective of this book is that the researchers have also found cyclical phenomena among their societal data. For instance, they have identified two major trends in political instability. The first is a supercycle of 200-300 years, in which societies move from a state of relative equality to a very polarized condition and back. The starting point is a society where there is a balance between the supply and demand for labour. As the population grows, supply exceeds the demand for labour. Elites start to form, and the poorest lose out on their living standards. Eventually, the top-heavy society falls into political instability when elites start to fight for power. The result is a collapse of the system, and the cycle starts anew.[34]

Even more interestingly, along with this very long cycle, the researchers observed a shorter, about 50-year cycle, which Turchin explains by a generations theory – two generations constitute a cycle, and the life experiences of each generation are affected by the conditions left to them by the previous one. An example of this cycle identified by the researchers is the occurrence of violence in the United States.[35]

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[32] Marchetti, Cesare (1986): Fifty-year pulsation in human affairs. Analysis of some physical indicators. Futures, 17(3), June 1986, p. 376–388.

[33] Spinney, Laura (2012): Human Cycles: History as Science. Nature 488, 24–26, (2nd August 2012).

[34] Ibid.

[35] Turchin, Peter (2012): Dynamics of political instability in the United States, 1780–2010. Journal of Peace Research, 49, p. 77–591.

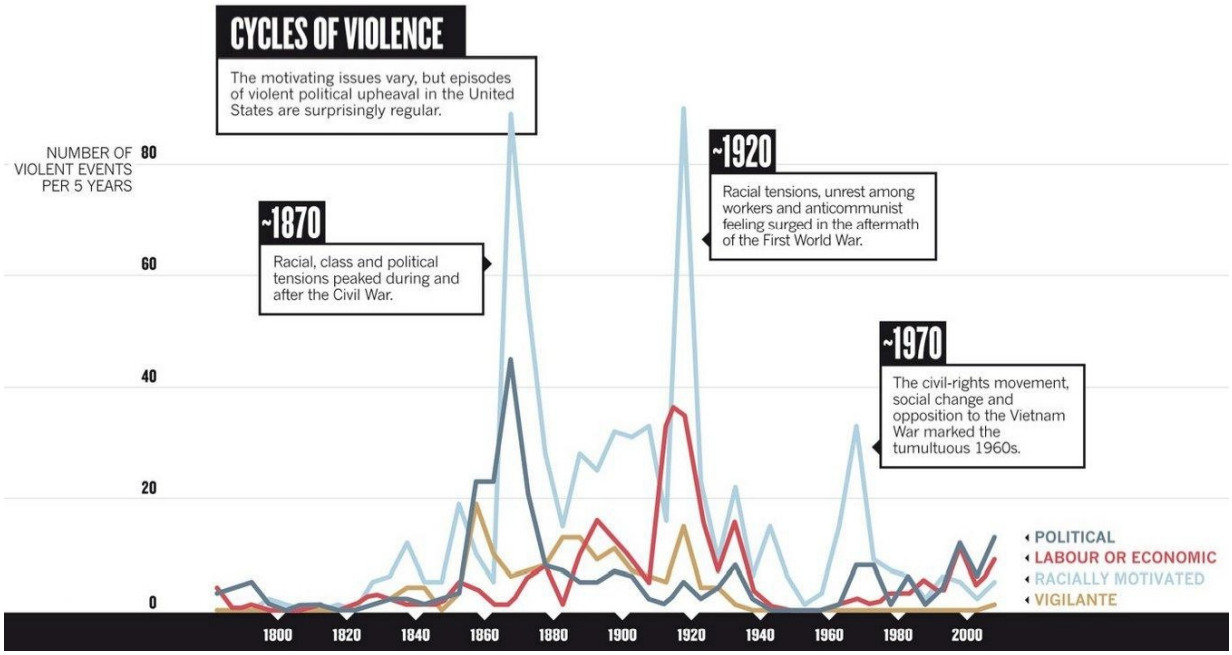

Figure 6. 50-Year Cycles in Violence. Reprinted by permission from Macmillan Publishers Ltd: Nature 488, p. 24–26, copyright (2012).

According to Turchin, the patterns of political instability in Europe and Asia from the first century onwards fit the pattern. He also claims that it explains the recent uprisings in the Middle East, most notably that of Egypt. In the decade preceding the revolution, the number of graduate students without prospects in the labour market multiplied by four, which according to Turchin is a sure sign of an imminent power struggle among the elite.[36]

Although traditional historians are suspicious of the cliodynamics method for understanding history, similar methods are not novel in computer social science or global policy, where models of societal trends have been searched for using algorithms, such as agent-based modelling, for some time. There is agreement between scientists in related fields that the modelling-based approach lends itself only to analyzing large societal trends, not individual events. Moreover, historical data about social practices that would be relevant for such research is very patchy, and for this reason historians strongly question using it for making predictions about derived historical trends. However, a large project to build a global database about rituals, social structure and conflict has been started at the University of Oxford, and when complete, it will give researchers more material to work on.[37]

[36] Turchin, Peter (2003): Historical Dynamics. Princeton University Press.

[37] Spinney, Laura (2012): Human Cycles: History as Science. Nature 488, p. 24–26, (02 August 2012).

DECONSTRUCTING THE SIXTH KONDRATIEFF WAVE – AN EXTREME VIEW

By John Casti, X-Center Vienna

The notion of change is inherently installed into the Kondratieff waves. To understand the dynamics of change is interesting for many parties. Investors would like to understand where are those emerging and lucrative business opportunities, social scientists would like to get hold of societal transformations shaking our societies, technology freaks would like to grasp how the next gadgets look like etc. But predicting future is much more complicated thing than we mostly allow ourselves to think even, if we have Kondratieff wave theory as our backbone[38]. In what follows, we are taking course on the dynamics of change.

Trends and Turning Points

Most of the phenomena of nature and everyday human life seem to repeat themselves in broad patterns. The coming and going of the seasons of the year, boom-and-bust cycles in financial markets, even the rise and fall of world powers illustrate this observation. But these patterns while cyclic, are not periodic in the sense that they do not unfold with metronomic repetition. So we cannot forecast with total assurance exactly when the next stock market crash will occur or who the next great power will be to fall by the wayside of history. Figure 1 below illustrates this argument for the rise and fall and rise again of the phases of gross domestic product (GDP) for a hypothetical country.

The figure shows that the GDP goes through periods of depression, expansion, recession and then depression again in a predictable manner. But the length of time for each of these phases is not necessarily the same, as in the figure we see the depression and expansion period exceeding that of slowing expansion and recession. But this is not what's important about this graphic.

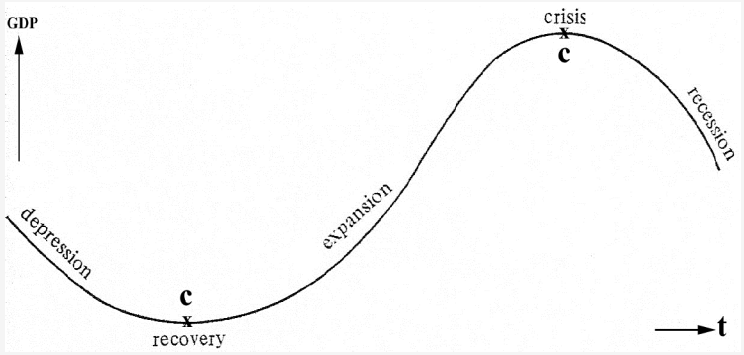

Figure 1. Cyclical decline and growth of a nation's GDP.

Looking at Figure 1, we see that the moments in time at which the economy is either growing or shrinking constitute literally almost all the time. In everyday language, we call such moments "trending" points, or more technically "regular" points. The only instants that are not trending points are those I've marked with the letter **c** to indicate that they are "critical" points. These are the places where the current trend, whatever it may be, is rolling over to a new trend. In the economic context of Figure 1, these are the moments when depression is giving way to recovery and when expansion faces a crisis that yields to recession.

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[38] See more discussion on the topic: "The Sixth Kondratieff – Long Waves of Prosperity." Allianz Global Investors, Munich, January 2010. Wilenius, Markku (2011); Johtajuus kuudennessa aallossa [Leadership in the Sixth Wave]. Tieto ja osaaminen kilpailuetuna [Knowledge and Competence as an advantage]. Kauppalehti publications, Helsinki; Casti, John – Ilmola, Leena – Rouvinen, Petri & Wilenius, Markku (2011): Extreme Events. Taloustieto, Helsinki; Moody, James & Nograd, Bianca (2010): The Sixth Wave. Random House, Sydney. Alexander, Michael (2002): The Kondratieff Cycle. Writer's Club Press, Lincoln, Nebraska, USA.

Now consider the question of forecasting. Suppose the economy is currently at one of the regular points, and you are asked to predict where the GDP will be at the next time instant. In this case, the answer is easy: It will be just where it is today, only a little higher or lower depending on whether the regular point is on the growing or the declining part of the picture. And you will be right! So almost all the time your "prediction" will be trivial to make and will even be correct. It will only fail if you are at a critical point. But these form an infinitesimally small set of points in the space of all time instants. Thus, if you pick a moment in time at random you have probability one of having your forecast be correct. Regrettably, the information content of such a forecast is basically zero, and you certainly shouldn't be ready to pay good money to anyone for providing you with such information-free "information." On the other hand, a method that could accurately predict where the critical points are and how sharp the turn is at those points would be real gold, not fool's gold, a method you should be ready to dig deep into your pocket to obtain. Sad to say (perhaps!), there are good logical and empirical reasons to believe that without possessing a formal dynamical model giving you the rule for exactly how the curve in Figure 1 unfolds, at every moment, there is no forecasting method that can consistently and reliably tell you where the critical points reside from just a knowledge of a finite number of points on the curve[39].

So it is the critical points that are the key elements in understanding a cycle. Often, these turns are quite sudden, at least within the timeframe of the overall cycle, since they unfold over a very short time compared to the length of the full cycle itself. While I have noted that the critical points are rare, this timing aspect also tends to make them seem surprising, or even shocking, to observers accustomed to the more leisurely pace of development of the waves formed by the regular points. We will call such rare and surprising events "extreme events," or more compactly *X-events*[40]. It is the X-events that we would like to be able to more fully identify and understand.

The reason our armory of forecasting tools doesn't allow us to predict the specific timing of the X-events is that at a given moment there is always a spectrum of potential events that might take place at the next instant. That spectrum of possibilities is fixed by the circumstances of the moment, the *context* of the current situation. The event from that spectrum that actually does occur is then a combination of the context and an inherently random "shove," or "trigger," that sends the system from its current state to the new state that we in fact observe.

The context is continually unfolding and is what shapes the set of events that are possible at any particular instant; the random trigger is inherently unpredictable, since by definition it is random and thus has no pattern. So when we say we have a model, we are saying that we know the rule by which not only the context changes, but also the rule that encapsulates the action of the random trigger as well. Even in physics it's a very tall order to claim knowledge of such a rule; in the social domain it's essentially unheard of since the random trigger is just that, random. The next section takes up the issue of what we can do when we have neither a dynamical rule of change for the system nor enough data to effectively use probability theory and statistics to characterize the likelihood of any possible new state. Before moving on to that story, though, let me say a word about the interpretation given to the various phases of the cycle shown in Figure 1, since this will play a big role when we come to talk specifically about the Kondratieff cycle later in the paper.

Consider the idealized picture shown in Figure 2, one that many analysts regard as valid description of the last five Kondratieff cycles. This picture is of great interest for us now, indications are that we are currently rather deep into the D part of this picture for the fifth wave. So our focus in the current study is to understand and identify the critical point marking the beginning of the sixth Kondratieff cycle.

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[39] For more information on critical points, see Chapter Three in Casti, John (1996): Five Golden Rules, Wiley, New York; Peters, Edgar (1994): Fractal Market Analysis, Wiley, New York.

[40] See Casti, John (2012): X-Events. The Collapse of Everything. HarperCollins/Morrow, New York.

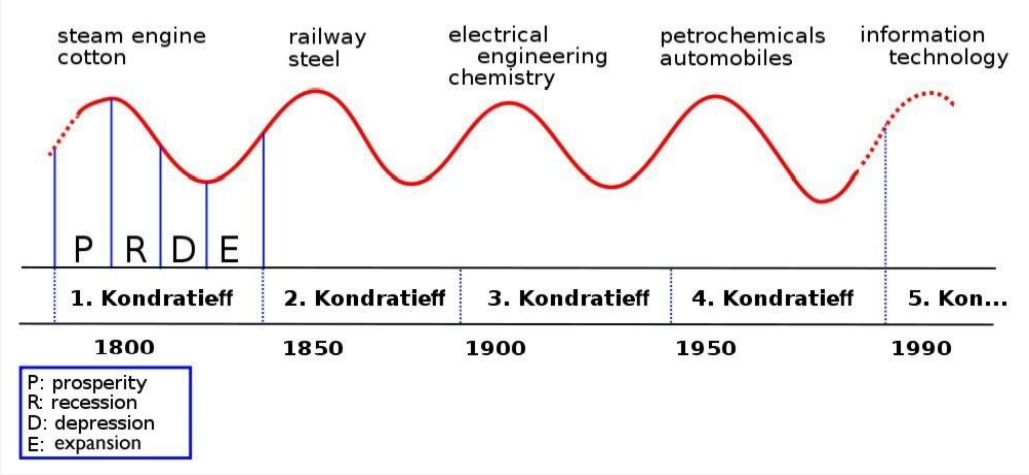

Figure 2. The last five Kondratieff cycles.

It's of more than passing interest to note that the while the chart in Figure 2 is essentially a timeline of the rise and fall and rise again of an industrialized economy, the labeling at the top of each of the five waves is a characterization of the dominant technology of the wave. This specific interpretation of each wave plays a central role in the literature of "global Kondratieffs," a subject that we will return to in the last section of this paper. For now, it suffices to ask the question: Where did these labels come from? They are certainly not predictable from the Kondratieff curve itself, since that curve is only about economic factors like GDP. Obviously, the labeling is an *ex-post facto* artifact, generated by pundits and seers after the curve's timing and the length of its cycles have revealed themselves. So a major component of the question is how much information can we squeeze out of the Kondratieff picture by way of predicting, not "postdicting," the label that people place today on the Sixth K-wave? To address this matter, let's delve a bit deeper into the way not only the Kondratieff cycles, but all cyclic human phenomena, are actually generated.

X-Events, Social Mood and Resiliency

As one might expect for a process called "cyclic," there is a more-or-less standard set of steps that human social processes follow, a fact that as illustrated in both Figures 1 and 2 leads to their recognizably repetitive pattern. For the sake of definiteness, we quickly review those steps.

Trending: As noted earlier, a dynamical system is in a trending mode (at a regular point) at almost every moment, the cyclic behavior starts with the system in either an uptrend (Expansion and Prosperity) or a downtrend (Recession and Depression).

As time goes on, the various components of the system interact and the complexity levels of the components change in such a fashion that unsustainable complexity gaps emerge. These must be narrowed for the overall system to be capable of carrying on its activity. At this point, the system has reached a *Critical Point:* This is the point where the system begins to roll over from the current trend to a new trend of opposite polarity. This process might be relatively calm and smooth if the complexity gap is narrowed voluntarily. Usually, though, the gap is not closed by thoughtful action on the part of the system's regulator (generally the government or some form of corporate controller).

Random Trigger: The critical point in unstable, in the sense that a small disturbance is all it takes for the trend to now reverse itself into the opposite polarity. This perturbation, or sometimes "shock" if the disturbance is great enough, is random; without pattern. As a result, the disturbance cannot in principle be forecast. If the new state of the system following the triggering disturbance is both rare and surprising, as well as one that leads to large social impact, then we say the system has experienced an *X-Event:* This is a rare and most often surprising and rapid flip from the current trend to its opposite. The specific form the crash-generating X-event takes is like all events, dictated both by the circumstances at the moment of the crash and the specific random trigger that catalyzes the event. So we can only place bets on the relative likelihood of the different possibilities. One way to do this is to recognize that the "landscape" of the context

that determines a large part of the actual event is strongly biased by the social mood of the population, what the population believes about its future. So if we measure the social mood at the critical point, we can then weigh-up the likelihood of the various possibilities for the character of specific X-event that will occur to close the complexity gap.

Innovation: Generally, the X-event will give rise to considerable physical damage, loss of life, financial costs and/or psychological stress, at least in the immediate aftermath of the event. For this reason, people generally jump through hoops of fire to avoid having *any* X-event at all take place, the principle at work being that the status quo must be preserved. The historical record, though, is not very kind to this sort of wishful thinking. Neither Mother Nature nor human nature seem to care very much about what people actually want. So the X-event happens anyway, and is generally far more destructive than it need have been if the futile efforts to prevent it had not occurred. This is a generalization of what happens when you refuse to authorize a controlled burn of trees in an overgrown forest. That refusal eventually leads to a far more damaging forest fire than would have otherwise been the case when nature steps-in with a lightning bolt to set the entire forest ablaze. So in the immediate short-term, the X-event generates a huge negative social impact. The longer-term perspective though is quite often a different story.

Consider the earthquake and resultant tsunami in March 2011 that led to the meltdown of the Fukushima Daiichi nuclear reactor in Japan. There is a good reason to expect that if we went to sleep now and woke up in 25 years, it would be a good guess that just about everyone in the room would not see the Fukushima meltdown as the worst thing that ever happened to Japan, but would instead regard it as one of the *best* things that ever happened.

Why? Simply because the total reexamination of Japanese society that's currently underway could never have taken place in a gradual, evolutionary fashion. Japan had to be literally blasted out of an orbit that the country had been in since the end of the Second World War, in order that such a massive social reconfiguration could even be discussed. The nuclear reactor destruction was the type of X-event that in the scope of history will be seen as the trigger that sparked off an entirely new set of social, economic and political structures in Japan[41].

This process of reconfiguration of Japanese society is a *prima facie* example of what Austrian-American economist Joseph Schumpeter called "creative destruction." According to Schumpeter, the new world that emerges from the ashes of the X-event is shaped by innovation[42]. Just as with the Fukushima X-event, old ideas and ways of social activity are always opened up for examination in the destruction phase of an X-event. Many new societal "eco-niches," or degrees of freedom, not present in the pre-event period arise and call out to be filled by novel, innovative services, products and processes. In essence, totally new ways of carrying-on life and doing business emerge. The essence of the concept of system *resilience* is the idea that those organizations and institutions that are strong enough and lucky enough to be able to not only survive, but also absorb and assimilate, the X-event, as well as be adaptive enough to change their ways to fit in to the new, post-X-event world, will actually prosper from the X-event instead of being blown away by it[43]. At this point a new trend sets in, and a rebirth of the system takes place. Then the process starts all over again from that new trend.

The entire cycle of old trend to new trend can be seen in the diagram displayed in Figure 3, which can be called the Fundamental Diagram of Social Processes:

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41 A comprehensive overview of the way the Fukushima incident is changing Japanese society is given in the following special issue of the journal Foreign Policy: "Tsunami: Japan's Post-Fukushima Future. Essays on the Many Aftershocks of Japan's Nuclear Nightmare." J. Kington, ed. June 2011.

42 Schumpeter, Joseph (1942): Capitalism, Socialism and Democracy. Harper New York.

43 Useful references on the notion of resilience include Zolli, Andrew & Healy, Ann Marie (2012): Resilience, Headline, London; Gopalakrishnana, K. and Peeta, S. (eds.) (2010): Sustainable and Resilient Critical Infrastructure Systems, Springer, Berlin; Gunderson, Lance & Holling, C.S. (eds.) (2002): Panarchy, Island Press, Washington, D. C.

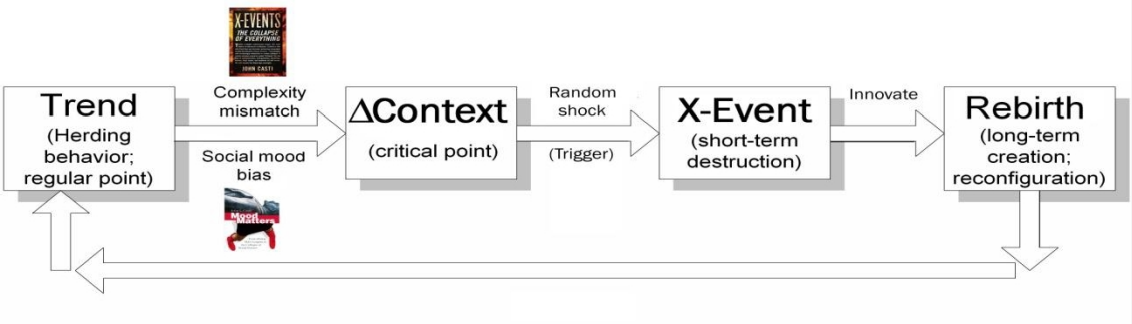

Figure 3. The Fundamental Diagram of Social Processes.

To make effective use of the Fundamental Diagram, we need to be able to characterize and quantify the boxes and the arrows in the chart. These are basically the action items, the "verbs," of the diagram, the elements that carry us from one phase to the next. In Figure 3 I have added icons for my two recent books, each of which covers in great detail the activity in its corresponding arrow[44]. In the next section we will take a telegraphic look at the distilled essence of the message from each of these volumes.

Measuring the Risk of Unknown Unknowns

Our concern here is with how the Fundamental Diagram of Figure 3 applies specifically to the Kondratieff cycles sketched at the beginning of the paper. But before setting out on this task, we need to have a quick look at the way we can address the first arrow in that Diagram, the one labeled "complexity mismatch" and "social mood bias." An effective measure characterizing the complexity mismatch would enable us to identify when the socioeconomic system is starting to become ripe for a revolutionary change. Measurement of the social mood at that critical point would then give us some idea of the specific *type,* or the *character,* of the X-event that's likely to upset the apple cart and send the system into an entirely new behavioral mode. So before turning to the Kondratieff cycle itself, let me spend a few pages outlining an approach to these two questions.

Some years ago when complexity science was still in its infancy, MIT professor Seth Lloyd took on the task of trying to pin down all the various notions of that had been proposed to measure the complexity of a system[45]. In the end, he put together what I believe is a still-unpublished account of what he'd discovered, titling it "31 Flavors of Complexity" in honor of the well-known slogan employed by the American ice-cream chain Baskin-Robbins. This exercise showed that what is and isn't complex depends to a large degree not only on a target system, but also on the system(s) the target interacts with, together with the overall context within which the interacting systems are embedded. In short, there is "no one-size-fits-all" definition of complexity that will be the "right" definition for each situation[46]. Let us illustrate this with the well-chronicled example of regime change in Egypt.

Egypt had a state-controlled economy that was wildly mismanaged for decades. Even the noticeable improvement in the past few years is a case of too little, too late. Moreover, the country was (and still is) monumentally corrupt, as crony capitalism runs rampant throughout the entire social structure. Such a system of corruption relies upon bribes to officials to get contracts, obtain jobs or to find adequate housing. Amusingly (and tellingly) the impotence drug Viagra was reportedly kept off the market because its manufacturer, Pfizer, failed to pay a large enough bribe to the Egyptian Minister of Health for its approval[47].

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44 See See Casti, John (2012): X-Events. The Collapse of Everything. HarperCollins/Morrow, New York and Casti, John (2010): Mood Matters, Copernicus, New York.

45 Lloyd, Seth (ca. 1993): "31 Flavors of Complexity," unpublished.

46 Some useful general references on complexity science include Casti, John (1994) Complexification, HarperCollins, New York; Miller, John & Page, Scott (2007): Complex Adaptive Systems, Princeton University Press, Princeton; Mitchell, Melanie (2011): Complexity: A Guided Tour, Oxford University Press, New York.

47 Naam, Ramez (2011): "Egypt, Twitter, and the Collapse of Top Heavy Societies"

This type of parasitic mismanagement and corruption worked to freeze in place an already low-complexity government, one that had very few degrees of freedom in either its structure or means of dealing with social problems as they arose. But as long as the Egyptian population had even more limited ways to express their dissatisfaction with a lack of proper housing, rising food prices, minimal health care and the like, the government had no motivation to create the framework(s) necessary to provide these services. Of course, there was a ministry charged with health care, for example. But it served mainly as a sinecure for career bureaucrats and cronies of those in power, and provided health care only as a kind of spare-time "optional extra." Who would expect this to ever change as long as the spectrum of actions available to the citizenry was kept at a low level (low complexity), one much lower than that of the government itself? But times change, and when modern technologies like instant global communication, widespread higher education, and rapid transportation started making their way into the Arab world, citizens quickly became empowered. At this point, the handwriting was on the wall (more to the point, Facebook walls) for entrenched regimes throughout the region[48].

Here I use the simple-minded notion that the complexity of a system can be characterized by the number of independent actions the system has at its disposal at a given time. Of course, these degrees of freedom change over the course of time. So the complexity gap between any two such systems in interaction also varies over time. My argument is that two systems, be they the populace and government of a country or the rich and poor classes in a society, can comfortably co-exist only if the complexity gap between them remains reasonably small. In short, the gap measures the level of stress in the overall system. If at some period the stress becomes too great to be sustained, then the system is on the edge of chaos and an X-event to reduce the complexity gap is looming. At this stage, the system's regulators have to step-in to reduce the gap or the entire structure will collapse[49].

We should keep in mind that while the number of degrees of freedom in taking action seems to work well in many instances as an operational definition of the system complexity, it is by no means a universal measure. So in another situation the "right" definition of the complexity could well be something very different. Basically, what measure to use is an empirical question, one that must be thoroughly explored for each situation in its own right. There is no magic complexity bullet.

Turning to the question of what type of X-event is likely to take place once a system is pushed over the edge, we need to create a way to measure the society's social mood. Recall that the social mood of a population is simply the belief the society holds at a given time about its future on different timescales[50]. So if the group believes that next month will be better than today, its social mood is positive on the timescale of a month; if the group believes that next month will be worse than today, then its mood is negative on that same timescale. Obviously, the question "What do you believe about the future?" has as many potential answers as there are timescales. This is important because collective social events unfold over different timescales, too. So we need to match carefully the timescale of the mood measurement to the timescale of the unfolding of the event. So, for example, if our interest is in a short timescale event like a trend in popular music, that event unfolds over a few months or so. In that case, we have to take our social mood measurements on a scale of weeks. On the other hand, weekly measurements wouldn't tell us much about a long timescale event like the decline and fall of a great world power like Russia or the USA, which unfolds over decades if not centuries.

A convenient and useful, although far from perfect, meter stick for measuring social mood is a financial market index like the S&P500 index for the US markets or the Nikkei index in Japan for the Japanese

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[48] A useful reference to the instability and complexity overload incipient in the so-called Arab Spring is given in Helgesen, V. (2011): "The Butterfly Effect and Arab Spring,"

[49] This remark is a re-statement of a famous theorem in complexity science called the Law of Requisite Variety. It was first expounded in the volume W. Ross Ashby (1956): Introduction to Cybernetics, Chapman and Hall, London.

[50] Casti, John (2010): Mood Matters: From Rising Skirt Lengths to the Collapse of World Powers. Copernicus Books, New York.

social mood. Basically, the argument supporting a market index as a measure of social mood is that when an investor or speculator takes out a position in a stock, they are making a bet about the future on a particular time scale. The market collects all these bets and synthesizes them into a single number: a change of price. If there are more negative bets about the future of the stock, the price declines, more positive bets, it rises. Let me illustrate the use of a financial index as a social mood meter ("sociometer") with a report on the ups and downs of collective political and economic events over a fifteen-year period in a major country, Brazil.

Since our concern is with events in Brazil, the right sociometer for this study is the Bovespa Index, which measures the gyrations on the exchange in Sao Paolo. The chart in Figure 4 shows the monthly movement of this index, as well as the major financial, political and economic activities taking place during this period from 1992–2007. The story told by this graphic is compelling. Whenever the social mood in Brazil turned negative, bad things like a currency devaluation, a bank failure, or a presidential impeachment were the *plat du jour*. On the other hand, when the Brazilian mood swung upward and people were optimistic about their future, economic recovery, election of a populist president, and the profitable sale of productive government assets dominated the headlines.

Figure 4. The Bovespa Index and major events in Brazil, 1992–2007.

Our leitmotiv in this section is to recognize that the progression from a positive social mood to a negative one is a movement from one polarity in the qualitative character of social events to another. We can label these polarities with everyday English words appropriate for the particular type of social trend or event we are focusing upon. So, for instance, if our concern were with the future of the automotive industry, a firm like Ford or BMW might be thought of as *adventurous* or *outward looking* in times of rising social

mood as they try to expand their markets to other products and/or territories. On the other hand, as the mood turns negative we might see a situation in which these firms become *protectionist*, seeking to preserve whatever market share they already have against real or perceived "poachers." So the two terms – adventurous/protectionist – represent polar opposites associated with strong positive or negative social moods. Table 1 gives several more such polarities:

Table 1. Polarities of positive (+) and negative (−) social moods.

Positive mood (+)	**Negative mood** (−)
Unifying	Divisive
Liberating	Restricting
Adventurous	Protectionist
Togetherness	Separation
Supportive	Opposing
Open	Closed
Happy	Sad
Hard-working	Lazy
Manic	Depressive
Tolerant	Bigoted/xenophobic

As we move from positive to negative mood, we move from a state of optimism and looking forward to a brighter future to pessimism and a future we fear. This psychological disposition in a population has deep implications for the relative likelihood of societal events of every sort taking place – including X-events. The implications we draw from this, however, should all be taken with several pinches of salt for the reasons we've already discussed. The more specific the type of event we're focusing upon, the less likely it is to occur as forecast, at least in fine-grained detail. But what is likely is that an event from the same "family" of events is more likely to occur than something from a very different family.

We also noted before that collective social events unfold on very different timescales. So the assessment of whether the social mood is positive or negative depends on what timescale we're talking about for the development of a particular type of event. It can easily be the case that the mood lies on the positive side of the foregoing chart for, say, a short-term event like a developing trend in tastes in popular films, while being very negative indeed for longer-term events like peace, or at least the cessation of hostilities, finally coming to the Middle East. Wars do not break out in hours or days but generally take weeks and months or even years to actually unfold. Similarly, a change in popular taste in music does not reveal itself over centuries; it is a phenomenon whose natural timescale *is* measured in weeks to at most a few months. So in evaluating a question about the likelihood of a future event, you should first ask yourself, "What is the natural timescale for the event in question?" At that point you can go to the chart of the DJIA or another financial index perhaps more relevant to the event in question to use as your sociometer, examining it on the relevant timescale for the event under consideration in order to evaluate whether the mood is rising or falling. This information, together with the polarities of Table 1, as well as any other supporting information is available such as media reports, personal observations, and the like, constitutes the raw material from which to formulate an answer to the question[51]. Let's now try to apply these principles to events about a longer-term question, which will then serve as a lead-in to our investigation of Kondratieff cycles.

[51] A reasonably full account of various types of sociometers, their pluses and minuses, can be found in Casti, John (2010): Mood Matters: From Rising Skirt Lengths to the Collapse of World Powers. Copernicus Books, New York..

Tension in the Middle East is a bellwether rift that has an almost perfect record of erupting into open hostility right at the onset of major downturns in social mood. Figure 5 shows that virtually every major change in social mood was presaged by either the eruption of active hostilities in the Middle East or by a period of easing of tension and hopes for a better, or at least more peaceful, future[52]

Figure 5. Ups and downs in the Middle East, 1925–2000.

A couple of points on this diagram are of special interest. We see that the longest period of goodwill and cooperation between the warring factions was a Middle East *Era of Good Feelings*, which ran from September 1993 through January 11, 2000 – *3 days* before a major high in the DJIA. By the summer of year 2000 tensions were rising, as the Palestinians threatened to declare statehood. As the social mood declined through the fall of 2000, riots were commonplace and Yassir Arafat's popularity underwent a major shift upward. By May 2001 newspaper headlines were asking, "Is It War Yet?" and Israel employed US warplanes against the Palestinians for the first time since the 1967 war. As stock prices were in a downturn in September 2001 that would only reverse one year later in October 2002, it would certainly be consistent with the idea of a major war breaking out after a trend change in social mood. So where do we stand today on the prospects for the Middle East during the next few years?

Recall the general principle operating here: good things tend to happen in the Middle East when the mood is positive, bad things when it's negative. But now let's get a bit closer to the action and look not at the US Dow Jones Industrial Index but at the index of the Israeli stock market in Tel Aviv. Figure 6 shows this index over the entire history of the state of Israel, together with several of the major political and military events in that period.

In general, the pattern of positive mood as a leading indicator of "nice" events was borne out during this period with a couple of nontrivial exceptions marked in red. These exceptions underscore the fact noted earlier that social mood is not a 100% sure-fire indicator of what will or will not happen. It only sets the tone for what is *more likely* than not to occur. This graphic illustrates that maxim in spades. It also strongly

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[52] Note: On the chart, the vertical scale is the DJIA adjusted for inflation via the consumer price index, i.e, the DJIA/CPI

suggests that if the Israeli social mood is indeed flattening out as it appears in this chart, we could be in for some "interesting" times in the Middle East over the next several years.

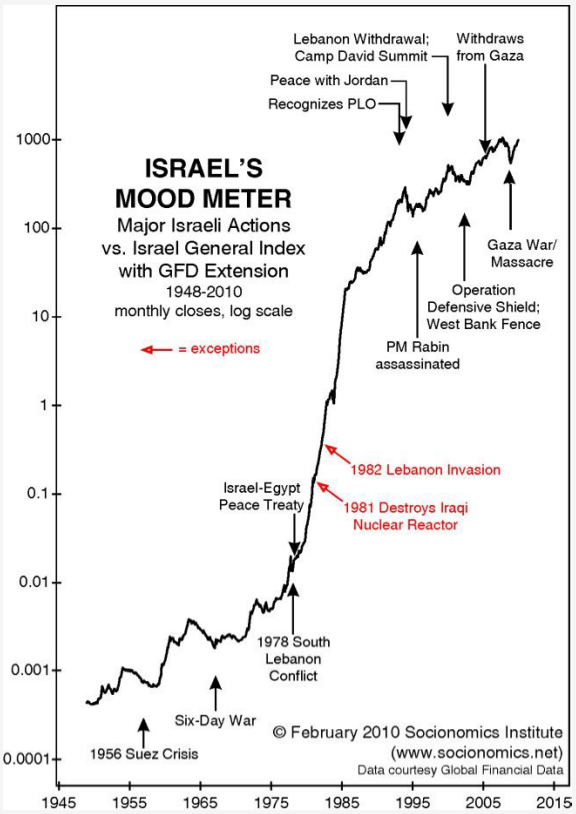

Figure 6. Israeli social mood and events, 1945–2010.

The foregoing arguments and examples provide evidence to support the notion that the mood of a population, it's so-called "social mood," biases the types of social events and behaviors that we can expect to see on all time scales. And this applies to all events, including X-events. At any given moment, the change of mood may trigger the change of events, and, eventually, the turn of trends. Let me speculate on how some of the megatrends we now observe as a basis for the coming wave might oscillate.

Globalization

Digging into the way in which people, money, goods and everything else makes its way around the world, we see the specter of complexity hanging like a shroud over every step of the process. The system of globalization has given corporations a vast array of ways (degrees of freedom) for the development of new products, for the manufacture of existing products, for the marketing of their wares and the like by picking and choosing where and when these functions are carried out[53]. Thus, in a world with no national boundaries or constraints, transnational corporations command a huge level of complexity. On the other hand, the system composed of the global population, at-large, as represented by national governments, has given up most of whatever freedom it had to regulate what can and cannot cross borders without having to pay. In short, nations have voluntarily reduced their complexity in the business realm to a minimal level. As always, as that complexity gap between business and government widened so did the social stress of growing un-

[53] The phenomenon of globalization has been widely chronicled in both academic and popular writings. A few milestones on that path are James, Harold (2009): The Creation and Destruction of Wealth, Harvard U Press, Cambridge, MA; Dumas, C. (2010): Globalization Fractures, Profile Books, London; Saul, J.R. (2005): The Collapse of Globalism, Penguin, Victoria, Australia.

employment in western countries, as all but the high-skill jobs moved to Asia. We are seeing the end result of this mismatch in these very days, as the US tries desperately to address the problems of a jobless recovery from the financial crash of 2007, while Europe struggles to deal with an even more serious financial crisis, not to mention the social disruption emerging from its own dangerously high levels of unemployment, particularly in the southern countries of the European Union like Greece, Italy, Spain and Portugal.

As the ongoing tension between the United States and China dramatically illustrates, net exporters like China must accept an appreciation in the value of their currencies. On the other hand, net importers like the US have to devalue. Of course, the exporting countries strenuously resist taking this step, as the revaluation process would bring the flow of goods and money into balance – precisely what the exporters do not want. Initially, this obvious fact gets played out in diplomatic circles. But if the diplomats don't get the job done within some acceptable period of time, financial markets will step-in to do it for them. The result of that leveling of the playing field will not be pretty. In fact, this is another good example of a complexity mismatch that is very likely to be resolved by an X-event, namely, a massive devaluation of the US dollar, protectionist legislation, and a host of other actions that will only accelerate the process of the world economy falling into a deep deflationary depression. Here's an example illustrating the basic problem of globalization.

The formation of the EU can certainly be seen as a "joining, globalizing"-type of event. And indeed that event, the 1957 Treaty of Rome, took place at a time of increasingly strong feelings on the part of European governments that the time had come to unite into a single political body. Despite some setbacks in getting the EU Constitution approved in 2005-2008, the history of the EU has been pretty much onward and upward – until now. Forces of "separation" and "localization" have begun to dominate, showing up in events ranging from the unwillingness of prosperous states in the EU to prop-up the finances of the weaker members to talk of the re-imposition of borders controls by some countries so as to stem the flow of unwanted economic refugees from the Balkans, Turkey and elsewhere.

When organizations, especially states or an empire, encounter problems the time-honored way to solve them is to add another layer of complexity onto the organization. Basically, this solution is the well-known process of "bureaucratic creep." As problems accumulate, the bloat of bureaucracy increases to the point where the entire resources of the organization are consumed in just maintaining its existing structure. When the next problem comes online, the organization falls off the "complexity cliff" and simply collapses[54].

Many times this complexity cliff shows up when two (or more) systems are in interaction. The gap in complexity between them becomes too big to sustain and an X-event emerges to close it. We saw this process earlier in the collapse of the repressive regimes in Tunisia and Egypt, both of which were facilitated by a rapid upgrading of the complexity of the lower-complexity system, the citizenry of each country, via social networking and modern communication channels. The governments could neither suppress this complexity buildup, nor keep up with it themselves. The end result was, of course, the X-event of rapid, violent regime change.

To illustrate this principle in the context of the EU, think of the Eurozone countries as a system in interaction with the rest of the global economy. If the countries were not in the Eurozone, they would have many options at their disposal to address changing economic times. They could, for instance, manage the supply of their own currencies, raise or lower interest rates, impose trade tariffs and the like. In short, they would have a high level of complexity that comes from the many different types of actions available to be taken.

Instead, the Eurozone members are severely constrained since no country can act unilaterally but must act in unison as per the dictates of the European Central Bank (ECB). So a complexity gap arises between a high-complexity system (the non-EU world) and a low-complexity one (the Eurozone states). Loans from the wealthier Eurozone countries to the indebted ones, along with other efforts by the ECB to bridge this complexity gap will almost surely end up falling into the category of "throwing good money after bad" (literally!). Ultimately, this will lead to human nature's default solution for such problems, which in this case

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[54] See how this has happened in the past at the level of complete civilizations: Tainter, Joseph (1988): The Collapse of Complex Societies. Cambridge University Press, New York.

will be the extreme event of a collapse of the Euro, and very possibly the EU itself. Here it is no pun to call it a "default" solution.

The take-home message from these examples is that the phenomenon of globalization as a driver of the 6th Kondratieff Wave is not a "slam dunk." It can easily come undone in a variety of ways, just as the EU can come undone. All it might take is for a substantial fraction of people around the world to start believing that the long-term future will be worse than today instead of better. At that point, a movement toward localization instead of globalization will be the way to bet, as countries retreat behind their national boundaries, (re)establish border controls and, in general, return to their earlier tribal patterns as a protective mechanism to weather the global storm.

Demographics

Trends in age-group cohorts, migratory movements from one geographic area to another and other such dynamical changes in the makeup of populations are among the most reliable of all forecasts in the social arena[55]. One of the underlying reasons is that such shifts take place on a very long timescale, generally decades or longer, a length of time over which shorter-term fluctuations are simply "noise" on a seemingly inevitable march forward. So for an X-event-type of surprise to throw a demographic forecast off-course, it has to be a true bombshell of a surprise, not simply something that momentarily raises an eyebrow or two. The Four Horsemen of the Apocalypse – Famine, Pestilence, Destruction and Death – give a foretaste of what such an X-event might be like. Let's start with Pestilence.

Epidemics and even pandemics are far from a new phenomena. They have been with us for just about as long as humankind has walked the planet. And they're not going away anytime soon. Just to put some meat onto this skeletal statement, here is a short list of some of the more infamous and deadly outbreaks of such diseases over the last couple of millennia.

The Antonine Plague (165–180 AD): A suspected outbreak of smallpox that decimated Rome for more than a decade, killing 5,000 people a day at its peak. Estimated number of deaths: 5 million.

The Plague of Justinian (541–750 AD): This was probably bubonic plague in the eastern Mediterranean area. The disease began in Egypt and quickly spread to Constantinople and then to Europe and Asia. According to chroniclers of the period, the disease was killing 10,000 people a day in Constantinople at its peak. Estimated number of deaths: One-quarter to half the human population in the areas where it was active.

The Black Death (1300s–1400sand beyond): A pandemic outbreak of bubonic plague in Europe, the Middle East, China and India. Estimated number of deaths: 100 million over a period of 200 years.

Spanish Flu (1918–1919): The "Great Influenza" was almost surely the deadliest pandemic in history. It is said to have started in Haskell County, Kansas, and was then transmitted though movement of soldiers at the end of the First World War. Estimated number of deaths: 100 million. In contrast to the Black Death which killed over a period of centuries, the Spanish Flu claimed a similar number of victims in just six months. To put this figure into perspective, given that the world's population is now about four times larger than it was in 1918, the same illness with the same level of lethality would now strike down over 350 million people worldwide.

AIDS (1981–present): Most likely this is a virus that "jumped" species from monkeys to humans in Africa a few decades ago. Estimated number of deaths: 25 million and climbing.

This chronicle could be greatly extended but the point is clear. Epidemics and their much nastier relatives, pandemics, richly deserve their position as one of the Four Horsemen of the Apocalypse. But the foregoing list is just a summary.

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[55] An informative and entertaining source for the claim that population and demographic forecasting is one of the most reliable of all areas of scientific forecasting is the book Sherden William (1998): The Fortune Sellers, Wiley, New York.

One might wonder where these killer diseases come from and whether they have been around since living organisms crawled out of the primeval soup. According to recent work by Nathan Wolfe, Claire Dunavan and Jared Diamond, major human diseases are of a fairly recent origin[56]. For the most part, they have arisen only after the origin of agriculture. This work identifies several different stages through which a pathogen that originally infects only animals can evolve into one that exclusively infects humans. The main point in this research for us is that diseases leading to epidemics can arise from sources that originally have nothing to do with humans, at all.

At the level of growing complexity gap leading to an X-event, the picture is rather clear. We have two systems in interaction, the pathogen and the human immune system. Each has its own complexity level determined in one case by the tools that the pathogen can employ to penetrate the immune system's defenses, pitted against the tools the immune system can bring to bear to resist the attack. As long as these two levels of complexity stay more or less in balance, no infection takes place. But when the pathogen mutates faster than the immune system can react, that's when trouble begins. And as that gap between the two systems widens throughout a major fraction of a population, an explosive level of infection can occur. Eventually the gap is narrowed as the immune systems of the population finally adapt and catch up to the pathogen. But the speed of complexity increase on the two sides of this "arms race" may be very different, accounting for the many years it often takes for a plague-style pandemic to run its course. Now, what about the next Horseman, Famine?

The big firms that dominate food production severely restrict genetic diversity by employing just a few varieties of plant seed, sometimes just a single variety. If a disease struck that particular variety, food production would be in big trouble, and the entire food-supply system could collapse[57]. A virus strikes right at the deepest level of the food chain beginning with grasses, destroying that vital first link. But a virus isn't the only way to undo the plant world as there are other links in the chain from grass to the food.

In February 2011 the Food and Agriculture Organization of the United Nations reported that its food price index composed of a basket of key commodities such as wheat, milk, oil and sugar had risen 2.2 percent from its January level, and sat at its highest level since the organization started monitoring prices more than two decades earlier[58]. Let's take a quick look at the constellation of problems leading to this continuing escalation of food prices worldwide.

The huge increase in food prices over the past five years can be accounted for by forces acting to simultaneously reduce the supply of food and greatly increase its demand. As we all know from Economics 101, these two factors constitute the perfect one-two combo to rip apart the food budget of every household. The supply side factors leading to a decline in food production include:

Water shortages: Over-pumping of underground water aquifers in many countries, including China, India and the United States, has artificially inflated food production in the past few decades. For example, Saudi Arabia was self-sufficient in wheat harvesting for over 20 years. Now the wheat harvest there is likely to disappear entirely over the next couple of years due to a lack of underground water supply for irrigation[59]

Soil erosion and loss of croplands: Experts estimate that a third of the world's cropland is losing topsoil faster than it's being replaced through natural processes[60]. In northwestern China and western Mongolia a huge dust bowl is forming that will make the dust bowls in the US during the Great Depression look like a

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[56] Wolfe, N. – Dunavan, C. & Diamond, J. (2007): "Origins of Major Human Infectious Diseases." Nature, Vol. 447, 17 May 2007, p. 279–283.

[57] This point about the danger that reduced agrodiversity poses for global food security has been taken up in many places. One particularly graphic example is the article Siebert, Charles (2013): "Food Ark," National Geographic, Washington, D. C.

[58] This stunning statistic is discussed at lengths in the article Wallop, H. (2011): "Global Food Prices Hit New Record High." CommonDreams.org, 3 Feb 2011,

[59] Material supporting this statement is given in Part II of Casti, John (2012): X-Events. The Collapse of Everything. HarperCollins/Morrow, New York. .

[60] Ibid.

child's sandbox by comparison. A similar dust bowl is also growing in central Africa. So in these regions grain harvests are shrinking and farmers will eventually have to abandon the land and move to the cities.

Extreme weather and climate phenomena: Global warming is not a myth, and rising temperatures are here to stay. It's estimated that for each one degree Celsius rise in temperature above the optimum for the growing season, there is a ten percent decline in the yield of grain[61]. Photos of burnt-out wheat fields in Russia during the summer of 2010 give graphic testament to the role of climate change in dramatically reducing harvests.

High oil prices: There is a second "oil shock" taking place alongside the one you see at the gas station when you fill up your tank. This is the dramatic rise in the price of cooking oils like palm oil, soybean oil, corn oil and many other vegetable oils. And there is also the strong impact rising prices of petroleum products make on food supply, since oil enters into every aspect of food supply. As one wag put it, "Soil is nature's way of transforming oil into food."

These are but a handful of supply-side factors, all contributing to decline in global food supply. But what about demand?

The world is currently facing a confluence of mounting shortages in three commodities essential to the continuance of human life on this planet: water, energy and food. These three elements combine into something much greater than the sum of its parts, a looming global disaster by 2030. By 2030 the demand for water will increase by 30 percent, while demands for both energy and food will shoot up 50 percent[62]. All of this driven by a global population increase to about 8 billion people, which will place tremendous stresses upon our highly industrialized global food system. With a rising population of the sort forecast by demographers, the gap between the supply side and the demand side can only widen. When it widens far enough, something has to give. Betting odds are that that "something" will be population levels in the poorer sections of the world. In other words, mass famine.

Climate change

Many of the issues connected with market trends and the environment revolve about the changing climatic conditions, scarcity of oil, and efficient use of existing resources (see more of this debate in chapters 5+6). In the first category, the 800-pound gorilla in the room is global warming. It is a taken-for-granted background assumption that the global climate will be several degrees warmer in the decades to come than it is now. And what reasonable person could question this in the face of increasingly common record high summer temperatures in the northern hemisphere, accompanied by forest fires and droughts that decimate productive agricultural lands? Let's take a quick look at the historical record to get a bit of perspective on the situation.

According to many climatologists the three-hundred-year period from the middle of the 16thcentury to the middle of the 19thcentury constitute what's now called the Little Ice Age (LIA). During this time winters in Europe and North America were considerably colder than previously, with the river Thames in England and canals in Holland often freezing over. Even in Turkey this climatic change showed itself as the southern section of the Bosporus froze over in 1622. Not to be outdone by Europe, it's reported that Lake Superior in North America had ice until June in 1607, and in the winter of 1780 New York harbor froze solid enough that people could walk from Manhattan to Staten Island.

Perhaps the best account of the entire LIA is the book of the same name by Brian Fagan of the University of California[63]. Fagan says that the peasants of the time suffered not only bone-chilling weather, but also famines, bread riots, and the appearance of brutal leaders. Fagan writes that by the late 17th century, agricultural production had dropped so precipitously that "alpine villagers lived on bread made from ground nutshells mixed with barley and oat flour."

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61 Ibid.

62 Ibid.

63 Fagan, Brian (2001): The Little Ice Age: How Climate Made History, 1300–1850. Basic Books, New York.

Fagan goes on to note that life was especially difficult for those in the French Alps. Advancing glaciers moved forward "over a musket shot *each day*, [emphasis added] even in the month of August." And when the glaciers finally retreated, they left land so barren that no crops would grow.

Interestingly, the evidence of this global cooling period is somewhat less detailed for other parts of the world, especially the southern hemisphere. But this is not to say a LIA was any less severe below the equator, but only that documented evidence in the form of paintings, writings and the like is simply much scantier. However, ocean sediment cores from Antarctica to Africa seem to point to the same phenomenon.

So what were the causes of this massive, prolonged period of cooling?

Climatologists have narrowed the search for the proximate cause of the LIA to several factors: shifts in the Earth's orbit (discussed below), decreased solar activity, altered oceanic current flows, intrinsic variability in the climate and even increased reforestation following reductions in the human population[64].

Of considerable interest is the endogenous cause involving a shutdown of the famed "Great Ocean Conveyor," which moves warm water from the equatorial regions across the north Atlantic as the Gulf Stream current that warms northern Europe. If this process is shutdown by, say, an injection of large amounts of fresh water to the north Atlantic by means perhaps of a period of warming, then something akin to the LIA can be expected.

The example of the LIA shows that there are several ways to set off an ice age. So before proceeding, let me very briefly provide a bit more detail for a couple of the possible causes of a new ice age.

Widening of the Earth's Orbit: Presently, the Earth moves about the Sun in an orbit that is very nearly a circle. This means that the amount of solar radiation falling on the Earth is pretty much constant throughout the year, although of course some regions get more radiation than others due to the tilt of the Earth's axis of rotation. But the Earth's orbit widens very slowly, and in about 50,000 years it will be far more elliptical than circular. At that time there will be less solar radiation, on average, than there is today. Specialists believe that this is the primary cause of ice ages[65].

Change in the Tilt of the Earth's Axis of Rotation: The axis of the Earth's rotation is not straight up-and-down, but is tilted a bit with respect to the plane of its movement around the Sun. As the Earth moves around the Sun, this tilt is what causes the change of seasons. But the axis slowly tips and then moves back more toward the vertical. When the axis is straight up-and-down, we have warmer winters and cooler summers. In these periods there will be more snow at the poles and in the summer less ice will melt. Presto! An ice age in the making. Fortunately, the axis of rotation won't be vertical again for another 20,000 years or so[66].

Wobble of the Earth's Axis of Rotation: When a spinning top loses energy, its axis of rotation starts to wobble before it finally falls over. The Earth's axis of rotation also wobbles in just the same way as the top, one such wobbly rotation taking about 23,000 years. Some researchers believe that this wobbling gives rise to temperature changes on the surface of the Earth that can also lead to an ice age.

In addition to these reasons "from outer space," there are ice-age-causing actions from inner space, as well.

Volcanoes: Volcanic eruptions of the "super" type that occurred in Yellowstone National Park more than 600,000 years ago, can also cause an ice age. Such an eruption blows so much soot, gas and dust into the atmosphere that sunlight is blocked out for years. The cooling Earth then experiences "eternal" winter and, hence, a very long ice age[67].

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64 Wanamaker et al. (2012): "Surface changes in the North Atlantic meridional overturning circulation during the last millennium,"

65 Hays, J.D. – Imbrie, John & Shackleton, N. J. (1976): "Variations in the Earth's Orbit: Pacemaker of the Ice Ages." Science 194 (4270): 1121–1132.

66 Ibid.

67 Robock, Alan (1979): "The "Little Ice Age: Northern Hemisphere Average Observations and Model Calculations." Science 206 (4425): 1402–4.

Thinning of the Atmosphere: There are several processes, including a human-induced reduction of greenhouse gases that can remove carbon dioxide and methane from the atmosphere. Interestingly, without these gases the Earth would cool dramatically from the loss of its "heat blanket," and almost surely touch off an ice age[68].

Finally, there is one last generator of an ice age from human activity alone.

Nuclear War: The phenomenon of "nuclear winter," in which use of ground-burst nuclear weapons in a war sends vast amounts of dust, soot and other contaminants into the atmosphere, is much like the situation described above for a big volcanic eruption. The end result is the same: a large reduction in sunlight striking the surface of the Earth for many months, if not years, leading to cooling and some type of ice age.

Very Small Structures

One of the leitmotivs of the Sixth K-Wave is that it will involve a dramatic increase in the productivity attained from the use of resources and energy. A conventional wisdom in this connection is that a major contributor to this enhanced productivity will be vast improvements in biotechnology and nanotechnology. These developments in turn are projected to lead to new materials and processes that will make economic sectors far "greener" through the use of less energy and resources. As always with such rosy pictures of the future for investors, this is just one side of a coin. But there is a flip side that's decidedly darker. We need to look at this side from the X-event perspective as well, in order to get a fuller picture of the possibilities from these "very small structures."

There are three rapidly-developing technologies that concern most "small worlds" researchers. They are genetic engineering, nanotechnology and robotics, which taken together form what is often termed *The GNR Problem*[69]. Here's a bird's eye view of each.

Genetic engineering: In the past decade or so, the manipulation of the DNA of plants and animals opens up the possibility of producing organisms having specific properties deemed desirable by the "breeders." These might be practical things like disease-resistant tomatoes or bigger, fatter chickens. Or they might extend to breeding more attractive or smarter humans. In any case, people are concerned about this kind of advanced genetic manipulation getting out of control and leading to a runaway flood of species that could push humankind off the planet[70].

Nano-technology: Huge research efforts are underway to provide practical means for controlling matter at the molecular, or even atomic, level. The catch-all term "nanotech" is used to describe a cluster of such efforts, which include things like the use of engineered molecules to clean out clogged arteries (nano-medicine), the employment of molecules as switches in electronic devices (nano-electronics), and the construction of atom-sized machines to assemble totally novel sorts of products (nano-manufacturing). Ethicists and futurists worry about the possibility of these nano-objects attaining the capability to manufacture copies of themselves, leading to a cascade of "nano-bots" flooding the planet[71].

Robotics: The past decade or two have seen the development of machines performing specific functions like welding parts for automobiles or vacuuming the floor in your house. What is not at all common is a machine driven by a computer program outside the control of the programmer, one possessing the ability to think like a human being. Moore's Law, which argues that computer technology doubles in power every 18 months or so, suggests that computer hardware is approaching the point where such an artificial intelligence can be realized[72].

All three of these threats give the same apocalyptic vision: a technology run amok that's developed beyond human control. Whether it's genetically-engineered organisms pushing nature's creations off center

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68 Schneider, S.H. (1989): "The greenhouse effect: Science and policy." Science 243: p. 771–81.

69 Kurzweil, Ray (2005): The Singularity is Near. Viking Penguin Press, New York.

70 A good source for several perspectives on this question are several of the chapters in the volume Global Catastrophic Risk (2008): Bostrom, N. & Cirkovic, M. (eds.) Oxford U. Press, Oxford.

71 See the volumes cited in footnotes 69 and 70.

72 Geraci, R. (2010): Apocalyptic AI: Visions of Heaven in Robotics, Artificial Intelligence, and Virtual Reality. Oxford U. Press, New York.

stage, a plague of nano-objects vacuuming-up matter to leave waste products, a kind of "gray goo," coating the entire planet, or a race of robots breeding like hyperactive rabbits to force humans out of the evolutionary competition, the common factor underwriting each of these dark visions is the heretofore unseen ability of engineered technology to replicate. Killer plants breeding copies of themselves, nano-objects soaking up whatever resources they need to make more and more nano-objects or robots building more robots, all lead to the same unhappy end for humans: A planet that can no longer sustain human life, or what's worse, a planet in which we humans can no longer control our destiny but have been usurped by objects generated by our own technology.

Up to now, a potentially dangerous technology like a nuclear bomb can only be used once—build it and use it. Then we humans have to build it again. Technologists argue that genetically-engineered organisms, nano-objects and robots will be free of this constraint. They will be capable of self-reproduction on a speed and scale never before seen on this planet. When that crossover point is reached, the curtain starts to fall for humankind as the dominant species on the planet. Or so goes the scenario painted by techno-pessimists like Bill Joy, co-founder of Sun Microsystems, who argued in 2002 that we should impose severe restrictions on research in these areas in order to short-circuit this kind of technological "singularity"[73].

Thus, reflecting future options through unfolding drama set by abrupt events, these genetic and molecular levels can easily make their way to the macro-levels, polluting human air, water and food supplies, and even possibly engendering a robotic "takeover" in which intelligent machines mount a "takeover," friendly or otherwise, and replace human beings as the dominant species on the planet. Let us take a quick look at this last possibility as a game-changing X-event that could make the Sixth K-Wave the last one.

Speculative futurists like inventor Ray Kurzweil and mathematician, computer scientist and science-fiction author Vernor Vinge have conjectured that continuation of Moore's Law for only another few *decades* will bring on a so-called *technological singularity*. In his book *The Singularity is Near* (2005), Kurzweil suggests there are six Epochs to the process of evolution, starting with the emergence of information in atomic structures and moving to the state we're in today in Epoch Four, where technology is able to embody information processes in hardware and software designs. Kurzweil believes that we are currently at the forefront of Epoch Five, which involves the merger of technology and human intelligence. Put another way, this is the point where technology manages to incorporate the methods of biology – primarily self-repair and replication. These methods are then integrated into the human technology base. The "singularity" – Epoch Six – occurs when the knowledge embedded in our brains is merged together with the information-processing capability of our technology (read: machines).

Radical futurists claim that this merger between the human mind and machines will enable humankind to surmount many problems – disease, finite material resources, poverty, hunger. But they warn that this capability will open up the possibility for unparalleled capabilities for humans to act on their destructive impulses, too. This is all eerily reminiscent of the marvelous 1956 classic sci-fi film *Forbidden Planet,* in which intrepid intergalactic explorers discover the remains of the Krell, an ancient civilization that possessed the power of creation by pure thought alone. The Krell apparently vanished overnight when the destructive power of their alien Ids was given free reign. Shakespeare's play *Othello* makes the same point.

Conclusion

In this chapter we have focused on the fact that understanding the future means we need – to a certain extent - to count on uncertainties and surprises while investigating the patterns of social change. Kondratieff wave theory may work as our rough navigator in the roaring seas of often seemingly chaotic sequence of events that some may even interpret as human progress. But for every trend we think are closely tied to next wave, a surprising and abrupt event may change the course for good. The inevitable rise of complexity of our systems allow radical changes like never before. There is no better reminder of that possibility than

[73] Joy, W. (2000): "Why the Future Doesn't Need Us." Wired, April.

recent financial crisis that abruptly took our financial institutions by surprise and forced totally new picture of the future to emerge on the stage that was absolutely unimaginable for vast majority of so called experts of that system just some months before the crash occurred.

The same might be true – for instance – with what we think as digitalized future: there always remain a chance that due to some x-factor the global internet system hits the wall and we are faced with very different kind of future than we thought. One of many dystopias of the runaway climate change may one morning prove itself right, such as flip-flop of ocean currents causing abrupt cooling of Northern Europe[74] As this capacity to abrupt changes are built in into our modern societies in a ever intensifying fashion due to rising complexity we should be certainly be prepared for surprises to come. This should lead us to think of resilience and how to build that kind of capacity into our systems.

[74] See Calvin, William H. (1998): The Great Climate Flip-Flop. The Atlantic. Jan. 1998

3. THE WAVE THAT LASTS: THE EFFECTS OF DIGITALIZATION

As we have discussed in earlier chapters, the transition between two waves is driven by technology that is able to capture and fulfil the societal needs present at the time of the transition. Oftentimes these needs and preconditions, and also the technology infrastructures, are inherited from the previous wave.

For the sixth wave, an obvious candidate for such amalgamation of societal needs and technology is digitalization, a development that has taken the world by storm since entering into the mainstream in the beginning of the fifth wave, in the 1970s.

It would be easy to write ICT off as yesterday's news and look for the key technologies of the sixth wave elsewhere: we are already accustomed to expecting productivity increases to happen via adoption of ICT. In many important ways, the fifth wave was led by digitalization: the personal computer, automation and improved communications were but a few examples of how digitalization improved productivity in the past wave. Despite this, several authors[75] have suggested ICT to be the main driver for the next K-wave as well. Their analysis suggests the growth in the next wave to come from the user-centered services that build upon the basic infrastructure laid out during the last wave. Also, digitalization will be markedly moving towards assuming a position of a general technology, facilitating resource optimizing revolutions in several key areas of development that we will discuss in detail in the following chapters.

HOW THE QUEEN OF THE INTERNET SEES THE FUTURE
A Blogpost by Markku Wilenius (19 November 2012)

Mary Meeker is known to be extremely sensitive in her understanding of the future. Already from the mid-1990s, when she was working at Morgan Stanley as a financial analyst, she was able to catch major IPOs, such as Google and Netscape, and also to see the potential of such companies as Amazon or Dell. Last year she entered the VC firm Kleiner, Perkins, Caufield & Byers.

In the recent issue of Wired -magazine, she reveals how she detects the future: it is a combination of trends and close observation of things happening around her. Her latest discovery was beauty. She came across with the word so many times during a day that she thought "vow, this must mean something", and so beautification was born. Observation and previous knowledge connected through intuition.

This was also very similar to what Steve Jobs promoted to the very end: put liberal arts and technology together and you get beauty! That is so much more than function. And when you get ethics in place as a third layer (Apple/Jobs never did), you hit the jackpot!

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[75] Lehti, Matti – Rouvinen, Petri & Ylä-Anttila, Pekka (2012): Suuri hämmennys: Työ ja tuotanto digitaalisessa murroksessa. ETLA.

Perez, Carlota (2010): Foreword. In Grin, John – Rotmans, Jan & Schott, Johan. Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Routledge Studies in Sustainability Transitions.

The interplay of technology and its uses is one of the fundamental issues in futures research, and a prevalent view among futurists now seems to be that technological development as a more straightforward process is more readily understood, while the real challenge lies in understanding its future societal uses that actually select and give meaning to the technological possibilities.

The revolution that the Internet started as early as the fifth wave was essentially about the paradigm shift it allowed in communications: the last three decades have witnessed an unparalleled increase in communications technology, with two main implications for communication. The first is of course that digitalization has made different forms of content compatible, enabling a convergence in media. The second is a more profound shift in power relations in communication, as broadcasting to mass audiences is no longer exclusively reserved for large organizations, but due to declining costs and more universal entry to new communication technologies, individuals are also now able to reach mass audiences.

As visions of the future Internet are steadily moving from seeing it primarily as a communications platform to viewing it as an almost all-encompassing venue for societal and industrial functions, historical metaphors for understanding the shift are changing as well. While even a decade ago, the change the Internet was bringing about was being compared to that started by the printing press[76] now the relationship of the Internet and the societal changes that are based on it are often referred to as a general purpose technology generating a service with wide-ranging purposes, more in the vein of a steam engine as a source for electricity. Recently, many authors have referred to the next massive shift in productivity enabled by ICT to be on a par in significance with the Industrial Revolution[77].

As the general understanding of what the digital revolution means for societies is still forming, and the assumption is that what has happened so far is still but the first steps in the new digital era, much of the writing on digital futures has centered on the few constants in the development process. On the technological side, Moore's law predicts that the number of transistors on integrated circuits doubles approximately every two years. This basic observation has had significant linkages to capabilities of digital electronic devices (that are currently improving almost at an exponential rate). The other seemingly constant factor that has more to do with the societal implications of the Internet has been the steadily declining costs, increased scope, and diminishing barriers of access to communication. These two main lines of thought form the structure of our discussion.

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[76] e.g. Dewar, James A. (1998): The Information Age and the Printing Press. Looking Backward to See Ahead. RAND Corporation Paper Series.

[77] Brynjolfsson, Erik & McAfee, Andrew (2011): Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy. Digital Frontier Press (October 17, 2011).

Arthur, Brian (2011): How Technology is Recreating the 21st-century Economy. PARC Forum 4.8.2011.

Moore's law

While the continuation of Moore's law into the future has been subject to debate ever since it was observed, its persistence has been one of the few constants in the development of technology. Moore's law was named after its initial observer, Intel co-founder Gordon E. Moore, who in 1965 published an article where he pointed out that the "*number of components in integrated circuits had doubled every year from the invention of the integrated circuit in 1958 until 1965*" and predicted that the trend would continue for at least ten years.[78]

Moore's law in a strict sense does have relevance only to the semiconductor industry, and only as a side effect to the efficiency of electronic devices. Like the Kondratieff wave, Moore's law is essentially an empirical observation, but the way it has been able to highlight the astounding pace of development in a key technology has glossed over its more or less heuristic nature, and over the years, Moore's law has taken on properties that make it seem more like an economic, if not a physical law. It has largely been the force behind the emergence of the commercial software industry by making computers affordable and widely available, and streamlining and unifying the hardware architecture so that software can target all of the market with their products. Senior computer scientist David Liddle argues that the main effects of Moore's law: growth of the semiconductor industry, commoditization of computer industry, and emergence of the strong software industry, are together the basic pillars of our current economy, and he claims that this has contributed to the longevity of Moore's law itself. Moore's law, our trust in its continuation, along with the vast increases in wealth and productivity we assign to it, have had a profound impact on our civilization, our relationship to information and technology, and our access to both.[79]

Perhaps not surprisingly, then, Moore's law has also inspired some of the most dramatic visions of the future, not just for technology, but for humanity as a whole (Moore himself has objected to the prophetical flavor his simple observation has later taken on). One such instance is the technological singularity theory, developed by science fiction writer Vernon Vinge and later popularized and strongly promoted by inventor Ray Kurzweill. In its original formulation by Vinge the theory states that singularity, the rise of super-intelligent machines that will take charge of technological development right from their coming into being (a moment referred to as the singularity), might occur as a result of one of four scenarios: 1) individual computers might develop cognition or 2) large networks of computers and their users might develop a collective, superhuman intelligence, 3) the computer and its user could develop a complementary intelligence that supersedes normal human intelligence or 4) human intellect can be significantly improved by biological sciences.[80] According to Ray Kurzweil, the Singularity will take place in the year 2029[81].

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78 Liddle, David E. (2006): The Wider Impact of Moore's Law. IEEE/SSCS Journal.

79 Ibid.

80 Vinge, Vernor (1993): "The Coming Technological Singularity: How to Survive in the Post-Human Era", originally in Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace, G. A. Landis, ed., NASA Publication CP-10129, pp. 115–126, 1993.

81 Meghan, Kelly (2012): 17 years until the Singularity: A conversation with futurist Ray Kurzweil. Venturebeat.org.

Technological singularity as such is regarded as highly controversial a theory, but some of its more practical derivatives have appealed to technologically oriented audiences in diverse fields as an inspirational vision for the future. Current projections expect Moore's law to continue at least until 2015 or 2020, although possibly slowing down after 2013. Driving on this wave of technological promise, a recently founded Singularity University, funded by Google and Microsoft, and with some of the leading Silicon Valley technologists on board, is dedicated "*to assemble, educate and inspire a new generation of leaders who strive to understand and utilize exponentially advancing technologies to address humanity's grand challenges*".[82] In practice, they explore technologies as diverse as 3D printing in space to enable intergalactic travel, programming the genetic code, the Internet of things, interplanetary Internet, and robotics. Their ideas are strongly based on the assumption that the exponential development rate of technology will continue into the future. Should these visions sound too techno-utopian, according to Kurzweil this is because our conventional expectations about the future are based on a linear development trajectory, not exponential. At the Singularity University, thoughts about the future are not focused on the resource crises to come. On the contrary, they expect to see a post-scarcity world, where technological solutions will have helped solve all the grand challenges of today. And of course, this will happen in a world where, in 10–15 years of time, according to Google's Sebastian Thrun, "*computers will be able to capture the experience of a life*" meaning the capacity to store every aspect of a lifetime online forever, and where, in no more than 20 years "*AI abilities are going to be indistinguishable from those of human abilities*", and then probably surpass them.[83]

The second economy

The Singularity thinkers represent an extreme position on the technological potential, but considering the scale and scope of the global challenges, there are quite a few academics a little closer to the mainstream who see more reason for slight optimism than one might think just by looking at the current indicators. There are two key sources for this outlook: ICT's potential ability to dramatically optimize the usage of all kinds of resources, and the opportunities it offers for grassroot entrepreneurship.

In October 2011 W. Brian Arthur, an economist and pioneer in complexity science, published an article in the McKinsey Quarterly, a journal put out by an international consulting company of the same name. The article begins with a reference to the long waves: about once in every 60 years a new technology comes along that quietly, almost unnoticed, changes the whole economy. Not naming specific new technologies that are often referenced in technology roadmaps or key driver analysis, Arthur joins a number of established long wave theorists in claiming that the really big technological leap in the next wave will come from the continual adoption of ICT in all areas of economic activity.[84]

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[82] singularityu.org

[83] Cadwalladr, Carole (2012): Singularity University: meet the people who are building our future. The Observer, 28.4.2012.

[84] Arthur, W. Brian (2011): The second economy. McKinsey Quarterly October 2011.

There are solid historical grounds that back up this claim: In previous waves and their key technologies, the period of investment and infrastructure building preceded major increases in prosperity: in the US, for example, by the year 1920 all the major infrastructures had passed their peak development phase: railroad development had peaked in 1920, the development of urban road networks, although still growing, had already slowed down, a gas distribution system was in place by 1920, and all cities and towns had electric power generation and distribution systems, along with the telephone, by 1920.[85]

NOT NEW ECONOMY, BUT SECOND ECONOMY
A Blogpost by Markku Wilenius (29 November 2012)

There was a time, not long ago, when the new flashy thing was the "New Economy". Nobody talks about it anymore.

Now something new is on the way again. This time it is the second economy. The term was coined recently by technology thinker W. Brian Arthur, who made a bold case that the second economy will be larger than our physical economy by 2030. So what is this economy?

The second economy means everything that happens beyond our sight. When you go to the airport and insert your card into the machine to check the flight, what happens? An incredible amount of information exchanges in which your identity is checked, your seat reservation is made, your luggage information is submitted and so on. Machines talking to other machines. Some decades ago all this was done manually.

Now a new study, commissioned by General Electric, says connecting industrial operations to the Internet could lead to significant gains in productivity, potentially worth $10 trillion to $15 trillion globally. The downside of this potential is that it will happen without creating almost any new jobs. Because, in this second economy, the machines do the work, as Karl Marx once prophesied. Whereas in the old economy, every million in economic output equalled 10 jobs, in the second economy it may equal perhaps only 1-2.

This is precisely the reason companies like Google or Amazon are doing so well. They really ride the wave of this second economy.

In addition to being good in this business, we should in the future focus much more on the distribution of wealth than on making it. The machines will do it for us.

It has been argued that synergies rising from the combination of these infrastructures, most importantly the telephone and road networks, were behind the dramatic economy-wide decrease in inventory requirements, and consequently a sharp rise in productivity during that decade. Ayres draws parallels with this build-up phase of the third transformation and our times, as he suggests that such synergistic combinations might occur again in the near future[86]. What he must be referring to, of course, is the ICT infrastructure that has been carefully laid out during the last wave: the Internet reaches on average 35% of the world pop-

[85] Ayres, Robert U. (1990a): Technological Transformations and Long Waves. Part I. Technological Forecasting and Social Change 37, 1-37 (1990).

[86] Ibid.

ulation[87], and according to International Telecommunications Union, at the end of 2011 there were already almost twice as many mobile broadband subscriptions as fixed broadband connections[88].

The new revolutionary potential of ICT lies in the ability to automate entire processes, such as supply chain management, to be conducted by interconnected, remotely located servers that are able to track, control, and reconfigure the process in order to optimize it, cutting wasteful resource use at every turn. Robots are improving almost on a par with Moore's law, and recent advances in pattern recognition techniques seem soon to be able to conduct complicated tasks once thought to be impossible for machines.

This way, with many of the once central operations and critical work tasks moved to the automated, digital background, we are witnessing the birth of the Second Economy, a vast, silent, connected, unseen, autonomous, remotely executing, global, always on, endlessly configurable, concurrent, self-correcting, self-organizing, self-architecting, and self-healing realm of digital economic activity that only briefly connects with the physical economy. In his article, Arthur already offers rough calculations to argue that in just two decades the size of the digital economy will equal that of the physical economy. General Electric has since made more precise calculations and assesses that the Industrial Internet could lead up to 10-15 trillion dollars in efficiency gains[89]. On a more philosophical level, it may be metaphorically seen to be developing into a kind of decentralized neural layer, a sort of primitive central neural system, for the world economy. And this, according to the report, might be the biggest change in the world economy since the Industrial Revolution. The increases in productivity it promises are vast, and opportunities within it yet to be imagined. The big, quiet change in our time might as well be the Second Economy: a digital economy parallel to, or under the physical economy we inhabit, taking care of most of the rote tasks that the physical economy needs in order to work.

KEY GAME CHANGERS IN THE NEAR-FUTURE INTERNET: THE CLOUD, BIG DATA, AND MOBILE

Moore's law has important implications for data storage and network bandwidth costs, which have declined following the same pattern as the increase in the power of microprocessors or the efficiency of electronic devices. The expectations that the Internet will transcend its previous role as just a more comprehensive communications platform into a general technology that is projected to revolutionize the world of work, manufacturing, basic infrastructure, healthcare etc. in the coming decades is mainly due to three developments that depend on cheap storage and fast access: the Cloud, Internet of Things, and Big Data.

The Cloud means moving some of the functions for which people today normally need hardware on their computers to a central computing facility, which offers computing services to the users via the net. Essentially, users would access the services they need, such as their desktop, software, data storage and so on, on demand, and with any device that is able to connect to the web. Popular applications of cloud com-

87 Wikipedia: List of countries by number of Internet users.

88 The Broadband Commission for Digital Development: State of Broadband 2012: Achieving Digital Inclusion for All.

89 Evans, Peter C. & Annunziata, Marco (2012): Industrial Internet. Pushing the Boundaries of Machines and Minds. 26.11.2012 General Electric.

puting include webmail services and, for instance, the collaborative text editing function Google Docs. The Cloud is enabled by the increased speed of the broadband connections: before, accessing large amounts of data remotely would have been too time-consuming and thus crippled the process. In some respects, the Cloud has been likened to the old mainframe era style in computing. Some see in it a return to a more centralized organization, and in contrast to the PC-centered world where a lot of the processes were controlled by the user, in the Cloud they are entrusted to an outside party. Nevertheless, the Cloud features in nearly all visions of future ICT, promising more flexible, scalable and easily shared computing services.

Based on the same set of technologies that are a prerequisite for the Second Economy, the Internet of Things is most often referred to in the context of consumer electronics and ubiquitous society. In essence, it means that most of the ”things”: devices we use in daily life, such as refrigerators, clothes, and cars, will have an IP address, and are connected to one another via the Internet. Information from those devices will then be a central part of the basic infrastructure and blend in with the physical reality. This has been illustrated by examples where your fridge would order groceries that are running out, or clothes that informed you about their need to be washed. The Internet of Things is quickly moving from an interesting but mostly theoretical idea into the mainstream: you can already get a Knut, a sensor that informs you when the house plants need watering, or a Wemo Switch, an app that allows you to control all electrical devices in your home (ideal for those who worry they might leave the kitchen stove on when leaving home, but also for those looking to optimize their energy use). There is the Nest Thermostat that is able to learn usage patterns and adjust the temperature accordingly, the Graphmasters that orchestrates the traffic through a distributed routing algorithm in an optimal way in order to prevent traffic jams, and the Tableau hall cabinet that prints photographs from your emails and moves messages and photos stored in it online. If This Then That (IFTT) can be programmed to monitor one thing (for instance tags with your name on photographs in a social media site) and produce a response (sending you an email). The Cosm platform enables developers and companies to connect devices and apps to exchange and store data in a secure way.

In all the aforementioned examples, the two drivers for the rapid development are price and ease of use. Sensors have become cheap, readily available, and more powerful than before. At the same time, the technology has reached a level where it is technically available for the masses. This combination is the brew in which experimentation and innovation take place. As a taste of what may be on the horizon, sensor technology has already been employed in such cases as Japan’s nuclear disaster, where hackers devised a grid of self-made Geiger counters that were connected to an online map. In Chile, sensors give early warning alerts about possible earthquakes. What is interesting in both cases is that innovation is rising from the grassroot level and serving a communal interest.

Big Data refers to the increasingly sophisticated data mining methods for analyzing the vast quantities of data produced by people using the Internet (or any system that leaves behind a digital footprint). Big Data has been readily taken up by the advertising industry as a way to personalize commercial messages, but the potential scope of application for the approach is huge.

One of the fields projected to be facing a major boost from digitalization and Big Data is energy distribution. Smart grids, essentially meters which enable electricity to be supplied and priced according to current need, enable more efficient energy usage. Other forms of basic infrastructure are also expected to develop along the same lines. RAND researcher Robert Lempert has pointed out that the development of the basic infrastructure: transportation, energy and water systems, has remained almost stagnant for the past 50 years. In contrast, the fifty years before that (1910-1960) was a period of almost revolutionary change. Based on this, Lempert believes that time is ripe for a major reorganization of these systems. New powerful enablers, such as the big data approach, are able to facilitate great improvements in the efficacy of these systems.

Societal impacts of the digital age

The Luddite fallacy revisited

In some respects, the economic crisis of 2008 seems to be over, large companies and big banks have reached profit levels that can be described as "normal" considering the depths they plunged into during the crisis. What have remained, though, are unemployment rates that have moved on a higher plane, and stubbornly seem to be stuck there. There are probably several factors that feed into this situation, but increasingly there have been voices that have brought to discussion the effects of automatization on the number of jobs, and jobless growth. While most policies in developed countries are aimed at creating jobs, there are strong signals suggesting that jobless growth might not be just a temporary anomaly but could in fact be the new normal.

A new generation of industrial robots is emerging and replacing workforce in manufacturing and distribution jobs around the globe. A lot more sophisticated than their predecessors commonly used in the automobile industry and other heavy industrial work, the new robots are able to perform tasks that have previously employed vast masses of low-skilled workers in plants around the globe. Binne Visser, a manager at a new Philips assembly line, claims that these new robots can already manufacture "any consumer device in the world". In addition to technology forerunners like Philips, also Foxconn, a large-scale manufacturer mainly based in China, is planning to install over a million robots in its factories in the coming years. This is due to the fact that not only has the technological sophistication of the robots advanced but also their cost has come down to a point where it starts to be a serious competitor to human labour. As an illustrative example, if a robot system costs 250,000 dollars to implement, and it replaces two workers who each would earn 50,000 dollars per year, it is easy to calculate the savings this makes when the robots have an estimated 15-year life span[90].

But industrial robots, however sophisticated they may be, are just a new round of iteration in a series of advances that have displaced large numbers of low-skilled factory workers from their jobs during the past decades. Arguably more disturbing to a contemporary mindset are the advances in artificial intelligence that target jobs in the higher end of the value chain.

Automation has been, and continues to be, a source of increased work productivity. However, if the second economy theory and even wilder ideas about the future of ICT (see the chapter on Moore's law and Singularity) are anywhere close, it seems inevitable that in the future automation is replacing humans in surprising new ways in fields where human contribution used to be at the centre of the task. This means that increasingly also traditional knowledge work is subject to being conducted by sophisticated algorithms.

Erik Brynjolfsson and Andrew McAfee, MIT economists and authors of the book *Race against the Machine*, take up this point to argue that the AI revolution (another name for the second economy) will subject knowledge work to the kind of radical rationalization that robotics have done in factory jobs. They see AI

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[90] Markoff, John (2012): Skilled work, without the worker. 18.8.2012, The New York Times.

as a force that will restructure the economy on a scale that is comparable to the transition from the agricultural to the industrial age. As the Industrial Revolution multiplied the power of human musculature, they claim the ongoing AI revolution will multiply the cognitive capacity of humanity[91]. And this is not just science fiction:

For a long time, artificial intelligence was considered a somewhat utopian goal, and decades of meagre progress seemed to prove sceptics right. At the centre of the AI discussion is the computer metaphor of the human mind, an idea originally put forward by computer scientist Alan Turing (1912–1954). In a very simple formulation the computer metaphor is the idea that the way human cognition works is in some ways analogous to the computations performed by computers. This idea was central in the cognitive revolution, an intellectual movement in the 1950s and 1960s that was born at the crossroads of computer science, philosophy and psychology, mainly as an objection to the behaviourist school of thought in psychology. Later the programme matured into a new research paradigm known as the cognitive sciences. Most current methods and approaches in the brain research base on the computational theory of the mind, which in its basic form means understanding human cognition as a process where input from the outside world is manipulated in the brain by way of algorithms into mental and/or physical states. And all along to some extent there has also been an attempt to use the models derived from research on human cognition to mimic the same processes in computers.

Artificial neural networks are inspired by the way the human brain learns from information that it gathers from the surrounding world. Software components divided into inputs, hidden layers and outputs can be "taught" to recognize patterns in data by repeated exposure to them. Recent advances in artificial intelligence, especially in a technology termed "deep learning", have brought about unprecedented progress in the field of computer vision, speech recognition and pattern recognition. The vast computing speed and power of contemporary computers makes this approach more and more feasible, and in some conditions and limited tasks, deep-learning systems are already better in recognizing patterns than humans.

Artificial neural networks can be used in various applications, ranging from autonomously driving vehicles to factory work, and personal assistants (such as the iPhone's Siri). And the progress seems to be accelerating: in the past year the speed and accuracy of deep learning programs has advanced by leaps, describes Yann LeCun, a computer scientist at New York University. What is radically new about the deep-learning technology is that it is able to progress with smaller data sets than neural network approaches typically, and do work that is usually seen as better suited to humans, such as complex work involving identification of molecules that are promising as a new drug.

Although yet in its infancy, the technology is already able to perform stunning feats, such as simultaneous translation from speech, as in a recent performance by Richard F. Rashid, a Microsoft scientist who had his lecture translated by a machine into written and spoken Mandarin Chinese, with a simulation of Dr.

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[91] Brynjolfsson, Erik & McAfee, Andrew (2011): Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy. Digital Frontier Press (October 17, 2011).

Rashid's voice speaking the translation. The new speech recognition programme makes 30% fewer mistakes than the older ones, and the error rate is still one word in seven. Still the advances are said to be "the most dramatic since 1979". And what is most promising about the new deep-learning approach is that it is expected to scale up as the computing power and the new graphics processors improve.[92]

There is no need to underline how radical the consequences of these developments will be if the optimistic development trajectory will realize itself. It suffices to say that the logical consequence of the digital second economy is the same as that faced by the skilled 19th century textile workers who understood how their expertise was about to become obsolete, as unskilled labour and automated looms were replacing their function in the industry. As much as we today may ridicule the Luddites who retaliated by destroying the automata that threatened their livelihood, maybe a situation where a highly skilled workforce would face large-scale unemployment due to being replaced by algorithms might provoke an only slightly more sophisticated response. This is still the case, because the structure of our societies in this regard is essentially similar to that of the 19th century. The system is built on jobs as the main mechanism for wealth distribution, and despite temporary shocks that have shaken the mechanism, there has never been a situation where there was real, large-scale scarcity of jobs. As the world continues to struggle with the societal effects of automation in industrial jobs, the replacement of expert positions by automation is bound to been seen as a profound societal threat.

The discussion around job loss due to technological progress is an old one[93]. In previous instances, the worry for structural unemployment has always proved to be unmerited to the extent of this kind of alarmist thinking having earned the nickname "Luddite fallacy". In a nutshell, Luddite fallacy refers to the following scenario that has already played out a few times in history where disruptive technological change has occurred: When labour-saving technologies improve productivity, they do at the same time destroy jobs for the people who used to be employed in the areas of improved efficiency. However, as production becomes more efficient, it also leads to lower prices for the produced goods and services. This, in turn, enables consumers to spend money on the original product, and with the same money they can also buy an additional product. The additional product may be something that needs more specialized labour and is better compensated for the worker who produces it. In any case, in the end technology does not destroy jobs permanently, but results in diversification of the economy, and more and better jobs, the thinking goes. The classical way to illustrate this is to look at agriculture at the start of the 20th century, when it was starting to become mechanized. The masses it freed from agricultural labour were mostly absorbed by the emerging industrial production that needed a large workforce. After industrial production started to decline in the developed countries, service production emerged as a large, labour-intensive field.

Rising inequality is already one of the biggest social, economic and political challenges of our time. Inequality has been a major issue of dispute ever since Richard Wilkinson and Kate Pickett came out with their

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92 Doyne, Shannon (2012): Great Strides for Deep Learning. The New York Times 26.11.2012

93 For instance Antti Kasvio provides a comprehensive overview on the discussions about the future of work in the past century in Kasvio, Antti (1994): Uusi työn yhteiskunta. Suomalaisen työelämän muutokset ja kehittämismahdollisuudet. Gaudeamus.

research pointing out that in fact more equal societies are also stronger economically and politically[94]. For those societies, like the US, where some key indicators of economic equality, such as income distribution, show rapid movement in the course of the last thirty year towards increased inequality, the issue is whether and how such societies can survive in the long term. In 2007, America's top 1% obtained 23% of the nation's total income. Their share in 1980 was only 8%. In the line of thinking that Arthur represents, one reason for this might be the technology which directs the vast profits of automation into the hands of those who control the operations, and diminishes the number of the workforce who can enter the economy through jobs.

History proves that at some point, inequal societies simply explode in one way or another, the tensions become too intensive. Another interpretation for this is that societies cyclically alter between more and less equal phases. (More on this in chapter 2 in conjunction with the work of Turchin et al.).

In his book *The Economic Possibilities for Our Grandchildren*, written in the 1930s, Keynes' vision of the societal effects of technological progress was that in the future we may be rich enough to solve most of our production-related issues by way of technology. The flipside of this would be that there might be massive technological unemployment.

The key challenge for economies at this point, in addition to understanding and seizing the technological frontiers, comes down to societal foresight. Philosophers, sociologists, and economists should be employed to think ahead to make sense how this qualitative change in production logic will affect our societies, and how we want it to affect them. A basic truth about us as human beings is that we do not thrive on enjoying more and better goods, but on overcoming challenges.

W. Brian Arthur argues that any response to the ICT Revolution will have to entail a transition from producing prosperity to distributing prosperity. With the rise of the new AI-based productivity increase that promises us economic growth and production of physical goods but not necessarily jobs, we need to ask: what will be the work that, in the words of Voltaire, will "spare us from three evils: boredom, vice, and need"?

At the moment the social model based on the industrial model of wage labour seems to be struggling. On one hand, it is unequipped to deal with the higher levels of unemployment brought about by industries outsourcing production in search of cheapest possible labour, and, increasingly, automation. On the other, there are no ready models for dealing with the huge differences in individual productivity that stem from the information technology tools, whose command is very unevenly distributed within society at the moment. Even more, the demographic trends in the developed world produce severe sustainability issues as the ratio of working population to the retired drops. So far, the technology has been a major factor in the growing financial inequality, and this fact should feature in discussions about the way we want to shape our societies in the sixth wave[95]. In previous, large-scale shifts in employment, there have also been changes in the nature of social insurance and education[96]. The open question is what, if any, are we about to see in this

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94 Wilkinson, Richard & Pickett, Kate (2010): The Spirit Level. Why Greater Equality Makes Societies Stronger. Bloomsbury Press, New York.

95 Krugman, Paul (2012): Robots and Robber Barons. The New York Times, 10.12.2012.

96 The Economist (2009): Rethinking the Luddites. The Economist. 6.11.2009.

one. There are, of course, no ready answers as to how things are going to play out in this regard, but there are plenty of ideas and options already visible.

Surely, a counter-argument to the pessimistic view about future job markets put forward by Arthur is that services will continue to provide jobs. The nature of those services is something to be defined by the new socio-economic paradigm. There are others who claim that the paradigm shift will entail a more profound change in how our societies function. Several authors have noted that we may be entering an age where the key societal question shifts from issues of producing wealth to the ways of distributing it within a society. Therefore, it is possible that the next wave will already start a process of re-examination of the industrial age principles of the current societal models and will be a part of the dynamic of the next wave.

SERVICE WITH A SMILE

A Blogpost by Markku Wilenius (18 November 2012)

Today I went do some shopping here in Palo Alto, California, where I landed some days ago. As always, I wanted to hit the best grocery store around, which means Whole Foods. The service you get there is something I could only dream of back in Finland. There is a sense of ease, smiling and attention on part of the personnel. They show in many ways how genuinely interested they are in my needs. And if I need something, they really go out of their way to help me find what I am looking for, instead of – as so often in my beloved home country of Finland - just showing me with a lazy twist of the arm where the stuff is. What I really get – in addition to high quality food – is an experience of being really taken care of.

In all Western countries, we are supposed to be moving into a service economy. This shows in the numbers. In some countries, as here in the US, services comprise close to 80% of the GDP (2011: 79.6%). In Finland, we are lagging behind: our share is around two-thirds of the GDP. In most European countries, it is somewhere between 70% and 80%, and rising. If you think of the future of any manufacturing businesses, it will evolve around the idea of adding more services into the products. Some Finnish companies are putting a lot of effort into this, with some good results – notable examples being such engineering companies as Kone or Wärtsilä. On the other hand, on the consumer business side, Nokia might serve as an example of the kind of company that lost the touch of how best to serve their customers.

Here in Silicon Valley, you can see some new interesting landmarks of digitalized service business. Take Airbnb, a company that helps people find accommodation in foreign locations. I needed to go to Santa Barbara next week, and wanted to stay in a home instead of some lousy hotel. So I looked at what Airbnb had to offer in that particular spot of California. I found an interesting offer, the system connected me to the local service provider, which in this case was a family who had some extra space in their home. I had a wealth of information at my disposal from which I could distill not only the basic data, but also the kind of information that helped me to get a feel for the house and its owners. Next, I chatted – using the aitbnb server – of my particular needs as they got to know me a little bit while I got to know them. In the course of that chat, we experienced each other.This helped create a feeling of trust, even before we had actually met.

This is service economy at its very core. Create a human-touch connection between provider and customer in the digital space and help the customer find exactly what he/she needs. More of this, please!

One possible direction for the future is emerging from the area of social production and the sharing economy. Although social production has strong roots in the western alternative culture, the new open source tools and more sophisticated methods for self-organization have made social production viable on a much larger scale than before. In some contexts, social production already has an effect on redefining and reorganizing wealth. What is interesting is that most of these initiatives under social production involve

volunteering to fix problems in the field of commons. For instance, in the United States, underemployed hackers and volunteers are seeking solutions for civic problems. Citizen scientists are building ad-hoc laboratories and global scientific networks.[97] There are a number of different platforms and groups for sharing goods and services. In a nutshell, there are two features that seem to define most of these new kinds of efforts to rethink production of services: 1) the principle of sharing resources in a new way, and 2) a self-directed, problem-solving oriented mindset.

Maybe, in the very long run, the new production model might change the old model of wage labour and consumption into a new kind of civil society formed around social production. Maybe by the end of the next wave the whole notion of wage labour will have vanished, and people will see themselves as citizens of the local and virtual ecologies they inhabit. In the meantime, these trends may be reflected in a vision of a Silicon Valley entrepreneur and investor, Navir Ravikant. He sees the near-future world as one without large companies, where a number of loosely coupled small companies will replace the old model of paid labour in large companies. In his view, there are two main reasons for this. Firstly, the cost of starting a company has come down dramatically in the past few years. Increasingly, a starting company is able to break out once central elements of the company and outsource them, keeping the necessary investments to a minimum. He believes that the economic system and especially the ICT sector already come with so much leverage that a company can be built on that leverage alone. There will be companies with very few employees, which will need very little capital to start off.[98] The second, and maybe more important reason is that people are looking for meaning in how they spend their time. An interesting re-examination of what work signifies to us seems to be echoing in his justification of why a work-filled life of a start-up entrepreneur would be more enticing than a life as an employee in a large company:

"When you're doing your own way, it doesn't feel like work. To me the definition of work is a set of things you have to do but you don't want to. By definition, if you want to do it, it is not work. That is the difference between work and leisure. Like when you're playing a videogame, for example, and you're raising cows in Farmville and paying money (for it) that's work, farming is work! (…) But you don't consider it work because you want to do it."[99]

Ravikant also thinks that in the not so distant future, a world awaits where people will be able to define their way of earning a living each day by picking up a task that suits their competences and preferences at the time. In this, he joins quite a few people in the futures community, who think that one likely consequence of the ongoing digital revolution is a task-based working life. The Finnish writer, Esko Kilpi, provides an overview to the topic that he calls "Human centric work": Kilpi argues that as the nature of knowledge work is increasingly independent from spatial or temporal constraints, the top down managerial processes that once defined work and shaped it into professional roles and corresponding task entities no

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97 Bennetsen, Henrik – Dunagan, Jake – Fidler, Devin – Harp, Gabriel – Jeffery, Lyn & Liebhold, Mike (2012): Internet Human / Human Internet. Institute for the Future (NB: not public until 2013

98 Ravikant, Navir (2012): Company size is shrinking. Pandodaily.com

99 Ibid.

longer works. Kilpi sees a future which is much more reliant on the self-organization of the individual agents. According to Kilpi, in task-based work

"people from all over the network contribute small pieces of their time and expertise voluntarily using mobile smart devices to common projects modularized as tasks. Knowledge workers do this based on their availability, interest and experience. People choose themselves what they do, they choose the tasks they take up and the colleagues they temporarily want to work with. Task-work has systemic advantages over traditional production hierarchies when the product under development is mainly immaterial in nature and the involved capital investment can be distributed in the network."[100]

The task-based model of work could also be a source of inspiration for renewing the current social welfare model. Kilpi suggests that human-centric work could be a remedy for the current difficulties in youth entry into the job market, as well as being a way for pensioners to maintain a part in the world of work without the stress full-time employment brings. Kilpi also refers to studies that found social engagement to be a good way to combat mental disorders such as depression, a health problem of epidemic proportions affecting mostly working age population in developed countries, and suggests the human-centric model for work to be one way of engaging people more fully into work without subjecting them to the stress that mostly derives from practices stemming from industrial society.

When taking a radically pragmatic look at the workings of our society, we soon discover that what is at stake in the envisioned scarcity due to the AI revolution is not meaningful work, but work that has economic value in the current system. In fact, there seems to be plenty of work that there are no economic incentives or resources for, and that for this reason are neglected and underappreciated. Most of this kind of work falls under the category of social responsibility: in a society where voluntary work is not very well integrated into the mindsets of its citizens, the system struggles with keeping the elderly and children taken cared of, the underemployed on board, and the workforce from becoming alienated by the strict division of paid labour and civic duties, often leading to a situation where the cultural and monetary emphasis on the importance of the former narrow the individual's possibilities to participate in the latter.

A GLIMPSE INTO THE FUTURE? VALVE SOFTWARE EMBRACES FLAT ORGANISATION AND EXPLORES HUMAN-CENTRIC WORK PRINCIPLES

The Valve Software Corporation is a video game company based in Washington, US. Its most famous products include the Half-Life series and a digital distribution and digital rights management platform Steam. Beside its acclaimed products, Valve has also gained fame by its highly unorthodox flat organization structure. It is a company of 300 employees, but has no bosses and no preassigned roles for the workers, and each project is cast on the basis of the interests and skills available in the company. Every employee has hiring capabilities, and they can come up with a development idea or approve one. People are encouraged to work on their own project, or join those that interest them.

Valve co-founder Gabe Newell explains organization structure as being a result of a concerted effort to think through the goals for the company: what was it that they needed to be good at? As the result was

[100] Kilpi, Esko & Saarikivi, Katri (2012): Human centric, task-based work - a concept description. Unpublished manuscript.

soon clear, i.e. that they were in the business of creating things that had not existed before, they chose the organizational model accordingly. As Newell explains, managers are very useful in industries where processes need to be institutionalized, but in the kind of work that Valve does, a melange of technology, design and art, this is not always good. There is a need for flexibility and also for sharing the burden of leadership between the workers. There are two kinds of roles in the company: "individual" and "group" jobs. A group contributor's job is to encourage and help group members to be more productive. People usually take leadership of the projects that they really want to see done, and afterwards they can go back to being individual contributors, a role that can be more highly compensated for than the group contributor role. Valve does not have a sales or marketing organization either, but sees it as the responsibility of each employee to think about how to measure and optimize customer satisfaction. This very independent, multi-role organization obviously relies entirely upon each employee's responsible and self-directed mode of working and thinking. This is also the source for potential downsides of this model, according to Newell: "If somebody is screwing up, we don't have a lot of internal controls to monitor that. We assume people know what they're doing. On Half-Life 2, one of the engineers made a bunch of really bad decisions. There was no monitoring system along the way, so it took us about six months longer than it should have for us to catch it. It cost everyone on the team a whole bunch of extra work." But ultimately people who cause damage will be weeded out.[101]

The source from where most people look for a refuge to humanity to emerge in the pressures of an automated future is creativity. Kaivo-oja and Andersson write in their book *BohoBusiness* about the need to renew societies, organizations, and the nature of work to respond to technological progress[102]. It no longer makes sense to use humans for mechanistic work tasks, regardless of whether the tasks are considered manual or knowledge work.

From this perspective, there are interesting trends and even mainstream currents that seem to go directly against these kinds of ideas. One of the most vocal critics of the current mode of the digital era, Jaron Lanier, the author of the book *You are not a Gadget – A Manifesto*, argues that the way social media is understood today runs contrary to the original spirit of the Internet, and more importantly, is antithetical to the needs and development trends of society. The Internet, to Lanier, is a platform for free self-actualization. According to him, in its current incarnation it rather tries to mold interactions to fit a uniform model that is designed largely according to advertisement interests and a mechanized conception of human creativity. His critique is especially poignant when he is accusing social media companies of viewing their users' self-expression on the social media sites solely as "data" that can be sold to paying customers, mainly advertisers, a point that even at the time of the publication of his book in 2010 had not yet entirely sank into the collective consciousness.[103]

In the same vein of thinking, futurist Alex Soojung-Kim Pang regrets the way discussion around "smart" technology has led to a conceptual confusion around the differences between human cognition and

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[101] Suddath, Claire: Why There Are No Bosses at Valve. 27.4.2012 Bloomberg Business Week. Retrieved 27.11.2012. Suddath, Claire: What Makes Valve Software the Best Office Ever? 25.4.2012 Bloomberg Business Week. Retrieved 27.11.2012.

[102] Andersson, Cristina & Kaivo-oja, Jari (2012): Boho Business. Ihmiskunnan voitto koneesta. Helsinki: Talemtum.

[103] Lanier, Jaron (2010): You are Not a Gadget. New York: Alfred A. Knopf.

artificial intelligence. The misunderstanding has led to attempts to augment or better human cognition in ways that make sense only in the context of machines. For instance, reconstruction and forgetting are crucially important elements in human memory, and total recall in the sense of a computer memory is neither possible nor desirable in humans. However, trends that aim at this, for instance by way of recording one's life via ever present sensors, are on the rise, as is the idea that human cognition is somehow flawed with regard to machines.

ALEX SOOJUNG-KIM PANG ON CONTEMPLATIVE COMPUTING

Alex Soojung-Kim Pang is a futurist specialized in the future of science and technology. He is an Associate Fellow at Oxford University's Saïd Business School and a visiting scholar in Stanford's HPST program. Recently he was also a visiting researcher at Microsoft Research Cambridge, working in the Socio-Digital Systems group on contemplative computing. Previously, Pang has acted as the Research Director of the Institute for the Future, a non-profit futures research organization in Palo Alto.

In 1970s, the futurist Alvin Toffler coined the phrase 'information overload' to describe the anxiety resulting from the massive growth of broadcast media. In 2012 the amount of information we handle daily is many orders of magnitude greater than in Toffler's time, and there is no clear end in sight for its growth in the future. The Internet, personal wireless mobile devices and interconnected sensors are enhancing our abilities to communicate and access knowledge in an unprecedented way.

The Tofflerian anxiety about our ability to control and organize this mass of information is still very much alive in today's world. Writers decrying the effects of the Internet and related technologies on our cognitive abilities have found an audience in those who worry about the role information technologies are already playing in the formation of our personal and social identities. Pang feels that the current discussion about the ubiquitous information environment, maybe well illustrated by the approach in Nicholas Carr's book *The Shallows*, is much too fatalistic and does not take into account the tools humans already have for fighting the ever-increasing sources of distraction.

Contemplative computing is a concept developed by Pang. In his new book, to be published early 2013, he is exploring ways to design information technologies and user experiences that promote concentration and deep focused thinking, qualities that are central to creativity and human intelligence. For Pang, the whole concept of "attention economy" is symptomatic of the situation where companies de facto compete over best ways of distracting people and grabbing their attention. In this situation the user has to be equipped with and educated about ways to make use of information technology's potential to enhance human cognition without falling prey to its distracting capabilities. Pang draws from the ancient techniques of mind control as practiced by different meditation schools that have grappled with the problems of distraction for centuries, and argues that the same methods are at least as relevant in the information age.

Knowledge and learning in the sixth wave

In the long-term development of societies, maybe the most significant factor predicting success has been an education system that reaches out to all members of society. In Finland, primary education in particular is exceptionally strong and has brought wealth to the whole society. The education system varies in strength between countries, and in some cases it has experienced a considerable decline as a side product of general development towards a more unequal society. However, as the issue is recognized to be of crucial im-

portance for a balanced, harmonious and competitive society, new initiatives have sought to renew the education system. Especially in the United States, information technology has been key to some of the most exciting developments in both basic level education and in higher education.

Khan Academy is an online video library, currently consisting of courses in primary and secondary level mathematics, science, computer science, finance and economics, and some humanities, and its vision is to be able to teach "anybody almost anything for free." The Khan Academy was founded by Salman Khan, whose ancestry is from Bangladesh, but who was born and had his schooling in top universities in the US. He got the idea for a web-based school when tutoring his cousins in Bangladesh via the Internet. Currently the khanacademy.org -website boasts 214,175,338 lessons delivered, and the site has over 320,000 registered users worldwide.

The Khan Academy's success is based on an ingenious but simple technological set-up and a pedagogical innovation that is to a degree able to mimic the "one-on-one tutoring" effect that has been shown to yield best learning results[104]. In the lessons, which are mostly 10–15 minutes long pieces on a specific topic, Khan introduces a problem and then shows how it can be solved, simultaneously explaining the logic behind the solution. Visually, the student sees a blackboard where Khan writes down the stages of the process, but Khan is not himself shown on the screen, just his voice is heard in the background. Videos are followed by exercises, where the student can independently test the newly learned skills, and if necessary return to more videos for help, or ask questions from the student community.

A stated vision for the future of Khan Academy is to use the platform to deliver lessons in more topics, with help from an expanding faculty (now constituted by Khan himself and three others who are in charge of the humanities section). Khan has also started piloting a model in northern California, where 20 % of school time would be used by students for watching videos and solving theoretical problems, and the rest of the time would be dedicated to group work in practical problem-solving and artistic work.

Network-based free education has also been on the agenda of universities for some time. Massachusetts Institute of Technology (MIT) started its MIT OpenCourseWare initiative to put all the educational materials from its undergraduate- and graduate-level courses online, partly free and openly available to anyone, in 2002. Yale University with its Open Yale Courses and the University of California, Berkeley's Webcast. Berkeley has also moved educational contents on the web. However, these have mostly consisted of broadcasting taped lectures to the Internet audiences, and other aspects of the courses have been closed to enrolled students.

The breakthrough in higher virtual open education was achieved at Stanford University in the fall 2011 when Sebastian Thrun, professor of computer science, decided to open up the course for artificial intelligence to free access over the Internet. Lectures and assignments were posted and auto-graded online each week, and the online students had the same schedule for exams as the "official" course. Thrun had been inspired to this by hearing Salman Khan's TED talk in the summer of 2011 about his Khan Academy, and

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[104] Thompson, Clive (2011): How Khan Academy Is Changing the Rules of Education. 15 July 2011 Wired. Retrieved 2.12.2012.

decided to see if the same model could be applied to a university level course. He invited potential students for the open course by email, and eventually over 100,000 students signed up for the CS221 course. At the end of the course, 24,000 students were able to graduate from the course, which was usually reserved for 200 Stanford undergraduate students. The prestigious Stanford University does not issue course credit to the non-matriculated students, but at the end of the term, students who completed the course received an official Statement of Accomplishment by the teachers of the course, Peter Norvig and Sebastian Thrun.

Thrun was very impressed by the results of his experiment; especially the constitution of the student base in the course was highly encouraging: the students represented nearly all the countries in the world, except for North Korea, and the age distribution was much wider than in a typical college. Many students were exceptionally highly motivated, as the course represented the only chance they had to obtain education of such high level. As the course was relatively demanding, the fact that so many were able to graduate from it was a signal to Thrun that there was a genuine need for this kind of service.

Based on their experiences from the CS221, Norvig and Thrun founded a web-based educational start-up called Udacity. At first it will concentrate on courses in computer science, with a few courses on physics and statistics, but the vision is to build it up into a complete, multi-department university. The founders' explanation as to why they wanted to start their own organization and not continue offering courses as part of Stanford's open courses was that the structure and architecture of a completely web-based course is so different from the traditional university course that it was much simpler to start from scratch and build a completely new platform for e-courses. Udacity as a company is also very innovative. It keeps its courses free by taking its business model from headhunting: Udacity has direct access to the students' abilities and is thus able to identify the most gifted students and connect them with companies looking for new talent. The companies will then pay a fee for a successful recruit.

Another for-profit company in the field of MOOCs (Massive Online Open Course) is Coursera that partners with multiple universities to provide a variety of online courses.[105]

This rise of new models for education taps two interesting drivers from the next wave: the first is of course the digitalization that expands to new areas. E-learning has already been a hot topic for a few decades, but now the technology, societal needs, aptitudes and structures finally seem to align in this regard. This is maybe happening most forcefully in the context of the United States, where the cost of tuition in higher education institutions has risen significantly, threatening to move to the cost of university education to a level where it is no longer within the reach of middle class families: after controlling for the effects of general inflation, college tuition and fees inflated at four times the rate of cost-of-living inflation from the year 1978 to 2008 (in the same time frame, medical costs inflated at twice the rate of cost-of-living). The reasons for this come from a complex set of different factors, most importantly rising costs in some of the universities, which have invested heavily into improving research facilities, while public support for education has been on the decline. As an end result, the amount of student loans has soared, currently exceeding

[105] Coursera.org

the credit card loan amount. The rising cost of higher education has led to a situation where the parents' financial status predicts the children's level of education, and social mobility has slowed down.

A second driver is the geographical mismatch between the young generations that are in need of education and lack traditional outlets for it, and the institutions that are able to provide high quality education. For the first time, technological development now effectively enables these two to meet.

What is the way forward for the Internet?

The way the Internet is organized and understood now makes it seem to be the epitome of grassroots democratization and emancipation. From the Orange Revolution to the Arab Spring and the Occupy Wall Street movement, new political awareness seems to be at the heart of the Internet. As the old gatekeepers to publicity have faltered and given way to a multitude of voices from all around the globe, there is even fresh hope of truly global movements uniting people from all over the world around issues that have resonance for the whole humanity. On the other hand, the Internet is now clearly on a development trajectory that many of the communication technologies of the past have traversed: the pioneering phase of a technology tends to be a time for free-spirited idealism and techno-utopianism (the pattern seems to date back to the invention of the telegraph). What follows is normally institutionalization, where corporate interests, high profit margins, and eventually business models that find ways to monetize the services that in the pioneering phase were free. In time, these forces take control of the technology and its development.

Here we need to note, however, that this development rarely proceeds by mere power grabbing: business interests usually have a market demand that they respond to, and in the case of the Internet this is clearly the users demanding a more stable and safe environment – in exchange for money and yielding control of the environment. Jonathan Zittrain, in his book *The Future of the Internet – And How to Stop It*, argues that such freely willed development towards a more consolidated Internet may be on the way as users become frustrated with the vulnerabilities and dangers of the PC world and shift to using what Zittrain calls "tethered appliances": smart phones, tablets, game consoles and other curated, well-functioning but essentially closed gadgets (meaning the user cannot write new code to them or repurpose them, contrasting closed appliances with generative appliances, such as a PC). This move, if the majority of users were to adopt it, would effectively end the open phase of the Internet, at least in the form it exists today, and leave the development of the Internet in the hands of the companies that control the hardware markets and the "walled gardens" that exist within them. Even if the whole phase of personal computers and programming as a hobby for the masses can be seen as an anomaly in an otherwise corporate and government-led project, Zittrain's main worry is that institutionalization will halt the uniquely rich innovation environment that the Internet has been able to provide by way of giving opportunity to individual users' experimentation. [106]

On the other hand, it is also possible to interpret the current situation along the same lines as Tuomi (in chapter 2 in this report): the models of innovation and organization that once sprung out from the op-

[106] Zittrain, Jonathan(2008): The Future of the Internet - And How to Stop It. Harrisonburg: Caravan.

portunities provided by fast development of computing hardware and related software have moved onwards and started a wave of ongoing innovation that is no longer confined to the computer industry.

And, to counterbalance a certain cyber-utopianism that might colour the discussion around the empowerment fuelled by social media, a backlash of cyber-scepticism is also on the rise, with Belarussian Jevgeni Morozov, author of the book *Net Delusion – The Dark Side of Internet Freedom* articulating some of the main concerns. Morozov points out that not only pro-democracy forces are using the Internet, the anti-democratic governments have also become better at controlling and manipulating the web. The democratizing possibilities of the net are still huge, but according to Morozow, the thought that the Internet will automatically be a force for democratization is not only a little bit naïve but also dangerous. Also, one of Morozov's main complaints is the deep contradiction in the rhetoric on the important role of a free Internet as a tool for democracy, and on the other hand the way democratic countries are constantly taking measures to control it through making demands on Internet companies to, for instance, build back doors to their services that enable surveillance of most of the communications on the web.[107]

MAKER MOVEMENT: A BLAST FROM THE PAST OR THE MAKINGS OF THE 6TH WAVE?

An interesting offshoot of the fact that many electrical appliances today function on the basis of generative appliances is the maker movement. It can be as a spiritual descendant of the DIY tradition in the 1960s and 1970s that was, for instance, behind the computer hobbyists that ended up starting the personal computer revolution.

Whereas the DIY movement revolved around the Whole Earth Catalog, an American counterculture magazine, the maker movement centers around the Make magazine that showcases projects involving computers, electronics, robotics, metalworking, woodworking and other disciplines. As a stable feature of the scene, Make often features projects that involve hacking of different kinds of household appliances, from espresso machines to Toyota Priuses. Where the hobbyist computer movement in the 1970s encouraged toying with bits, now the spotlight is on the intersection of bits and atoms.

The maker movement started in California and is closely connected with the rise of the so-called hackerspaces, which provide room for tinkering with electronics. Since 2006 the movement has convened around Maker Faire events. The main Faire in San Francisco was attended by 120,000 people in 2012, and the movement has also spread, even globally, with an event held in Cairo in 2011.

[107] Morozov, Jevgeni (2011): The Net Delusion. The Dark Side of Internet Freedom. PublicAffairs.

Finland in the second economy?

On the whole, Finland is in a good position to take advantage of the opportunities arising from the second economy. The basic digital infrastructure is among the best in the world, and with the relatively high level of education in the population, the basic capabilities needed are firmly in place.

There have been major setbacks in the way important Finnish sectors have been able to make use of digitalization (most notably, the problems experienced in the healthcare sector, as well as in the process aiming to reform the university system and a recent redesigning of the digital services at the national railway company). In all instances, the way digitalization has been introduced to the organization has not been able to streamline processes and free humans from time-consuming rote work. On the contrary, digital systems have come to be viewed as increasing bureaucracy, thus making the work more complicated, not less, and having resulted in measurable losses in work efficiency. The basic cause of the problems has been a mismatch between the needs of the organizations for which the digital systems are designed and the engineering mindset with which the changes have been implemented.

Still, in many fields central to the new paradigm, Finland is close to the leading edge. The gaming sector in Finland is very strong, and in addition to producing entertainment, it is projected to have a central role in a variety of societal functions, from healthcare to collective decision-making. Despite its recent worries, Nokia as a company still contains a lot of structural capacity for understanding and tapping the mobile markets, one of the key pillars in the second economy. The recent downsizing operations have also freed plenty of knowledge capital that can now look for new ways to take advantage of the opportunities of the digital age. In Finland there are also examples of companies using sophisticated digital technology to tap growing global markets in solving environmental issues. One of them is Zen robotics that uses advanced computer vision software for making waste recycling robots. To support these strengths, a Finnish working group ICT2015, led by former Nokia president Pekka Ala-Pietilä suggests that growth in the Finnish economy can be best facilitated by systematically improving four elements that relate to the conditions for ICT companies. First, a government led renewal of the public ICT infrastructure, which at the moment is patchy and leads to costly, insular improvement efforts, needs to be commenced as soon as possible. New funding mechanisms need to be developed to respond to the different needs that companies in different phases of development face. Continuing emphasis on learning and expertize are central to maintaining Finland's core strengths. And finally, the Finnish society needs to become more agile to be able to react to the rapidly changing environment.[108]

Finnish energy companies are well aware of the opportunities that digital technology offers for energy distribution by way of e.g. smart grids. There are also several projects investigating the feasibility of electric cars in Finland. In most instances, the questions are not so much about whether the new forms of organizing production or a technology are the way forward, but rather about when the technology will be ripe enough to be worthy of a costly transformation.

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[108] ICT 2015 (2013): 21 polkua kitkattomaan Suomeen. Työ- ja elinkeinoministeriön julkaisuja. 17.1.2013

On the societal front, there are plenty of signals of the system reorganising to embrace the potential for digital revolution. Avoin Ministeriö has started a new service, the first in the world, where citizens have direct access to the parlamentary law-making process. Collecting 50 000 signatures for a law proposal will oblige the parliament to take the proposal into hearing. Joukkoenkeli is a platform for grassroot organization around a project. Stadin Aikapankki experiments with service bartering. The yearly Aalto Camp for Societal Innovation aims at building a culture of self-organization around its members.

4. AGEING WITH STYLE: DEMOGRAPHIC CHANGE AND THE FUTURE OF HEALTH CARE

Demographics and ageing: a challenge and an opportunity

The last century represents a dramatic change in the size of the world population. The global population grew from 1.6 billion to 6.1 billion while the average life expectancy of a European grew from 40 years past 60 years. The 21st century will be a century of ageing population. By the end of this century, the average proportion of people over 60 will rise from the current 10% or so to somewhere between 25–45%. This is a huge step into a very different kind of society. What is more, the world as a whole is likely to see the end of population growth in the course of this century. That world will also be demographically divided, with rapid population growth still being a major issue in Africa and Western Asia. Europe, on the other hand, together with East-Asia, will be infected by rapid ageing and a declining fertility rate.

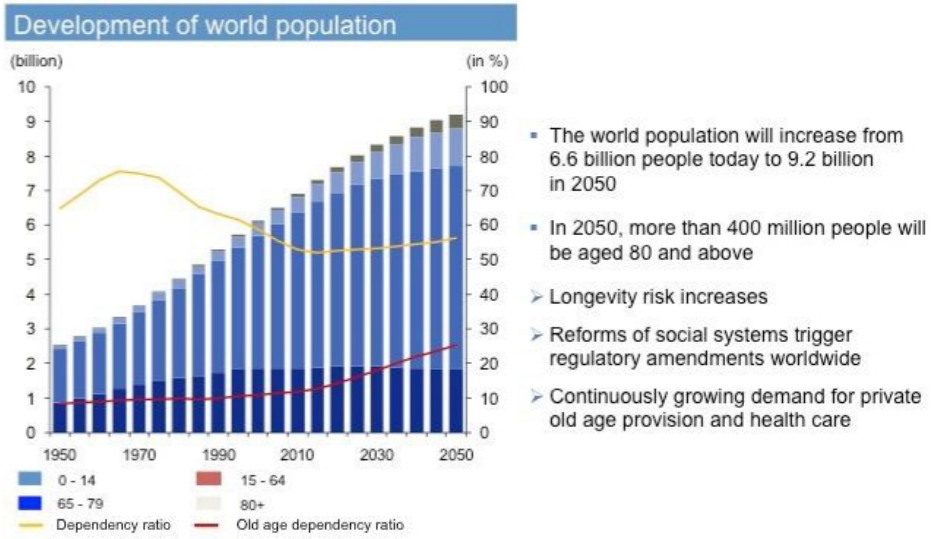

Figure 7. The big picture of demographics… World population is ageing. Source: UN Department of Economic and Social Affairs, Allianz SE.

Demographic change is definitely one of the key trends in the 6th wave, reaching its climax around the middle of this century. In the decades to come, it will shape our societies possibly more than any other social trend. There is a massive change of needs as the share of elderly people grows. Together with a rising standard of living and a shift to post-industrial socio-economic structures, the ageing population will not only affect the health sector and pension policies, it will also imply a major revision in the general architecture of our lives. The change in the demographic map of Europe in particular will be substantial:

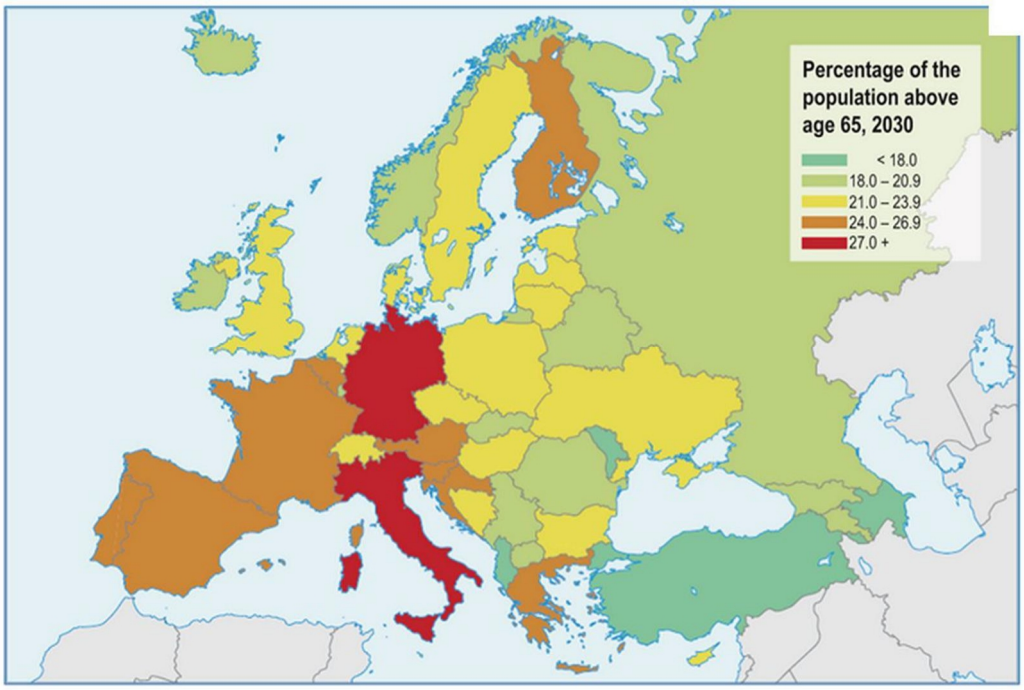

Figure 8. The Changing Demographic Map of Europe. Source: Prof. Wolfgang Lutz/Global Education Trend Scenario, World Population Programme, IIASA 2009.

We will see an increasing number of older people wishing to be active members of society and the economy even past their official pension age. We see already that, with the help of digital devices and the Internet, an increasing number of people are able to break the barrier between home and work. In the future, the legacy of the industrial age, a rigid system dividing life into working age and pension age, will to a certain extent be abolished.

The challenges are not any means small: the following graph illustrates the fact that, due to our tormented war history, the size of the baby boom generation from the 1940s is now causing Finland to take the top position in dependency ratio:

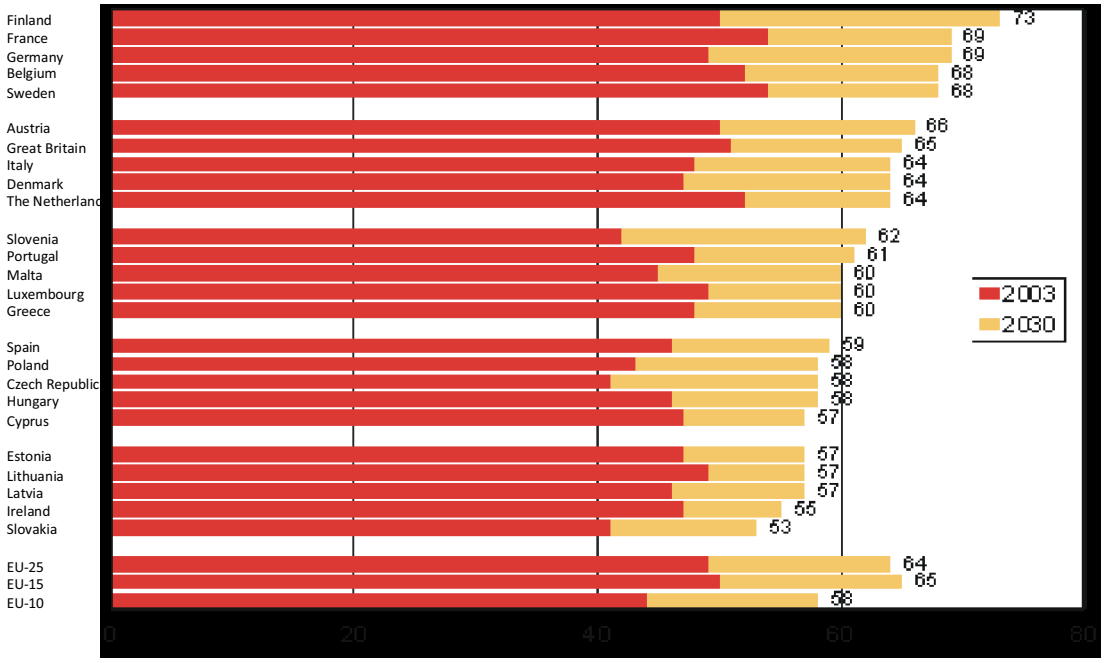

Figure 9. Dependency ration in EU-countries 2003 and 2030. Children (0–14) and seniors (65–) per 100 people in working life age. Source: Nieminen, Mauri[109] & Eurostat, New Cronos.

Demographic change has a devious, but quite predictable impact on the economy. In industrialized countries, ageing will exacerbate the decline in the human capital base while increased longevity will place an enormous burden on public welfare systems. The two most populous countries on earth, China and India, are set to become global heavyweights in education and qualification: China within the next decade and India some time later. As the demographic change penetrates societies over time, the massive impact will unfold in various ways. This is also reflected in a country's performance, as with the case of Japan, the slowing down of Japan's economy after the 1980s is understood to be one of the key symptoms of its ageing society. Japan's demographic structure is a showcase of our own future situation: the number of people over 65 has already gone past 20%.

Japan is indeed an interesting laboratory for us Europeans of ageing societies[110]. By 2030, over one third of the population will be over 65, and 25 years later over 75! In 2040, for every new born baby, there will be one 100-year-old person. The absolute size of the Japanese population will shrink from 127 million to 114 million by 2030. Moreover, by that year the number of Japanese in the world of work will drop by almost 20% from what it is today.

By measuring the walking pace of senior Japanese, Japanese demographer Takao Suzuki has concluded that their physical condition has improved over the years to the extent that elderly people have actually grown 11 years "younger" in just 20 years[111]. As Teppo Turkki, Sitra´s expert on Asian development, has

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[109] Nieminen, Mauri: Eurooppa eläköityy eri tahtiin. Tilastokeskus.

[110] Akiyama, Hiroko (2010): Leading the World through the Creation of a Model for an Aging Society. Science Links Ja-pan. http://sciencelinks.jp/content/view/1179/241/

[111] See Ishizaki, T. – Watanabe, S. – Suzuki, T. – Shibata, H. & Haga, H. (2000): Predictors for functional decline among nondisabled older Japanese living in a community during a 3-year follow-up. Journal of the American Geriatrics Society [2000, 48(11): 1424–1429]

remarked, Japan's development as a laboratory of an ageing society should provoke us to shift our focus from chronological age towards "functional age". All in all, the performance of elderly Japanese has improved considerably from the previous generation.

Meanwhile in Europe, Ursula Staudinger, professor of psychology at Jacobs University Bremen, has come to conclusion that, contrary to the publicly held belief, people continue to improve their cognitive capacity and capability to learn new things even in old age[112]. For instance, the average life expectancy of women in Japan is close to 90 years, and 9 out of 10 women live happily independent lives long after they have turned 80. Astonishingly, 85% of all people at 65 would like to continue to work. As we pointed out earlier, the real issue with ageing societies is how to build a welfare system that supports the participation of active elderly citizen. Moreover, ageing populations in Western countries also imply that the elderly will be healthier in the future. Interest in this topic will therefore not only be generated by improved medical care, but will also be primarily based on senior citizens playing a far more proactive role in societies.

As a consequence of this long-term development, the influence of the elderly will increase in all areas of society. How can societies and pension providers support elderly people to maintain their economic activity? This demand will probably materialize in the form of new products and services. German researcher Leo Nefiodow has argued that good health and the pursuit of well-being will set the pace for the 6th Kondratieff wave[113]. The development of health industries is a very important aspect of the 6th wave, although it is not the only driver in the coming era. Yet it is true that, in Finland, the public health sector is clearly sliding into a permanent crisis in which growing demands can no longer be met adequately with the current model.

What ageing really demands of our societies is more resilient systems. This means we need to reconfigure the way that the public and private sectors with common efforts help us to sustain. This is one of the key reasons we are assuming that the health industries will grow rapidly in all industrialized countries to the extent that by 2025 it may be the largest business sector in the world.

Towards a new understanding of our healthcare systems

As the demographic shift towards ageing societies with increasing longevity is inevitable and will shake the existing ways in which we deal with health, there is a new paradigm emerging which is age-old, yet revolutionary at the same time. It is the very idea on which Chinese medicine is founded: to focus on maintaining health rather than treating diseases after person has fallen ill. Instead of saving people from acute or chronic dysfunctions, the emphasis should be on how to increase their level of healthiness. In other words: a shift towards preventive health care.

Even a brief examination of the current health care system in Finland gives reason to think that something must be changed. The scene is dominated by cardiovascular diseases much more than in other Nordic

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112 See Etzold, Sabine (2008): Alte an die Arbeit. Die Zeit 6.3.2008, n.11

113 Nefiodow, Leo A. (2006): Der sechste Kondratieff. Wege zur Produktivität und Vollbeschäftigung im Zeitalter der Information. Sankt Augustin. Sechste Auflage 2006.

countries[114]. Cardiovascular diseases are – by definition – diseases that are directly related to our lifestyle. Thus, with healthy lifestyles a lot can be done to prevent cardiovascular dysfunctions.

It appears that the future of healthcare will be shaped especially by 1) the necessity to cut costs and increase productivity of the care systems, 2) new technologies and services that help with diagnosis and treatment, 3) changes in the images, values and culture of healthcare systems.

All these change factors are tightly interconnected. New technologies, be they medical or general ones, are especially important, as they enable structural and cultural changes in the healthcare system. As in every sphere of current society, most of the core technologies in healthcare will be digital or ICT assisted: ICT systems, new tools such as genetic mapping, Internet-based and mobile services. Digital technologies are providing the basic infrastructure for future healthcare, as they do for the society at large.

Changes caused by digitalization are often associated with cultural and structural attributes, such as dissolution of hierarchies and rise of networks, decentralization, openness, self-service, self-organization, peer-to-peer, prosumerism (disappearance of boundaries between producer and consumer), heightened individualism, neo-communalism, and different forms of "exchange economy" [115] (see e.g. Lehti et al. 2012; Castells 2000). What this all implies is that we are indeed undergoing a cultural transformation where the relationship between people's life-world *vis-à-vis* the system-world is changing because of new tools and information.

The new healthcare systems will also form around these structural and cultural features. We expect healthcare to become ubiquitous and grassrooted instead of being confined into large institutions. One of the most crucial aspects of this change is the shift of focus from curing diseases in institutions to preventing them by supporting people in their everyday lives to proactively ward off sickness. In countries such as Finland, individuals will in practice (and also for cost reasons) be increasingly responsible for their own health, with essential help from various networks and medical experts.

The trend towards individualized healthcare is linked to the general individualization process of modern societies, to the rising need to express one's own personal values, so visible in all spheres of life[116]. However, in healthcare as well as in society at large, individualization is increasingly not about individuals separated and isolated from their communal bonds, it is actually about creating new kinds of communities that are no longer based on factors that are "given", such as one's immediate surrounding or socio-economic background. Peer-to-peer is a crucial part of individualized healthcare, as like-minded people in similar physical condition discuss their situation, share information and support, and form communities. Community forming can happen around any issue, health included. We believe that health issues will be increasingly important in all communal activities people take part in.

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[114] See Koponen, Päivikki & Aromaa, Arpo (2005): Suomalaisten terveys kansainvälisessä vertailussa. Duodecim Terveyskirjasto

[115] Castells, Manuel (2000): The Rise of the Network Society. Second Edition. Blackwell Publishers, Oxford.
Lehti, M. – Rouvinen, P. & Ylä-Anttila, P. (2012): The Great Confusion: Digitalization Revolutionalizes Work and Production (in Finnish: Suuri Hämmennys: Työ ja tuotanto digitaalisessa murroksessa). Helsinki: Taloustieto (ETLA B254)

[116] In value research, this is called the tendency towards self-actualization, see particularly World Value Survey with almost 30 years of collected data on global value change

As healthcare systems become better fitted to the current ethos, the above mentioned features can also increase the efficiency of healthcare in terms of economics, health and the environment. However, ICT and other technologies in themselves are no guarantee of any level of efficiency or quality. If individual and organizational attitudes and behaviour remain unchanged, the value added may be negligible. In fact, if new technologies are implemented within old structures, productivity can *decrease* as seems to have happened in the Finnish public healthcare system after adopting ICT[117].

All in all, the key concepts for future healthcare are *prevention* and *decentralization.* Prevention may be the most efficient solution to deal with chronic diseases that are mostly caused by lifestyles and thus basically preventable. The shifting of healthcare away from medical institutions is in line with the general societal change towards informal bottom-up joint ventures. Highly hierarchical and formal medical institutions are ill-fitted to the current cultural climate that values self-actualization and takes advantage of decentralization.

From medical institutions to grassroots

Because new technologies "demand" organizational changes, they often go hand in hand with larger, even paradigmatic changes. These sweeping changes alter the fundamental logic, structures and values on which systems are built. What we might be seeing is the emergence of a whole new healthcare paradigm.

In the years to come, the health sector will merge with other sectors and spheres of society, especially with people's free-time and everyday living. This is part of the general paradigm shift in society's power relations away from the top-down and towards the bottom-up. Empowered and knowledgeable patients will investigate and manage their physical and health condition, discuss them with other patients, and demand a more equal partnership with clinicians. Managing health will be less about treating illnesses and more about striving for wellbeing.

Let's look a bit closer at some of the key issues the health care sector is about to confront, particularly here in Europe[118]: The basic problem is the spiralling cost of healthcare, which is expected to continue even in spite of growing efforts to put a cap on it. Ageing, as we have pointed out, adds its own grain of salt. The steady rise of chronic diseases is another one, very much observable today in any of public hospitals. Moreover, there is the lifestyle issue that has led to an increase in preventable health problems: too little physical exercise together with a wrong diet leads to obesity. A startling 75% of the people in the 10 richest countries are obese. In the last 10 years, there has been a clear increase in obesity in many developing countries as well. All in all, the total number of obese people has grown rapidly, approaching two billion [119].

What can be done? Here are some measures to combat the growing health care problems:

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[117] See the case of Finnish health care system in Lehti et. al. (2012), p. 58–82.

[118] See Economist Intelligence Unit (2011). The future of healthcare in Europe.
EU eHealth Task Force Report (2012). Redesigning health in Europe for 2020.

[119] See Weil, Richard H. (2011): Levels of Overweight on the Rise. Vitalsigns – Global Trends that Shape Our Futur.

1. Building decentralized healthcare systems

Decentralized service provision will be the basic institutional structure in the new healthcare paradigm. Decentralization helps to cut costs and resource consumption, and provides platforms better suited to preventive care. Decentralization empowers individuals to act on their own and in their communities in order to build healthcare in novel and more meaningful ways. In Finland, our fine community home-service that is available to pensioners and gives them the opportunity to live in home-like conditions, is a fine example of a decentralized health care structure.

Bottom-up healthcare and remote services are highly functional for the prevention and management of chronic diseases. Physicians, nurses and other professionals are in control of decisions in high acuity cases such as when one is unconscious in the hospital. In contrast, in low acuity situations such as managing a chronic condition, the individual, the family and the community are in control of actions. Making decisions about exercise, diet, medication adherence or monitoring one's condition, the outcome is determined by the patient, the family and the community[120]. (Chase 2012)

Healthcare is being democratized as power tilts towards patients and away from doctors. The model of ubiquitous healthcare cannot be physician-centric. In healthcare, too, expertise is increasingly spreading to crowds. This would mean a shift away from doctor-patient relations to open patient-community-network relations.

Due to decentralization, medical as well as service innovations are being spread to the whole society. Open data has a huge potential especially for healthcare innovations, because the amount of health data being constantly collected is huge. However, large amounts of data are currently sitting in various silos inside healthcare institutions. If this data be liberated in an appropriate manner and used effectively, it could spur new innovations and services and transform the way that care is provided.

Governments should ensure that the freed data is accurate and reliable, is gathered in a standard way and anonymized properly. After these preparations and precautions, it can be made freely available to anyone who can add value to it. The open data approach encourages a multitude of entrepreneurs and citizens to innovate rather than try to create a monopoly or market domination by a few service providers[121].

Finally, the power shift in healthcare means that clinical objectivity is giving way to more socio-cultural approaches. Communication will be acknowledged as one of the most important instruments of medical care. Healthcare will be more closely linked to the patient's everyday sphere, creating a need for more informal practices and services. Physicians and healthcare professionals must learn to communicate in ways that are not only comprehensible, but also inspiring and fun. As an example, the website http://zdoggmd.com/ provides professional medical instruction in quite an unconventional style.

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[120] Chase, Dave (2012): Communication is the most important medical instrument. TechCrunch,

[121] EU eHealth Task Force Report 2012, 10.

2. Providing more individualized and personal healthcare

Modern medical science tends to treat people as populations and patients. Within the emerging new healthcare ideology, they will be treated as individuals. In the decentralized and preventive model, individuals have a more active role in the personalized treatment process. "Patients" will no longer be subjects of power use, but empowered actors instead.

Personification of healthcare is propelled by advances in medical science. Sequencing each patient's genomic map enables the treatment to be tailored according to the patient's unique genome. Genetic mapping allows medicine, diets and exercise to be tweaked and planned so that they are optimally suited to each individual's genome[122]. Companies such as 23andme[123] are already providing extensive information about one's future health prospects by reading one's genome. For instance, they can track markers that suggest a predisposition to Alzheimer's disease.

Besides genetic monitoring, new powerful measurement technologies will provide increasingly accurate and diverse information on each individual. Together, genetic sequencing and finely tuned medical information gathering assist in predicting diseases and noticing them at an early stage. In addition, they offer a far more holistic view on how the components of an individual's body affect each other[124]. As the maintainance of health becomes predictive, personal, preventive and participatory, it begins to mirror larger transformations occurring in our societies and helps people strive for personal wellbeing, happiness and meaning in their private lives. Meanwhile, healthcare professionals are broadening their expertise by making available content, information, encouragement, motivation and compassion[125].

What all this requires of healthcare service providers is that they must tailor their advisory to suit the tastes of different communities and cultural niches. As medical information becomes more accessible as well as understandable than ever before, people will sometimes end up knowing more about their condition than their physicians. Furthermore, people also have increasingly refined means for collaboration. Because of the dramatically lowered costs of information and joint ventures, people are likely to want to implement their knowledge and out their cooperation potential into practice. The trend of DIY (Do-It-Yourself) could be applied to healthcare as well as[126].

DIY healthcare will result in patients taking tests by themselves and constantly monitoring their physical condition with the help of affordable medical devices. It means making simple peer-to-peer or self-diagnoses, and even prescribing medication. It can also lead to the manufacture of medical devices and instruments with the help of developing digital manufacturing technologies and collaborative tinkering networks. Self-

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122 Hammond, Ray (2012): The World in 2030. p. 238.

123 23andMe https://www.23andme.com/

124 Hood, Leroy (2009): A Doctor's Vision of the Future of Medicine. Newsweek 6/29/2009.

125 Garrettson, Jim (2010): Preventive Medicine: The Wave of the Future.

126 Salber (2010): The Doctor Weighs In

manufactured devices can be very finely tailored and also exceptionally cheap to produce – for example, the Fablab Amsterdam is currently designing a leg prosthesis with manufacturing costs of less than USD 50[127].

3. Embracing preventive healthcare

A straightforward solution to the problem of chronic disease is to prevent it. Healthcare will be moving away from curing diseases to aiding patients to be well and staying healthy. Preventing chronic illnesses can cut healthcare costs dramatically, as chronic diseases already account for 80% of the disease burden and may continue to rise, driven by unhealthy lifestyles[128].

At its core, preventive healthcare aims at identifying each individual's top health risks and then customizing a plan to help avert those risks or slow the progress of existing disease. Prevention can be divided into three different levels. Primary prevention is about keeping healthy people healthy. Secondary prevention means diagnosing conditions earlier with efficient screening. Tertiary prevention aims at treating conditions at an early stage with appropriate medicine and health programs[129].

Genetic sequencing is likely to become so cheap it can be performed on every patient. Genetic mapping helps to figure out which diseases the individual has a hereditary disposition to, and then to plan a personal health program – or impose gene therapy – to prevent these probable illnesses. Prevention can mean choices involving lifestyle, diet and exercise, but also medical intervention. A systems approach to medicine which acknowledges that diseases are a complicated sum of different factors all affecting one another, can be used to develop drugs that help prevent or reduce the probability of disease.

Preventive healthcare cannot currently be provided properly by hospitals and clinics, as they are primarily designed to treat acute illnesses with medical methods[130]. However, they may change their focus in the future, allowing their human capital to be used in an anticipatory approach. As for now, preventive healthcare can be seen as consisting of a healthy way of life in which healthcare professionals, together with other actors such as public officials and peers, play an important role as tutors and instructors. "Treatment" takes place in people's homes and everyday lives, while mobile technologies, e-health applications and digital services are increasingly providing a crucial aid.

Ubiquitous computing has the potential to spread healthcare technology and communication everywhere.[131] Preventive measures mean learning and acting upon that information to prevent dysfunctions. Prevention requires that patients take an active role in managing their own health. Thus, to be effective, patients must be highly motivated and must see their actions as meaningful and significant. As a result, healthcare may shift to be less clinically objective and more subjectively meaningful.

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[127] FabLab, http://fablab.waag.org/

[128] Ibid., 7

[129] Garrettsson, Jim (2010): Preventive Medicine: The Wave of the Future.

[130] Mah, Jean & Guenther, Robin (2011): For the Future of Health Care Design, Look Beyond the Hospital. Fast CoDesign.

[131] Font, Joan C. & Sato, Asuza (2012): Health systems futures: the challenges of technology, prevention and insurance. Futures September 2012, p. 696–703.

5. CLIMATE AND ENERGY IN THE SIXTH WAVE: TURNING UP THE HEAT

In November 2012, Potsdam Institute for Climate Studies, the world's most respected research institute on global warming, came up with new rather dramatic results concerning the so called 4C world, a world in which average global temperature reaches 4 degrees above preindustrial level, which will happen unless much more radical steps are taken to curb greenhouse gas emissions[132].

In that report, commissioned by the World Bank, the major point is this: it is impossible to think that we might possibly preserve decent living conditions for all people on this planet if this scenario, which is now more or less the business as usual scenario, should become actuality. Using various simulations they show convincingly what will happen to coastal cities when sea level rises (a substantial share of big cities are located on the coast), and particularly what will happen to some least developed countries when they are hit by drought and heat waves. In a very short time, the world will become a rather unpleasant place to live. And this concerns us in Finland as well, since indirect consequences such as the pressure of massive migrations would be devastating to us as well.

This graph from the report illustrates changes we are imposing on our living conditions:

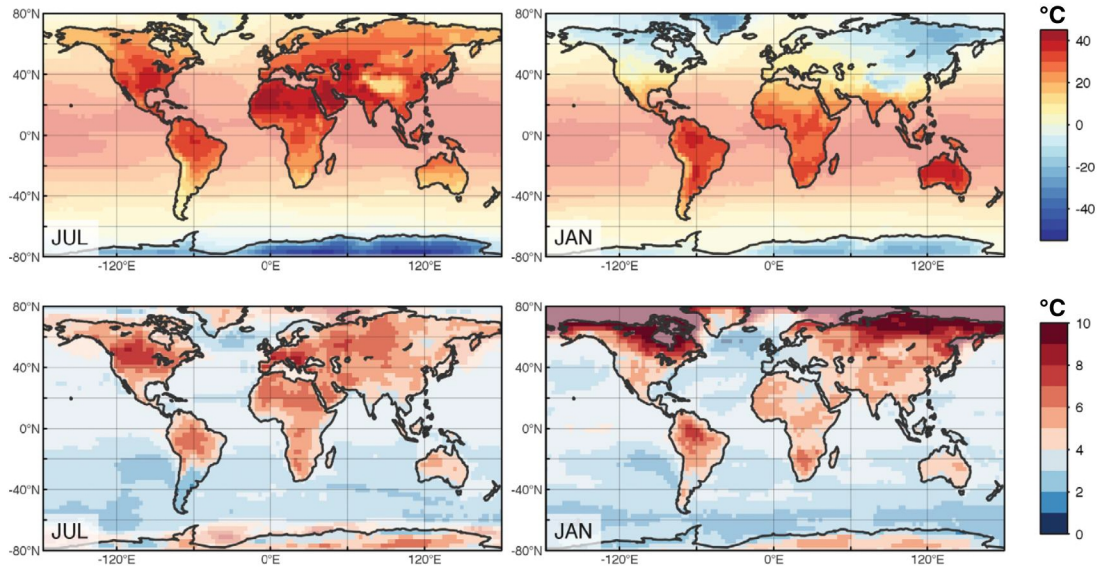

Figure 10. Multi-model mean combination of the most extreme warm monthly temperature experienced at each location in the period 2080–2100 for the months of July (left) and January (right) in absolute temperatures (top) and anomalies compared to the most extreme monthly temperature simulated during present day (bottom). The intensity of the color scale has been reduced over the oceans for distinction. Source: World Bank (2012) Turn Down the Heat. Why a 4C Warmer World Must Be Avoided. A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington: The World Bank.

[132] See the report: World Bank (2012): Climate Change Report Warns of Dramatically Warmer World This Century.

It shows the dramatic temperature differences we have today across the globe vis-à-vis the climate by the end of the century. There are two basic messages: the weather is becoming hotter, but also in many ways more extreme. What is undeniable is that this is a world that needs to be avoided.

The first period of the 6th wave is our last chance to do something about it. It is our last chance because of the time delays in the steps from resolutions to binding targets to political decisions to measures to emissions to concentrations. As this report is being finalized, the last round of negotiations at the Doha climate summit for the second Kyoto commitment period is still underway. It remains very much uncertain whether the world will ever see the second commitment period. And even if that commitment should arrive, it may be totally inadequate to deal with the magnitude of the issue.

We need all our efforts to be geared around building more sustainable economies and lifestyles. This is the ethical challenge of the 6th wave, and we simply cannot afford to fail it. In essence, this entails the dematerialization of our economies in the massive scale and certain immaterialization of our lifestyles. But it also means commitment from the international community to really use the various means at our disposal to impose the necessary legal structures.

In that "turn down the heat" report, there is a telling foreword by the chairman of the World Bank, Jim Yong King: "It is my hope that this report shocks us into action". Indeed, as we learn from the report, to support the message there has been growing number of climatic extreme events in the last 10 years or so. Some of them are caused by climate change, some by environmental degradation, such as deforestration. The massive scale of environmental destruction, so well observed in UN-led Millennium ecosystem assessment, has already taken our biosphere to a state where it is becoming increasingly fragile.[133] As the assessment shows, virtually all of Earth's ecosystems have been significantly transformed through human action.

VISION + SUSTAINABILITY

A Blogpost by Markku Wilenius (1 December 2012)

When you start a new business, you only need three things: a good business idea, the competence to execute it, and funding. In Finland, the last bit is a particularly tricky one. Investors, angel capitalist in particular, are far and few between.

Tero Ojanperä, a former Nokia executive, has done a great thing by creating the Vision+ fund, a firm that invests in new digital ready to market initiatives by providing funding and also support for business strategy implementation. The return of the investment comes in a revenue-share basis, without diluting existing equity value.

This kind of activity helps build new critical grassroot companies that our economy needs very badly. And of course we know that the Finnish game industry is currently in a hot phase, and major thrust in digital business funding seems to be going in that direction.

It is my strong belief that in the next few decades – when the 6th wave of development rebuilds our world – the really new thing will be the way we share and use our resources more intelligently. The reasons are the growing scarcity of non-renewables and the rising prices of such key commodities as foodstuffs and fuels. On the other hand, as pollution, deforestration and worsening water problems become more and more evident, there is growing pressure to really do something about it.

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[133] See Millennium Ecosystem Assessment

As far as I know, there is currently no fund in Finland that would focus on sustainable businesses. This is shame, because I believe the greatest potential for long term success will come from nurturing ideas for how to make the world a better place. I am also sure there are quite a few ideas around this theme that just might never have had the chance to really fly.

Here in California, there are some good examples of initiatives of this kind:
http://www.givesomethingback.com/CustomLandingPage.aspx?cpi=Founders
http://www.shareable.net/users/neal-gorenflo

The point is that they are based on the idea of sharing, which is one of the most effective means to drive society into a sustainable direction.

Finland, too, would need the same kind of fund as Vision+, focussing on sustainability business/economy. I would be prepared to set it up, once I found a investor who believes in this kind of business and is willing to shell out $10 million ($50 million would be ideal) to establish the fund.

Any serious forecast of the long-term future must take into account environmental conditions. It was the Club of Rome's first 1972 "Limits to Growth" report that woke the world up to observe its long-term future predicaments. Recently, one of the authors of the original research team, Jörgen Randers, professor of climate strategy at the Norwegian School of Business in Oslo, published his own update to the original "Limits to Growth" study, called "2052: A Global Forecast for the Next 40 Years"[134] . His report contains two basic observations: 1) The key shortcoming in the way we deal with our economy and politics is short-termism. Otherwise we could deal with the situation right away, because we already have the necessary technical measures and tools to do so. 2) The key issue here is global governance: how to improve the way we handle this problem since we witness so much lacking of the proper structure and processes that would help governments to deal with this issue. Perhaps we need a new global superstructure to impose action, since UN based negotiation marathons seem unable to provide sufficient conditions for positive results.

These are some of the reasons, why we believe in the 6th wave, we are going to see inevitable turn of economies, technologies and politics towards sustainability. This means that, in the imminent 6th wave, the driving force and the direction of economy and society will change once again from the previous wave. The driver in this cycle will be improved resource productivity, more effective use of materials and energy. Economic development will be governed by climate change and by the scarcity and rising price of raw materials and energy. Resource productivity will become the key instrument for economic and social development, particularly because globalization is inexorable and will lead to the scarcity of many key raw materials, such as oil, with the demand increasingly often exceeding the supply.

134 See Randers, Jörg (2012): 2052: Global Forecast for the Nect 40 Years. Chelesea Green Publishing. White River Junction. http://www.2052.info/

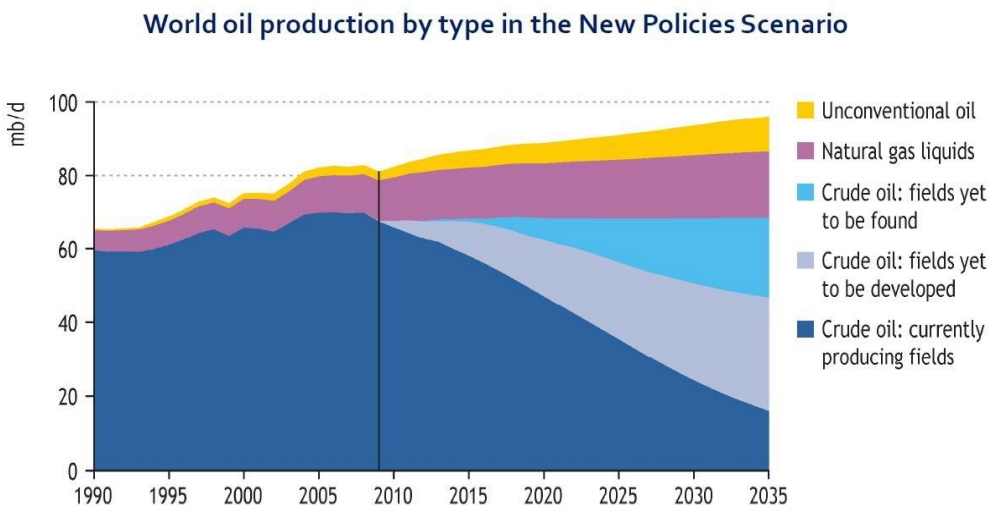

Figure 11. World oil production by type in the New Policies Scenario. Source: World Energy Outlook 2010, International Energy Agency.

As the above graph shows, although there are different ideas concerning the point in time of the global peak oil, it is clear that we have come close to the point where supply begins to fall. As a result, the price of the raw materials of the economy, oil in particular, will rise inevitably, which in turn will put pressure on decreasing consumption and finding alternatives.

Declining oil production will ultimately be the key factor of the energy revolution in which the world will inevitably shift to the use of renewable energy. Consider that oil consumption in China grew 20% from 2009 to the end of 2010; that very year, China became the largest consumer of oil in the world after the US. Accordingly, China will need to increase its oil imports, while all economies in the world must face a situation where demand exceeds supply. World oil production has in essence already peaked and what remains is (at best) twenty years of reserves. This means we are facing a real transformation, a catalysmic change. And some of the alternatives are to some extent dependent on fossil fuels, such as photovoltaic cells or hydrogen fuel cell membranes that are made of petroleum based plastics.

As we will probably see further rises in oil prices in the coming years, those countries that are heavy oil consumers will most likely face a major shock. But while this shock may be necessary, greener grass may yet be found on the other side: higher oil prices will also spur innovation on alternative energy sources.

Clean technologies: a promise for the future

Existing and emerging clean or environmental technologies known as eco-innovations provide highly potential future markets. According to statistics, eco-innovation has grown more than other industries in the last years[135]. These innovations hold a big promise, particularly for Europe. In response, the European Un-

[135] See Eco-Innovation Observatory (2012): Closing the Eco-innovation Gap. Annual report.

ion has adopted a sustainability strategy to increase resource productivity through improved efficiency in material and energy production, and the development of new goods and services.

Clean technologies hold the promise of providing new and badly needed jobs for an aging Europe. Moreover, we need them at least as a partial solution to global warming. As fresh water has already become a scarce resource in larger areas around the globe, we also need new technologies to preserve existing fresh water resources and to obtain fresh water from waste water or salty water. We need also new technological solutions for growing crops in arid coastal zones. And of course, we need clean technologies to address the problem of the depletion of non-renewable energy resources: we simply need new sources of energy and competitive substitutes to fossil fuels.

In 2010, renewable energy supplied an estimated 16.7% of the global final energy consumption; of this figure, 8.2% comes from "modern" renewable energy sources, such as hydropower, geothermal power, biofuel, solar and wind energy, and 8.5% from traditional biomass. Global investments in renewables rose to a record USD 257 billion in 2011[136]. Interestingly, solar photovoltaics (PV) energy has been the fastest-growing type of renewable energy in terms of installed capacity in the period 2006–2011. According to Bloomberg energy finance analysis, global investments into renewable energy projects will increase to USD 395bn in 2020 and to USD 460bn by 2030.

In renewable energy, the EU has dominated the global market, led by Germany and Italy. In wind power, China holds 44% of the world capacity, followed by the USA and India. Germany is by far the biggest market in Europe. Solar energy experienced an extraordinary market growth in 2011. For the first time ever, solar energy accounted for more capacity additions in the EU than any other technology. In solar thermal heating and cooling, China is a leader with Europe following in its footsteps, whereas in concentrated solar thermal power, Spain had the greatest capacity additions. In biomass technologies, we can observe increasing international trade of biomass fuels. The US leads the world in biomass-based power generation followed by EU, Brazil, China, India, Japan and the sugar-producing countries in Africa. In ocean energy installations, global ocean power capacity almost doubled during 2011[137].

It seems obvious that renewable energy will become a major source of energy in the future. According to the *Renewables 2012* global status report, modern renewable energy (hydropower, geothermal power, biofuels, solar and wind energy) can substitute for fossil fuels in four distinct markets: power generation, heating and cooling, transport fuels and rural/off grid energy services. Moreover, it has been assessed that some 39 countries have the potential to meet 100% of their electricity needs through domestic geothermal resources[138]. The use of renewable energy is projected to increase steadily in the observable future, although without any major leap forward, while fossil fuels will probably remain the main source of energy until 2050.

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136 See Renewables 2012, A global status report.
137 See "Global Renewable Energy market Outlook"
138 See report "Geothermal Energy: International Market Update"

The Promise of Green Nanotechnology

Green nanotechnology is an idea and a promise of key sustainability technologies to become more productive. This could include using nanotechnology to make solar cells more efficient or to clean polluted water more effectively. The nature of green nanotechnology overlaps with green chemistry – the chemical design of products and processes that are energy efficient, safe, eliminate or reduce waste, and use renewable materials. Green nanotechnology seeks such goals through design and engineering at the nano scale, but also by incorporating contributions from other disciplines, including physics, biology and life sciences, materials and environmental sciences, ecology, electronics and computing, as well as economics and other social sciences.[139]

For example, in the US, nanotechnology for solar energy collection and conversion is one of three signature initiatives in the NNI's (National Nanotechnology Initiative) 2011 strategic plan. This area was comprised of research investments in seven different areas: (1) conversion (2) conductivity, (3) nanoparticle fluid, heat transfer, (4) thermoelectric, (5) solar fuel, (6) solar characterization, and (7) energy storage (NSET 2011). This initiative received 3.7% (USD 68.8 million) of the overall NNI budget and the proposed budget for fiscal year 2012 calls for the budget to nearly double and account for 5.9% of the NNI budget.

Many of the early forecasts for nanotechnology suggested steep growth trajectories, often characterizing nanotechnology as fundamental core platform technology that would drive substantial economic growth worldwide and generate major environmental benefits. For example, the 2001 forecast of nanotechnology's global market size of USD 1 trillion by 2015 was first introduced in Roco and Bainbridge. This estimate is based on the total anticipated manufacturing, electronics, healthcare, pharmaceuticals, chemical processing, transportation, and sustainability improvements arising from nanotechnology. The economic downturn since 2008 has caused some downward adjustment in these market forecasts. Lux Research's 2009 global nanotechnology market forecast was decreased to USD 2.5 trillion by 2015, 4% less than the 2007 estimates. Declines in the automobile and construction industries were also estimated to affect market demand for nanomaterials and composites.

Considering that nanotechnology is estimated to be a multi-trillion dollar industry in the next decade, it is important to take a life-cycle approach to evaluate the environmental as well as human health impacts (both occupational and end-use) at each stage of a nano-enabled product's life cycle before arriving at any conclusions regarding the product's potential environmental benefits or drawbacks. The use of green chemistry metrics for assessing the greenness of nanomaterials and nanomanufacturing processes, and taking a more proactive approach when designing new nano-based products, are some of the recommended solutions to ensure that nanomaterials make an overall positive impact in future applications of this pervasive technology[140].

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[139] See OECD/NNI International Symposium on Assessing the Economic Impact of Nanotechnology Background Paper 3: The Economic Contributions of Nanotechnology to Green and Sustainable Growth.

[140] Mangematin, Vincent & Walsh, Steve (2012): The Future of Nanotechnologies.

6. THE NEXT WAVE: BECOMING SMARTER BY INCREASING RESOURCE PRODUCTIVITY

Introducing the resource aspect

The communication revolution, which marked development during the decades of the 5th wave from the 1970s onwards, needs to be transformed into a resource revolution. Moore's law, according to which the number of transistors on integrated circuits doubles approximately every two years, means in practice that computers double their productivity in a given period of time. Now the same should take place in the way we use our critical resources: energy, materials, food and water.

All our earthly resources have been under massive use in recent decades. Between 1980 and 2008, global resource extraction and use increased by 78%, from 38 billion tonnes to more than 68 billion tonnes. The number could rise to 100 billion tonnes in just 20 years. Simultaneously, there is an estimate that the biocapacity of the earth (including both extraction and absorptive capacity for waste and emission) has already been exceeded by 50%[141].

There are some fundamentals why we strongly believe that innovation, research and public policy during the next forty years will be shaped by resource use:

1. There has been dramatic rise in commodity prices since the turn of the millennium.
2. There are 1.2 billion new people joining the global middle class in the next 20 years, with the total size of the middle class then approaching 3 billion.
3. With the growth in Asia, demand for many raw materials has become very intense. World steel production, for instance, is expected to rise 80% by 2030.
4. There is globally a USD 2.9 trillion savings potential if resource productivity measures are applied to the full. It is estimated that 30% of demand could be covered by productivity increases.
5. We need an annual investment of USD 1 trillion to meet the needs of the global resource system.

Ever since the latest phase of globalization that took effect by the turn of the millennium, when China and India entered fully the global markets, there has been a very strong increase in demand:

[141] Eco-Innovation Observatory (2012): Closing the Eco-innovation Gap. Annual report.

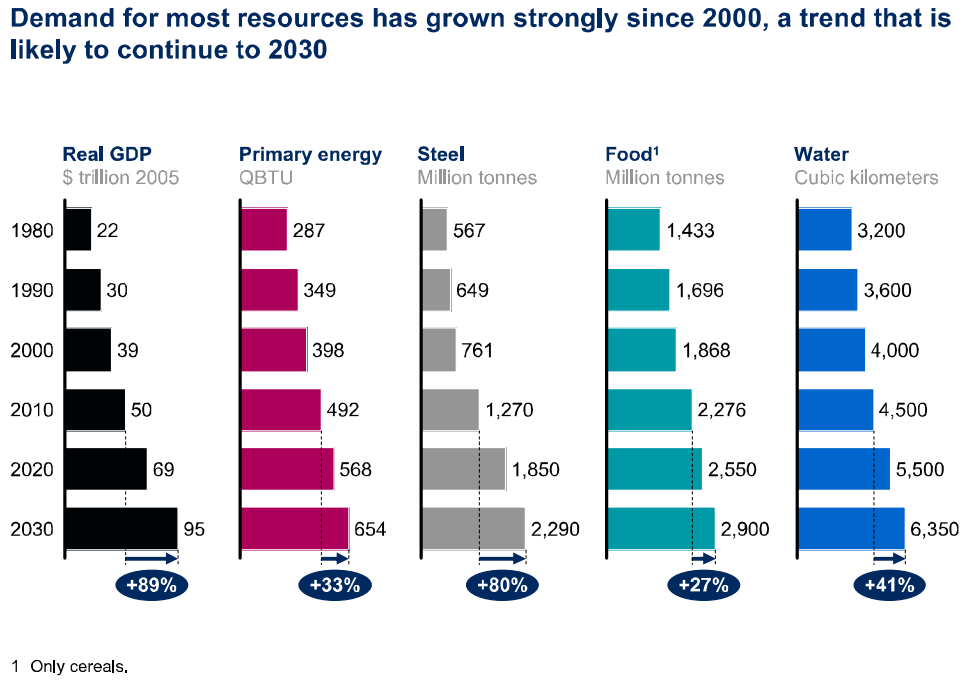

Figure 12. Demand for most resources has grown strongly since 2000, a trend that is likely to continue to 2030. Source: Global Insight; IEA; UN Environment Program (UNEP); FAO; World Steel Association; McKinsey analysis.

With rising demand and the difficulties of matching it with supply comes price volatility, which has plagued resource markets for the last decade:

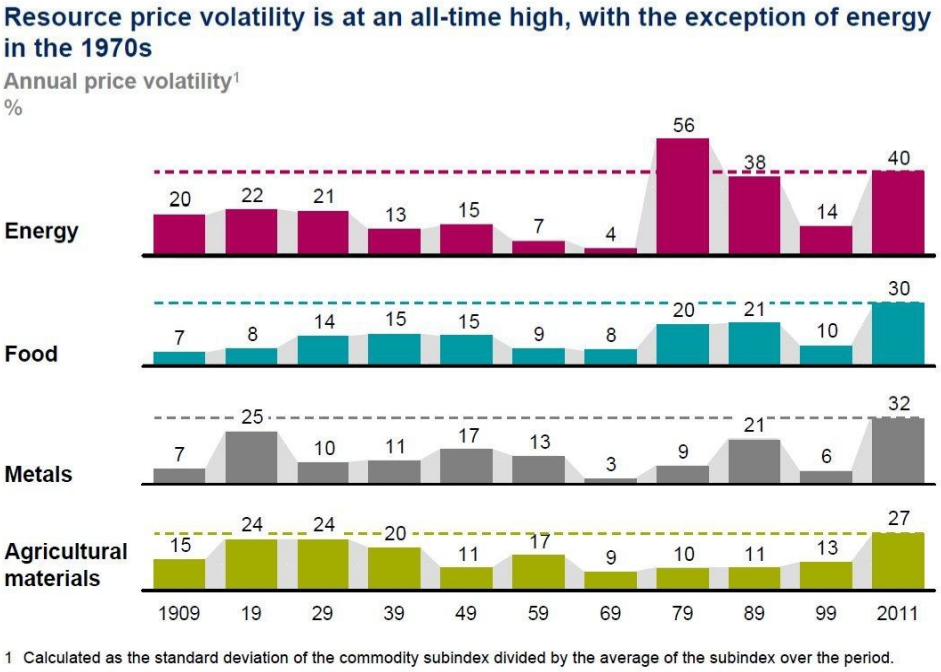

Figure 13. Resource price volatility is at an all-time high, with the exception of energy in the 1970s. Source: Grilli and Yang: Stephan Pfaffenzeller, World Bank; International Monetary Fund IMF; OECD Statistics; FAO; UN Comtrade; McKinsey Analysis.

This recent evidence suggests we are entering a new phase of global economic development, one in which the way we use our resources has a much more fundamental bearing on everything that we do. We need to see productivity increase by at least a factor of five unless we want to enter an age of dramatic resource struggles and even wars[142]. The supply side simply cannot expand in the way it has done in the recent past. From the private sector, this calls for radical innovations and new business models. All in all, companies have to consider how resource related issues should be incorporated into their strategic thinking. No companies will go through the next wave without experiencing, in one way or another, the issue of rising resource scarcity.

McKinsey has estimated that USD 900 billion in investments is needed to meet the productivity demands.[143] On the other hand, this could also create 9 million to 25 million jobs. In addition, the investment would help stabilize resource price volatility that would in turn encourage investment and lead to a new wave of systemic innovations.

In terms of scale, we are talking about major investments. While massive amounts of capital are needed, another problem arises that has to do with the fact that the entire "resource sector" is very fragmented. On the public side, its governance is generally divided between several ministries, and in the private sector it is quite common that companies have no one in charge of the resource aspect. It is quite often a part of general procurement, sometimes with corporate responsibility, but it really needs to be aligned with strategy.

Resource scarcity in the next wave

In our research framework based on Kondratieff cycle analysis, we have postulated that the key driver for the next wave we are facing is the search for resource productivity. This is largely because economic globalization has developed to the point where raw-materials and commodities have become or are becoming increasingly scarce. This development has and will have a particular price indication: there has been a fundamental shift from falling commodity prices into rising ones:

[142] Von Weizsäcker, Ernst (2010): Factor 5. Transforming Global Economy through 80% Improvements in Resource Productivity. Routledge, London.

[143] Mc Kinsey Global Institute (2011): Resource Revolution. Meeting the World's Energy, materials, Food and Water needs.

Figure 14. Commodity prices have increased sharply since 2000, erasing all the declines of the 20th century. Source: Grilli and Yang: Stephan Pfaffenzeller, World Bank; International Monetary Fund IMF; OECD Statistics; FAO; UN Comtrade; McKinsey Analysis.

It is remarkable that, in the course of the 20th century, the price of commodities dropped almost by one half[144]. This happened at the same time that economic output went through the roof by increasing 20 fold. The reason why resource prices fell was quite obvious: new supplies were discovered in abundance, and also new techniques developed that increased productivity. Moreover, prices did not always reflect the full cost of materials. The last ten years have been dramatically different: prices have been trend wise on the rise. This is particularly because of China: the huge Chinese demand has pushed prices up. When the financial crisis hit the global economy in 2008, the price surge of raw materials stopped for a while, only to continue after the most difficult phase of the crisis.

Because our industries are still very heavily material-intensive, we are indeed running into trouble, and the new battle for resources between global power centers has now started in earnest. Excessive use of materials and energy sparked the development in previous waves, coupled with inadequate technology to restrict pollution largely caused by the use of petrochemicals. This development has now created agenda for the next, 6th Kontratieff wave, which will dominate next 40–60 years of global development. The efficiency increases will be sought from reduced use of materials, non-renewables in particular, such as metals and minerals, and from decreasing energy intensity in production and lifestyles.

144 Mc Kinsey report (2011): Resource Revolution: Meeting the world's energy, materials, food, and water needs.

HOW TO SAVE RESOURCES AND MAKE MONEY
A blogpost by Markku Wilenius (21 November 2012)

You know what our biggest challenge is? No, not greedy bankers. Not even environmental pollution. It is our low level of resource use. Full stop.

We don't have to go far back in history when it was different. In the countryside, where the vast majority of people used to live, it was common sense to lend and borrow whatever was needed. This was the custom simply because it made sense in the context of scarce resources. Things were also fixed and reused. I still remember well how my late father-in-law hated to buy anything new to replace old things, simply because he wanted to maximize the object's lifespan. Presumably many of us share such memories.

A normal person in the Western hemisphere consumes around 25 tonnes of material per year. We should get it down to 8 tonnes is we wish to approach any kind of sustainable lifestyle. The current trend indicates the contrary: if it continues to 2050, we will be consuming three times as much as we do know. Clearly a no-go.

Actually, a lot of good things are happening around this theme. Some of it you can see here in the Silicon Valley region. Take Airbnb, the company that links people looking for a place to stay with local people who can offer a room, flat or house to stay in. Using intelligent software to display formidable amounts of information, it enables Seekers to learn about different options, while Offerers can chat with prospective clients and check with embedded tools what kind of a candidate they are interacting with. The outcome is that the visitor gets a much more authentic experience of the city, while the host gets some extra use and money for their space. We all know how boring and tiresome hotels can be. Instead, you stay in a real house, for a very reasonable price. So everybody is happy.

The story behind the company is nice: it all started some years back in San Francisco with group of friends who were organizing a seminar and all the hotels were full. So they decided to accommodate the quests in their own apartments. This experience served to spark off the idea for the business. Airbnb now operates in 192 countries, with more people joining network all the time. And it is a highly profitable business. Plus it saves all kinds of resources.

This is future, I hope. Becoming smarter in what and how we do things. Here's a look at what you could see out of your window while staying in San Francisco for the price of a standard hotel room:
https://www.airbnb.com/rooms/180100

This quest for greater resource productivity will steer our businesses as well as societies, and therefore set the tone for innovation[145] [146]. This is important particularly because we have learnt that, continuing on the same growth trajectory in resources use that we have as now, we will in theory use three times more resources by 2050 compared to the present[147]. We have ample evidence that this is simply not possible, which means the growth pattern will have to change fundamentally. Traditional industries must become much less material intensive, while whole new industries will emerge, some of which do not even have a name today. New professions will arise as well to facilitate development.

[145] See particularly interesting EU DG funded project Eco-innovation observatory.
[146] Measuring Material Growth and Resource Productivity (2008): OECD publications.
[147] See report of International Resource Panel 2011.

Materials are the basis of our economy. Historically, the extraction and consumption of materials have correlated strongly with economic growth. Interestingly, however, there has in the course of the last decades been a growing decoupling[148] between these two developments, as shown in this figure:

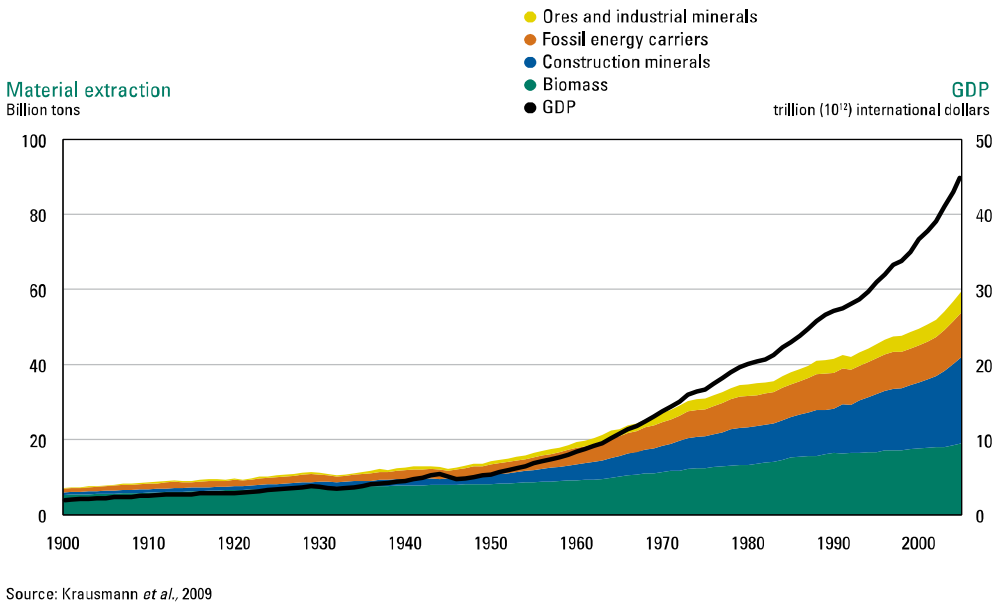

Figure 15. Global material extraction in billion tons, 1900–2005. Source: Krausmann et al., 2009.

Going back to the beginning of the 20th century, we might conclude that the dramatic change in extraction rates that has taken place has been for the human good. Driven by scientific and technological advances, the extraction of construction materials has grown by a factor of 34, ores and minerals by a factor of 27, fossil fuels by a factor of 12, and biomass by a factor of 3.6 (Figure 2). At the same time, the price of raw materials decreased by about 30%. Besides bringing material progress to our societies, this development has had a huge environmental impact. It has led to climate change, overexploitation of key natural resources, pollution etc., with the result that there is today a fairly large consensus that a change is needed, that we need to strive for an absolute reduction in resource use in order put ourselves on the path to sustainability. As our figure shows, there is still a long way to meet that goal. We simply need a whole new wave of innovations, some of it which is already on the way, as recent studies suggest[149].

Looking at material consumption levels in the EU, we can see that there was an interesting decrease in the consumption of material resources in the first years of the last decade. However, from 2003 onwards a quite dramatic rise in material consumption has taken place.

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[148] UNEP's International Resource Panel (IRP) has applied the concept of 'decoupling' to this challenge. While the term has been applied to everything from electronics to physical cosmology to linear algebra, in the sense used here, decoupling means using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken.

[149] See Eco-innovation observatory

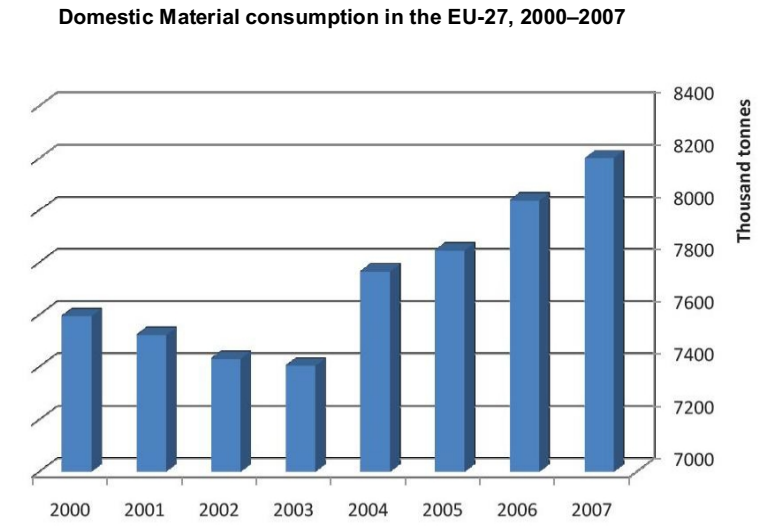

Figure 16. Domestic Material consumption in the EU-27, 2000–2007. Source: Eurostat, EIO database.

This trend was obviously hit by the financial crisis that set industries to downshift their operations. Simultanoeously, our dwindling reserves have become increasingly subject to international political manoeuvering as they are not uniformly distributed across the globe. For example, 60% of the iron ore in the world comes from three countries, Australia, Brazil and China, and 83% of the world's exploitable phosphate rock is in Morocco, China and South Africa[150] (Vaccari 2009). Phosphorus is a typical example of a raw material which is becoming increasingly scarce, thus creating good opportunities for new innovations to enter the marketplace. And remember: resource scarcity is closely bound to what is happening in population growth. According to UN estimates, population growth will reach about 9 billion by 2050[151].

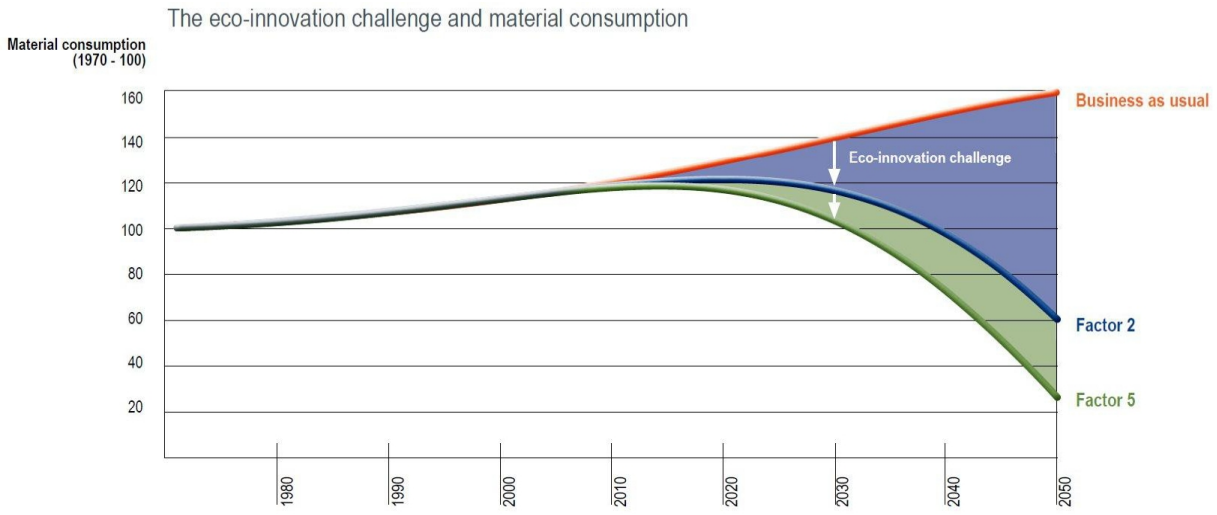

Figure 17. The path to sustainability means factor 5 productivity increase. Source: O'Brien et al. (2011).

[150] Vaccari, D.A. (2009): Phosphorus: A Looming. Scientific American, June 2009, p. 54–59.
[151] See UN: Department of Economic and Social Affairs. Population Division.

Eventually, one of the key drivers of innovation for the next Kondratieff wave will be material scarcity stemming from the anticipated shortage of metal and mineral resources in the next few decades. Simply put, material scarcity is controlled by two factors: the supply of the material versus its demand. With a growing world population and growing consumption, the demand for material resources already far exceeds the supply. In the past century, the exploration of new locations and technological innovations in mining and extraction kept material reserves in balance with the demand, helping the price level stay moderate. However, present knowledge indicates that this balance will not continue into the 21st century, as the production of a number of material resources has already peaked[152].

The most precious resources on our planet are food and water. In the decades to come, there will be a huge challenge concerning the sufficiency of these resources. In the food markets, we are already seeing the results of scarcity as food prices are rising. Some recent estimates anticipate severe and chronic food crises in just five years from now. These estimates come from the UN and several research institutes, but also from the investor community[153, 154]. Jeremy Grantham, the founder of GMO, a global wealth management company, writes in his report from last June that global food production is under severe constraints, for reasons varying from the overuse of fertilizers and other bad farming practices to the growing needs of the global middle class[155]. One thing seems certain: the crisis will hit badly those countries that are ill equipped to manage the situation.

The idea that we might face a full-fledged global food crisis in five years may come as surprise to some. Grantham has found several indicators that show this is indeed the case:

1. *Grain productivity* It has been falling every decade since 1970, rate being somewhere between 3.5% and 1.5%.
2. *Fresh water availability:* Water problems are really becoming a pain in the neck for humanity: even gains from accelerated irrigation are offset by the loss of underground water and salination of the soil.
3. *Non-sustainable farming practices:* These seem to perpetuate land degradation, which will continue to undermine our longterm sustainable productive capacity.
4. *Massive use of fertilizers:* The gain from increased use of fertilizers is declining on the margin, because fertilizer use has increased five-fold in the last 50 years and the easy pickings are behind us.

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152 See excellent report "EIO Horizon Scanning Report: Future Trends"

153 See Grantham, Jeremy (2012): Welcome to Dystopia! Entering a Long-Term and Politically Dangerous Food Crisis. GMO Quarterly Letter, July 2012.

154 See Vidal, John (2012): Food shortages could force world into vegetarianism, warn scientists. The Guardian, Sunday 26 August 2012.

155 See Romm, Joe (2012): Jeremy Grantham on 'Welcome to Dystopia': We Are 'Entering A Long-Term And Politically Dangerous Food Crisis'. Thinkprogress.org

5. *Changing climate*: There will be increasing weather instability, notably floods and droughts, but also steadily increasing heat. There is less and less debate about if this change is anthropogenic by origin (see chapter 5)
6. *The cost surge*: The price of fertilizers and fuel have rised rapidly and this can be expected to continue

The fact is that the price of key agricultural commodities have been increasing rapidly. From 2005 up to 2011, the price of maize went up 204%, rice 112% and wheat 105%. It is quite obvious that the riots in many developing countries have partly been ignited by this development. As for the future, it is estimated that global food production should increase from 60% up to 100% by 2050 to cover the demand. In other words, there is a huge call for resource efficiency that could match the growing need.

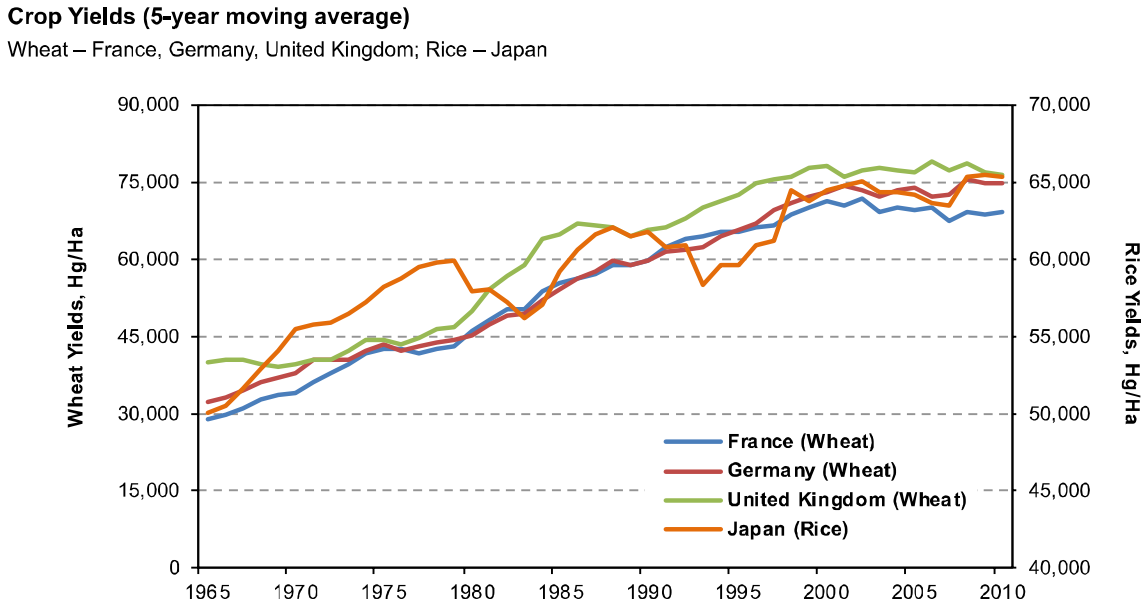

Figure 18. Crop Yields (5-year moving average). Source: UN Food and Agriculture Organization, 2010.

On the other hand, the data also shows that there has been no productivity increase in top-producing countries in the last 10-15 years. Thus the pressure is to find the productivity increase in developing countries. This challenge expresses in a nutshell what is at stake in the coming 6th wave: we have to become much more intelligent in how we use our resources.

What happens is that the severity of these challenges often fall short of the speed of change. A clear example is the melting of the polar ice cap. This summer, with its all-time low, it was at a level that was forecasted 15 years ago for 2050! We therefore have an escalating rate of change our environment caused by human action, on the one hand, and more intensive use of resources, also determined by human action, on the other. Just think of a global middle class that is expected to reach the size of 3 billion people, who will all want to eat meat like the average Westerner today.

This forthcoming age of natural resource productivity and enforced scarcity will be reinforced by a political agenda: climate change, the shift from fossil fuels to renewables, the overuse of critical natural resources such as forests, fishing stocks and water, the safeguarding of biodiversity along with many other environmental predicaments, will set the pace for national policies and thus for legislation, taxation and party politics. As before, a new political agenda will propel new business. This time, however, production will be globally distributed right from the beginning. This is exactly the novelty of this wave: the race to become trendsetters and benefactors in this new era is taking place on a global basis, for the first time in human history[156].

Facing reality

At present, we all are prisoners of a civilization that forces us to destroy the environment for the sake of survival. Facts speak for themselves: UN Millennium Ecosystem Assessment (2005) found that 15 of the 24 major ecosystem services that support the human economy – such services as providing freshwater and food, purifying air and regulating the climate – have already been or are being pushed beyond their sustainable limits. Even the Pentagon Quadrennial Defense review has warned that environmental destruction will have significant geopolitical impacts around the world, contributing to poverty, instability, mass migration, conflict and further weakening of fragile governments[157].

The problem is simply this: because of excessive use of natural resources, the world economy is racing at this very moment with increasing speed ever further beyond the carrying capacity of the earth. The global GDP has more than doubled in the last 20 years. While a slow resource decoupling is taking place due to gains in efficiency, the absolute consumption of natural resources is still rising. This is due to population growth, but also a consequence of our heavily biased economic system that supports excessive use of materials by keeping their price artificially low and by overtaxing human labour for state revenue. In other words, an abundant resource is made to pay for the common good, while scarcity is allowed to grow with foreseeable disastrous consequences.

The human economy must therefore be restrained to function within the limits of the environment and its resources, and in such a way that it works with rather than against the grain of natural laws and processes. The present state of economies shows poor understanding of the real service function of the economy in the human system.

For the economy, and indeed for the whole society, ecological sustainability means protecting the life-sustaining eco-systemic functions and services of the ecosphere without which humans cannot survive on the planet (e.g. the natural provision of clean air, liquid drinking water, edible plants and animals, the pollination of blossoms, as well as maintaining suitable weather and climatic conditions).

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156 See Wilenius, Markku (2011): The Sixth Wave and the Challenge of Global Democracy (Uusi maailmanjärjestys ja globaalidemokratian haaste), Futura 2/2011.

157 See US Department of Defence (2010): Quadrennial Defence Review

The loss of eco-systemic functions is primarily caused by resource-intensive goods, processes, systems, services, and procedures, driven by virtually cost-free use of nature. In agriculture, for instance, it is well known that the enormous current subsidies encourage ecologically destructive farming methods, increase poverty in Africa and elsewhere, and distort trade policies, while being fundamentally perverse economically: in which other sector are actors paid for using and exhausting natural resources? The worldwide total amount of annual subsidies is estimated to exceed EUR 1 trillion.

This implies that *the* major thrust of all policies must perforce be related to the demand of improving the overall *resource productivity* of the socio-industrial metabolism. In other words, all changes in technical, economic, financial and institutional procedures should be subject to the need of decreasing overall resource consumption per unit of desired outcome, as well as the overall use of natural resources.

What we need are eco-innovations – novel procedures, habits, goods, processes, systems, and services – that can satisfy human needs and bring better quality of life to all people with a life-cycle-wide minimal use of natural resources per unit output - and a minimal release of toxic substances[158]. In order to get here, we need to maximize resource productivity while minimizing resource intensity[159]. Resource productivity and resource intensity are the key physical indicators for decoupling welfare generation from direct and indirect environmental degradation. Their strength is that they can be used as a metric for both economic and environmental costs. Optimizing resource productivity is the currency and price for creating sustainable material welfare.

[158] See www.europe-innova.org
[159] See definition of the terms used: EU Online Resource Efficiency Platform.

NEW PARADIGMS FOR RESOURCE PRODUCTIVITY: TAKING THE LONG VIEW
A Workshop on December 10, 2012

The Sixth Wave project in collaboration with the Institute for the Future organized a roundtable workshop on new ways of creating business value that are reinventing what it means to use resources efficiently. The themes of the workshop ranged from green products to collaborative consumption, labor redistribution, and crowdsourced funding. The invited participants represented very different organizational backgrounds, from Amazon Mechanical Turk – an online microtasking platform – to New Leaf Paper that is manufacturing 100% recycled paper. The common denominator to all was an inspiration to re-think the old models of the industry they were operating in and come up with a smarter, more resource efficient mode of working. During the day we engaged in conversations with the participants about their personal motivation, practical ways they feel their organisations have managed to do things differently, and what is their take on improving resource efficiency.

Participants:
Casey Armstrong, VineStove
Kelly Bennett, Business Development Manager, Amazon Mechanical Turk
Devin Fidler, Research Director, IFTF
Neal Gorenflo, Co-Founder/Publisher, Shareable
Mike Hannigan, Co-Founder, Give Something Back
Lyn Jeffery, Research Director, IFTF
Jeff Mendelsohn, Founder & CEO, New Leaf Paper

Based on the discussions we produced a tentative framework to describe the represented "ethical companies", businesses that in addition to traditional business values also want to change the system according to a certain value set that is related to the quest for improved efficiency:

1) There are companies that accept the current economic system, but bring values to it (as in the company *Give Something Back*, an office supplies company that runs along a normal business logic but transfers theprofits back to the communities where it operates).

2) Others are trying to change the system incrementally for the better (*New Leaf*, a paper company that works in a traditional industry, and much assimilates its operating logic, but the product, 100 % recycled paper, aims to improved resource efficiency compared with the rest of the field).

3) An emerging group of companies represents a completely new paradigm: for instance sharing economy (*Shareable* provides for its customers a platform for sharing things and labour. It challenges the current paradigm of work, and introduces a novel form of bartering, much more efficient in the digital age).

4) An introduction of on-demand, scalable labour might by itself change parts of the economy (*Mechanical Turk* is a platform for posting microtasks: small tasks of work that pay very little but enable hiring labour for work that would not get done otherwise. *VineStove* is at the outset a similar microtasking platform, but differs in that it is based on donating labour for a charity cause. The systemic effect of such initiatives in the long run, or scaled up is unknown).

7. FINLAND AND THE EMERGENCE OF THE BIO AGE

Finnish industry at the crossroads

The key question to us is how well or badly Finland will to survive the 6th wave. If we look at what happened in the previous wave – 40 years from the early 1970s up until today – Finland did extremely well. We rose from a peripherial society with an unhealthy close contact to the Soviet Union into one of the top countries in the world in terms of economy, innovation and education. Our GDP grew by a factor of 9 in the period 1975–2011. Our big industries became international: before 1980, Finnish companies had no presence abroad, with the notable exception of some firms such as Ahlström. We became an open, market-oriented economy. Our competence portfolio expanded from forest, metal and machinery to electronics.

The question is now, what will happen to Finnish economy in the next wave? Some issues regarding the strength of existing sectors or clusters are particularly pertinent to this question.

1. The Finnish forest sector is in a very vulnerable position. The consumption of paper in all parts of the industrialized world has now peaked as a result of the digital revolution. This means that our major export products, pulp and paper, do not sell too well anymore. Several plants have been forced to close in Finland, and there will undoubtedly be more news such on that front. Forest industries would be well advised to start investing heavily in alternative products and services. This is easier said than done, because the industry is itself rather traditional and slow to move. However, there are potentially large markets as regards biofuels, wood construction and packaging industry products, for instance. The issue is how much is really invested in these new opportunities.
2. The ICT cluster expanded rapidly in the 1990s, but the growth slowed by early 2000s and the sector began to shrink later in that decade. Finland has become much more focussed on R&D, while the product lines have been largely removed to countries with cheaper labour.
3. The metal cluster had years of steady expansion, but the situation has changed for the worse in the last few years. However, the metal industry is a cluster that has been able to provide new job opportunities, and some companies have done a great job in increasing the service part of their business.
4. The Finnish clean-tech business sector has been growing rapidly, with revenues topping EUR 20 billion. It is quite certain that demand in the world – particularly in countries like Brazil, Russia and China – will continue to expand. As this is a sector that has a great impact on the resource productivity of economic activities, we believe there is a strong growth potential here in the coming decades.

5. Health business is growing rapidly in ageing industrial countries, and in 20 years' time it may grow into the largest business sector in the world. The Finnish health sector has grown as well, but this has happened mainly in internal markets. There is thus a challenge of how build valued-added services that can compete in global markets.

All in all, if we take a closer look at existing sectors and their potential, we may come to the conclusion that, in the future, wealth in Finland has to be created with different set of industries and services than what we have had in the past. This is particularly true since, if we are to believe the economist Richard Baldwin, globalization is moving now to Phase 2, where it is driven by progress in two very different types of 'connective' technologies: transportation and transmission[160]. What this means in practice is that, being connected by these new technologies, global supply chains will enable developing countries to become integrated in a very new way to the global economic system. Baldwin goes on to argue that, in the last ten years, by virtues of the fact that the North has rapidly deindustrialized while the South has industrialized, there has been a dramatic reversal of fortunes that has been the most momentous change in the last one hundred years. This might be just the beginning, but it is already reshaping many aspects of international relations.

What does this mean for Finland? It means that, with such rapid changes, the future becomes much more unpredictable. As Pajarinen et al. have shown, this development may have some positive aspects to it if we are situated in the right phase of the value chain. Their analysis shows that, in the case of mobile phones produced by Nokia, 39% of the whole value of the product can remain in Finland, even while the phone is produced in China and delivered to the US.[161]

Globalization, in addition to bringing new kinds of structures into global trade and making old operational models obsolete, has also another aspect: by endorsing the massive industrialization of developing economies, it eventually brings resource scarcity onto the agenda. It is here that we should foresee the threats and opportunities globalization creates along the way.

Finnish business goes out to a resource scarce world

The basic thrust of the Finnish economy is fairly resource intensive[162]. This is due to the forest and metal industries forming the bulk of our economy. Both of these industries rely heavily on a seamless supply of materials. In the future, the metal industry will face ever growing price competition, as some raw materials become scarce and pricy. That is one of the reasons the shift towards service components of business needs to happen fast, because that is where the new value-added will come from. The forest industry basically needs biomass, which, being a renewable resource, is more easy to get in sufficient supply. A much more

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[160] Baldwin, Richard (2012): Global Supply Chains: Why they Emerged, why they Matter and Where are They Going? CTEI Working papers, Geneva.

[161] Pajarinen, Mika – Rouvinen, Petri & Ylä-Anttila Pekka (2010): Missä arvo syntyy. Suomi globaalissa kilpailussa [Where Value is Created. Finland in Global Competition]. Helsinki, Taloustieto.

[162] Bringenzu, Stefan (2002): Towards Sustainable Rsource Management in European Union. Wuppertal Institute, papers.

important question is whether these companies will reinvent themselves so that their future portfolio will have more value added and less resource intensive products in it.

Finnish companies need to consider how they can factor resource-related issues into their strategic thinking to a much greater degree than at present. The time of abundant raw-materials and falling commodity prices that marked the development in the last century seems to be over. This means there are new reasons why resource productivity should be understood as a strategic priority. The next decades will show how resource scarcity, together with tightening environmental regulation and growing pressure from consumers, will underline the importance of how intelligent we are in our use of resources. In the Finnish context, these rising topics mean that our industries need to think how they can turn their business towards finding solutions to these growing challenges rather than being part of the problem. This means heavy investments in the kind of leadership capital needed to change the course.

We believe strongly that resource related issues will become an increasingly important factor for business in most of sectors. In the future, all businesses may gain considerably by being more watchful of how they use their resources. This should lead to a more integrated understanding of how resources are linked to profitability, how they reveal new growth opportunities and pose new risk management challenges. Furthermore, Finnish companies should in the future invest more in the understanding of volatile trends such as resource prices, as well as of growing supply risks. A particularly pertinent aspect of this would be to consider how they can anticipate new regulatory schemes and strategize how to contribute to evolving resource technology needs.

Internally, companies should focus on implementing resource productivity systematically throughout the value chain, from suppliers to end users. This could be a basis for new – even systemic – innovations in the business model, starting from more efficient procurement practices and continuing to more service orientated customer platforms. Moreover, capital investments needed for raising productivity in product lines and the supply chain may open the door for new major opportunities companies that accumulate the competence required to master it. Many of the opportunities ahead do involve rather attractive returns in excess of 10%[163].

What is needed, more than ever before, is will and competence for foresight. Companies need to find out the particular volatilities and radical change paths that can undermine their business. They should also investigate the impacts of these forces on their business models and services. And, finally, on the basis of this insight, they should plan and execure the necessary changes in strategy and tactics on the market. These concerns are particularly relevant for the many Finnish companies that are very dependent on raw-material and energy prices. And nowhere is this more so than in the Finnish forest industry.

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[163] See McKinsey Global Institute (2011): Resource Revolution: Meeting the world's energy, materials, food, and water needs.

From forest industry towards bio-industry

Finland is known to many as a technologically and socially advanced country. In this picture, the forest industry may seem like an oddity, because lumber, pulp and paper are classic examples of low value-added products. Although Finland is a relatively advanced information society, the forest industry seems like a remnant from the industrial age, even if we like to think that Finnish companies have the most advanced machinery.

Pulp and paper are the two main products of Finnish forest industry. The demand for paper has begun to stall and even sink in developed countries, while it is still increasing in emerging countries. This has undermined the profitability of paper production in Finland[164]. However, there is still a lot ambition within the Finnish Forest Cluster which aims to double the value of its products and services by 2030 by investing in new ideas[165].

Although the Finnish Forest Cluster's expectations can be accused of being overly optimistic, the Finnish forest industry has real potential to increase its significance and profitability, even radically so, in the 6th wave period.

This assumption is shown to be justified when we look at some drivers in the operating environment: the declining availability of non-renewable natural resources and the consequent higher price-levels; the urgency to cut greenhouse gas emissions; and the rising demand of consumers for more sustainable products. On the other hand, we also see the declining consumption of paper – in the US, the consumption of printed newspapers and magazines declined by one half in the last 10 years. Globally, the peak of paper consumption may already have occurred in the last decade. And even if it does continue to grow, that will happen only because of the growing demand in developing countries – consumption in more advanced countries definitely seems to be on the decline. The digitalization of transactions and consumption has had a major effect on the demand.

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164 Honkatukia, Juha & Simola, Antti (2011): Selvitys Suomen nykyisestä ja tulevasta puunkäytöstä [study on Finnish wood use capacity.] VATT tutkimukset 164.

165 See Forestcluster http://www.forestcluster.fi/

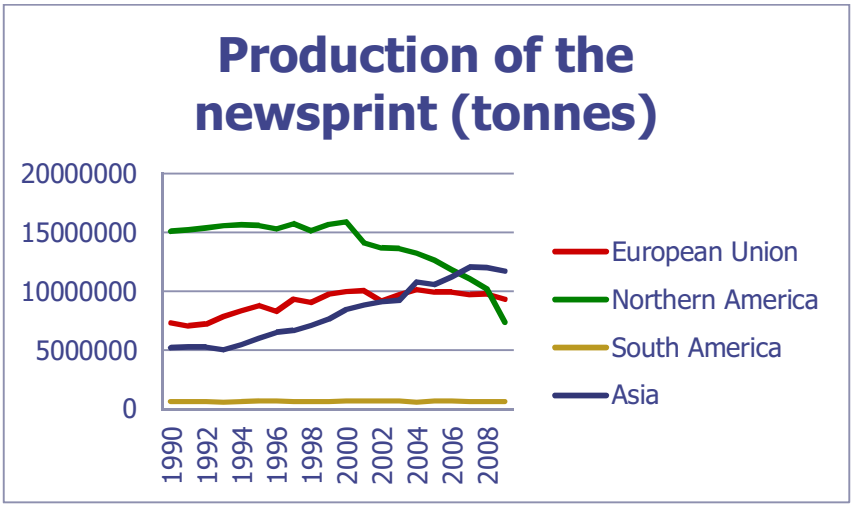

Figure 19. Production of the newsprint. Source: Game Changers project, IIASA.

The change of wind suggests that, for the Finnish forest industry, the key to future prosperity is to start consciously moving away from traditional paper and pulp production towards using forest ecosystems in their entirety as a resource for providing an array of high value-added products and services. Paper and pulp do not need to be abandoned altogether, as they can be merged with digital technologies to be used in smart paper and packages, for instance. Moreover, the rapid digitalization of lifestyles can also result in some counter movements that may increase the demand for products made out of paper. In the Finnish context, the key concept is "bioeconomy".

Bioeconomy refers to three different aspects to bio-based raw-materials: a) bio-based products, b) the use of biological processes in production, and c) cycles of material and energy as a part of the biosphere[166]. Bioeconomy products are based on biomaterials that are by definition biodegradable, so they are fundamentally renewable both in the beginning and as end products. The properties of these products may be manipulated using various biotechnologies.

The development of biochemistry has brought biological processes into industrial production. The novelty in bioeconomy is that it takes into account all the possible impacts on ecosystems and natural cycles. We can then talk about industrial ecology in terms of product plants and their dynamic with natural systems. In bioeconomy, all material and energy flows are either in use or are returned to the natural cycle. It is, in effect, a merger of industrial and natural economies.

The idea of bioeconomy, not only as a scenario of the future, but as a necessity for our societies, stems from the fact that, in the next decades, when population growth is expected to reach close to 9 billion people, we will be forced to abandon all economies that are based on fossil fuels or other oil-based products and non-renewable raw-materials, which are rapidly becoming scarce. Bioeconomy is an ongoing challenge that will stay with us for the rest of the century.

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166 See Kuisma, Juha (2011): Kohti biotaloutta. Biotalous konspetina ja Suomen mahdollisuutena. [Towards bioeconomy – Bioeconomy as a concept and as an opportunity for Finland] TEM kilpailukykyjulkaisuja 6/2011.

Moreover, recent evidence from climate change research shows that we need to radically cut emissions if we want to avoid the so-called 4 degree world (CO_2 levels in the atmosphere causing the global temperature to soar to 4 degrees above preindustrial levels), in which unprecedented threats could endanger the very existence of our civilizations[167] (see more in chapter 6). In the leap towards bioeconomy, we could pave the way for the kind of economy and society that would help to balance out the excesses of detrimental industrial patterns.

The forest industry has the potential to provide not only renewable energy, but also a broad variety of renewable biomaterials. Various forest-based products and services will most likely play a decisive role in the emerging bioeconomy as a source of renewable energy, raw material, and also experiences[168]. If most of both energy and raw materials were to come from renewable sources, that will certainly play a part in any scenario of diminishing natural resources. In principle: everything that today can be made out of oil can be made out of bio materials in the future.

Biomass-based energy production and biofuels have great potential in satisfying future energy needs. In addition, forests may also be increasingly attractive as destinations of increasing nature-oriented tourism. Moreover, eco-design in its various forms – design based on bio-based materials – has gained increasing momentum in recent years, while wood products have regained their status as high-end products. The key for our bio-related industries is how they can add value to products and services, since low value-added basic forest industry will certainly be facing tough times in the future.

Let us envision a more radical scenario: By mid-century, when we will probably be coming to the end of the 6th wave of development, we might be living in a society and economy in which most of goods are made out of biomaterials and resources. In that society, nature will be valued high as a source of raw materials, but also as a source of deeply significant experiences. This will bring us to a Bio Age, an age based on bioeconomy, in which production, processing and marketing as well as consumption will all be based entirely on the use of renewable natural resources. Moreover, in the bioeconomy, renewable resources will be utilized much more efficiently than today. The forest industry could extract more value from every tree harvested – for energy, materials and chemicals as well as traditional forestry products – turning yesterday's waste stream into tomorrow's revenue stream.

However, the Bio Age would be a much broader concept than just bioeconomy and sustainable development. It would cover all spheres of society and culture. The Bio Age could give rise to a culture that is less mechanical than culture has been since the industrial revolution. Its functions would not be separated into narrow pigeonholes, but would form an "organic" whole, or in buzz terms, an ecosystem. Throughout history, the human pursuit has been to seek shelter from nature and to guard again its effects. The new age

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[167] Potsdam Institute for Climate Impact Research (2012): 4-degrees briefing for the World Bank: The risks of a future without climate policy

[168] FPInnovations (2011): The New Face of the Canadian Forest Industry. The Emerging Bio-revolution. Forest Products Association of Canada.

would see a move towards nature, not seeking dominion over natural processes, but *mimicking* them instead[169].

However, a new kind of balanced relationship with nature would probably leave space for altering nature in completely new ways. In any case, the Bio Age could be seen as a merger between instrumental rationality and value-oriented rationality. A genuine drive for sustainable development could redefine the concept of growth, and even offer a new *grand tale*, a unifying vision for the future. The concept of neo-growth has been developed to reflect growth in this new era. To simplify, neo-growth means not only ecologically sustainable economic growth, but also, and above all, a valuing of human growth over economic growth[170].

The most promising fields for the future of the Finnish forest industry are construction materials, energy, fuels, wood construction, including wooden blockhouses, materials (including smart paper and smart packages), chemistry (including bio-medicine), tourism, and ecosystem services[171]. In the bioeconomy, much more emphasis is laid on design as a prerequisite for sustainable products and services. Bio-based production could make possible and comprehensive the idea of cradle-to-cradle, in which waste from a product is used as raw material for other products, or combusted for energy.

In the following we will look a bit deeper into some of these schemes:

Construction Materials

Wood has many advantages as an ecological construction material. It is renewable and ecologically discardable. Moreover, the production of wood materials is ecologically sound compared to e.g. concrete, which according to Patrick Dixon (2008) *causes 7% of global CO_2 emissions*. Comparing the material intensity of concrete and wood, it turns out that concrete is around 50 times more material intensive, which mean it inherently involves more material flows[172]. Wood is also ideal with respect to its physical properties as it is easily workable and can be combined with other materials such as stone, glass and metal. It is also conducive to a pleasant indoor climate. The demand for wood by the wood-using sectors is estimated to grow by 40% in volume by 2030–2050, with strong demand particularly in the building sector to replace steel and cement[173].

Wood as a construction material is defined by the following attributes:

- Light but strong, easy to process, insulates heat
- Excellent acoustical properties

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[169] See interesting scenario work at:
Michigan State University (2010): Future Scenarios for Michigan's Bioeconomy: Planning Your Strategic Responses. See also book with fascinating cases: Pauli, Gunter (2010): The Blue Economy

[170] Here we refer to the term coined by professor Pentti Malaska, see
Hyötyläinen, Mika; Manninen, Jari; Nikulainen, Kalevi; Ohtonen, Ville; Siltala, Juha; Rehn, Alf (2011): Understanding Neogrowth. An Invitation to Sustainable Productivity. Helsinki: TeliaSonera.

[171] Hietanen 2010

[172] Material Flow-Based Indicators in Environmental Reporting. Wuppertal Institute Environmental Issues Series no. 14.

[173] See eg. Purbond (2011): The renaissance of wood as a construction material – and the adhesives that started it.

- Improves indoor air quality
- The only 100% renewable construction material, due to sustainable forestry
- Recyclable, non-toxic
- Manufacturing of wood products requires little energy
- Wood products compare well in material life-cycle comparisons
- Natural, beautiful, warm, sensual

The last point deserves special attention, as wood can be used in buildings to create an entirely new kind of aesthetics. If brick and concrete epitomized the architectural aesthetics of the industrial era, and glass that of the information era, then wood and other organic materials could embody the aesthetic of the 6th wave. The present trend of urban and vertical farming could be seen as a weak signal for a city in which nature is omnipresent. Soon-to-be-ready-for-market 3D printing of houses makes it much easier to use organic, complicated and detailed forms in architectural structures[174].

New digital production techniques, such as laser cutting, are contributing significantly to the change in aesthetics, as they tend to produce organic forms and forms that are otherwise hard to create[175]. Wood-based materials could be used as raw material for 3D printers, or used otherwise for constructing organic forms in buildings because of their versatility and flexibility.

Bio energy

The political goal of sustainable growth, which the Finnish government is also committed to, the rising price of oil, increasing global energy consumption, and claims for energy security, these are the main drivers in the search for new, renewable and preferably abundant energy sources. The looming climate catastrophe requires swift action. It is estimated that growth in the production of easily accessible oil and gas will by 2015 no longer match the projected rate of growth in demand[176]. Since wind and solar power are still some steps from full market entry[177], and nuclear power has its own negative ramifications, bioenergy offers the most prominent solution for a rapid increase in renewable energy production.

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[174] Grabar, Henry (2012): Prototype of the Day: A Printer That Can Build a House in 20 Hours. The Atlantic.

[175] The shape of things to come. When products are printed, they often look like nature intended. The Economist, 10 Dec 2011.

[176] See Shell Energy Scenario 2008, p.8 & Signposts. A supplement to Shell Global Scenarios to 2025.

[177] Some of the reasons being not of economic nature but institutional, see for instance: Tarasti, Lauri (2012): Tuulivoimaa edistämään. TEM Energia ja Ilmasto.

THE VERY HARD NUCLEAR FUTURE

A Blogpost by Markku Wilenius (14 December 2012)

This morning, the leading Finnish newspaper Helsingin Sanomat advised us that Areva, the main contractor for the Olkiluoto 3 nuclear reactor plant, f has estimated that the reactor will cost almost three times more than originally planned. So, instead of €3 billion, it will cost (at least) €8.5 billion. Although it remains interesting to see who will pay the difference of €5.5 billion in the contract, the real issue is this: there are very few arguments left for claiming that, under present security standards, nuclear reactor would be a competitive choice, even if we forget all the other massive problems involved in it. And recently we learned also that the other nuclear plant plan by Fennovoima has done some serious miscalculations about the cost of the plant. The current estimate is close to 8,6 billion euros, which is simply too much to be economically viable.

One may well ask, how such an enormous miscalculation can happen? The simple answer is: this is the first time anyone has ever tried to build a nuclear reactor with sufficient security measures in an advanced Western country. It will be interesting to see any reactions from other parties involved in building new nuclear plants in Finland. And what about our politicians, those whose job is to think about long-term public interests?

Globally, biomass is already the fourth largest source of energy, following oil, coal and natural gas[178]. Despite the amount of bioenergy already produced at present, there seems to be a clear imbalance between bioenergy supply potential and prospective bioenergy demand in the world[179]. The main sources of biomass energy are residies from harvesting and industrial processes, fuel wood, charcoal and pellets, liquid biodiesel and ethanol, and biogas. All of these can be produced from wood. Wood has therefore the potential to significantly contribute to the rising bioenergy demand, and do it in an ethical way, because many other bioenergy sources are also used as food.

Wood pellets in particular show a lot of growth potential. They represent a very small share of current biomass energy, but pellet supply and demand have grown rapidly since the mid-1990s. Some estimates show that production has more than doubled since 2008 (by 2011). Demand for wood pellets is increasing quickly due to their convenience, affordability, and ease of shipping over long distances. Their high density and small, uniform shape make wood pellets ideal for use in automated combustion systems[180].

As most of the non-OECD countries are heavily dependent on biomass in their energy production, there is a huge global demand for not only high-end bio-energy technology, but especially for relatively cheap ways to produce bio-energy. Since bio-energy has the advantage of local accessibility and energy security, it is widely deployed in local communities in poor areas. However, current technologies are primitive in many areas and are causing a lot of problems, such as high CO_2 emissions, health problems and deforestration.[181]

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178 See Ladanai, Svetlana & Vinterbäck, Johan (2009): Global Potential for Biomass Energy. Swedish Institute for Energy & Technology.

179 Berndes, Göran & Magnusson, Leif (2006): The future of bioenergy in Sweden – Background and summary of outstanding issues. The Swedish Energy Agency

180 See Renewables 2012, a global status report.

181 MacQueen, Duncan & Korhaliller, Sibel (2011): Bundles of Energy. The case for renewable biomass energy.

Biomass-based heat and electricity production could be used at a local and domestic levels also in the OECD countries; heat production in particular is common already in some areas. The same, relatively cheap technology used at the domestic level could also be used at a communal level. This would be in line with the weak signal of local, self-sufficient communities. As relatively labour-intense production, bio-based energy could also boost rural and local employment.

In the future, energy production may be more about biology than engineering and chemistry. Gene manipulation will probably be a prominent biotechnology in the future, and genetic science a central factor in future forms of the information society[182]. Gene manipulation has a huge potential also in the energy sector. Using the rapidly accumulating knowledge of gene data, cells can be programmed to maximize the efficiency for energy production and processing[183].

Despite the promising prospects for sustainable energy, there are serious pitfalls in the increase of bioenergy production. Food competes with bioenergy for scarce land. The conversion of arable land for energy production may lead to biodiversity rich ecosystems being transformed into monocultural biomass plantations. Rising land prices could cause poor people to be evicted from their lands. Plantations require irrigation, which could lead to water shortages and increased soil salinization and acidification.

Biomaterials

Biomaterials are an alternative to plastics and polymers that are currently produced from petroleum. However, with current biomaterials capacity, a mere 1 percent of plastics could be replaced[184]. However, because petroleum is used in a bewildering array of products and packaging, biomaterials have a significant growth potential. Lux Research expects the market to grow by a minimum of 17.7% per year[185]. As the graph below shows, most of the petroleum-based products can be replaced even with current technologies[186]. In Finland, there are some interesting new startups developing replacements for existing oil-based construction materials.[187]

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[182] The great social scientist of the information age, Manuel Castells, has argued that gene technologies are equal in importance to traditional ICT in the information age

[183] Enriquez, Juan (2007): The Future of Bioenergy. Wall Street Journal,

[184] Byrne, Ciara (2010): 2015: The future of biofuels and biomaterials

[185] Ibid.

[186] See Bunger, Mark (2010): Will Biofuels ever be more than a drop in the barrel? Lux Research, Feb. 26, 2010.

[187] See for instance Fibertus.fi

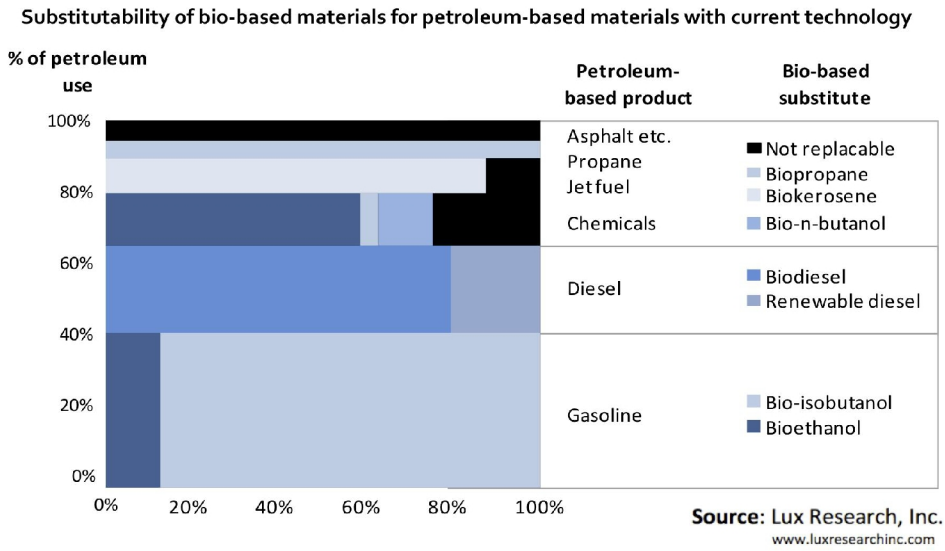

Figure 20. Substitutability of bio-based materials for petroleum-based material with current technology % of petroleum. Source: Lux Research, Inc.

The main driver behind the development of biomaterials is of course the business opportunities offered by them. Moreover, their inherent ecological sustainability makes them a great fit for the Government's agenda, because it makes them a fine tool for reaching the EU target of producing 20% of all energy from renewables by 2020[188]. Furthermore, as with bio-based construction materials, products made of biomaterials are an ideal match with the cultural and value trends of sustainability, wellness and recycling[189]. In addition to cultural, aesthetic and ecological trends, smart bio-packages have an application potential for products suited especially for the ageing population. Paper-based hygiene and indicator products could be highly usable in the healthcare sector. Obviously, smart paper and smart package applications have cross-cutting potential with the ICT sector[190].

Nanocrystalline cellulose composites can be used in the aerospace and aviation industry to replace heavier and more expensive, non-renewable materials. Lighter materials also mean lower fuel consumption[191]. Work is being done to reduce the weight of cars by as much as one half, which can be achieved by increasing the use of natural fibre composites[192]. Biodegradable bioplastic derived from renewable biomass can either replace traditional plastics directly or be blended with them. As an example, lignin, the organic substance that holds together the individual fibres of wood, could be used to manufacture the rubber needed for car tyres. Bioactive paper and packaging are examples "smart paper". Paper towels could indicate contamination on different surfaces, strips of paper could remove pathogens from water or confirm the water is safe to drink,

188 EUwood (2010): Real potential for changes in growth and use of EU forests.
189 So called LOHAS-lifestyle (Lifestyle of Health and Sustainability)
190 Cepi (2011): The Forest Fibre Industry. 2050 Roadmap to a low-carbon bio-economy
191 FPInnovations (2011): The New Face of the Canadian Forest Industry. The Emerging Bio-revolution. Forest Products Association of Canada.
192 Oske (2012): Future biomaterials from Kokkola, Finland.

medical masks could remove viruses, and packages could change colour according to the freshness of the product.[193] Printed electronics and biomaterials embedded with ICT will likewise open new possibilities[194]. The global cotton supply is shrinking rapidly, opening market opportunities for new materials. Wood fibres can be used for textiles and replace traditional synthetic and organic materials in clothing.

Biochemistry

Biotechnology can be used to produce an vast array of biochemicals, such as enzymes, solvents, amino acids, organic acids, vitamins, antibiotics, and biopolymers[195]. Forestry-based biochemical production can utilize the entire forest ecosystem, not just wood materials. Biochemicals could thus be an important part of a new kind of forest industry in which forests are used omnivorously.

Biochemistry is the basis for sophisticated bioproduction. In biorefineries, chemical compounds and ingredients are extracted from biomass. Biochemicals can then be used as raw materials for all kinds of of products such as food, pharmaceutical and cosmetics. Next-generation biofuels are most likely synthetic, which opens up new possibilities as well as risks[196]. Synthetic biochemistry could in general solve the problem of inefficiency in bio-based production.

The efficiency of bioprocesses need to be improved considerably before they can be considered a serious alternative to petrochemical industrial processes. As an example, the performance of synthetic biodiesel equals that of current non-renewable fuels[197].

Bioactive compounds in plants could lead to new and economically viable pharmaceuticals and other bioproducts. Paclitaxel, a bio-active compound originally isolated from the bark of western yew, is alreadyy a proven antitumour agent[198]. According to OECD, agricultural biotechnology producing complex pharmaceuticals in plants could reduce production costs for some pharmaceuticals by two thirds. Functional foods and nutraceuticals could be used in preventive healthcare to reduce the risk of certain diseases. For example, wood fibres could be added to food to combat obesity[199].

Tourism and ecosystem services

As society becomes more and more technological, as the environment is increasingly controlled and shaped by humans, as reality is perceived through digital media, and urbanization is triumphant, the demand for pristine nature and nature experiences grows inevitably. The signs are already there, as ecological values seem to have secured a strong position as part of our value structure.

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193 FPInnovation (2011)
194 Finnish Forest Industries Federation, the (2012). The forest industry is a forerunner in the bioeconomy.
195 The Bioeconomy towards 2030. Designing a Policy Agenda, p.74. OECD 2009.
196 See Wei, David (2011): Next generation biofuels and synthetic biology. FIELD. & Metsäteollisuuden tietopalvelu. Biojalostamot monipuolistavat tulevaisuuden metsäteollisuutta.
197 VTT 2010, 7
198 FPInnovation 2011
199 The Bioeconomy towards 2030. Designing a Policy Agenda, p.74. OECD 2009

Forests offer a range of possibilities for utilization by the tourism sector and service providers, especially if the services are combined with culture or nature-related recreation. Ecosystem services can build their product palette especially on experiences, sports and wellbeing, learning, natural products, and events[200].

The demand for forest-related services is highly heterogenic, the implication being that the markets for ecosystem services will be divided into different niches. One of the challenges is to create products that appeal to different age cohorts. How could youngsters be lured to spend their free time in forests? Overall, the challenge is to develop tourism and ecosystem services as pluralistic, exciting and novel. The forest should attract middle-class city dwellers with their highly individualistic values as well as enthusiastic hobbyists, professionals and families.

Ecosystem services can be roughly divided into two categories. First, the traditional, "wildlife" ecosystem services, and second, services embedded with culture. The latter denotes natural environments modified by humans. Such environments could, for example, be a mix between park, garden and wilderness. Could the forest be brought into the city? Or the city into the forest?

Finland towards the Bio Age?

It has hopefully become clear by now that a definite move towards bioeconomy will open up multiple opportunities for the Finnish forest sector. It is in essence a race towards a post-fossil fuel economy. Three of the world largest forest companies are Finnish, in addition to which we also have a lot of research capacity, particular in the Finnish Technology Research Centre. What we do not have so much of are new growing SMEs. If this sector is ever to grow in Finland, it can most probably only happen through the activities of small and medium-sized companies. The challenge is to create support systems that support the growth of innovation. The increasingly alarming news about future calamities that will beset us if greenhouse gas emissions continue to grow is surely one of the enablers for investment into this area.

The fundamental competence needed in the future is the utilization of natural fibres. With those skills – that are part of the cultural DNA of Finns – we can find new opportunities for development and investment in Finland. New needs are out there, waiting to be matched by new products and services. The global packaging industry is a EUR 500 billion business that need more recyclable solutions. In the construction sector, new wood-fibre based materials are desperately needed to replace non-renewable materials. Polystyrens, now used widely for packaging and insulation, should be replaced with products consisting only of natural fibres. In the future, there will be blockhouses made of wood, as there already are in some central European countries. We need biofuels to replace petroleum-based fuels. In fact, there is almost endless list of products and services that can we made out of biomaterials.

In principle, everything that is made using oil today, can be made with biomaterials tomorrow. And with rising crude oil prices, depletion of cheaply available oil and urgency to reduce greenhouse gases tomorrow might be nearer than we think.

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[200] Niskanen, Anssi – Donner-Amnell, Jacob – Häyrynen, Simo & Peltola, Taru (2008): Metsän uusi aika – kohti monipuolisempaa metsäalan elinkeinorakennetta [New Time for Forest – towards heterogenity in Forest Sector]. University of Eastern Finland, p. 189.

FOREST INFINITY

The Sixth Wave collaborates closely with another Tekes funded project, the ACSI 2.0 which studies emergence of self-renewing innovation ecosystems and focuses on societal innovations. The name ACSI is an acronym for Aalto Camp for Societal Innovation, an eight day long camp held each summer since 2010, where groups of about ten experts tackle a case presented to them by a case owner, based on an idea that an outsider view to a topic is likely to produce fresh thinking and ultimately societal innovations. In the summer of 2012 the Sixth Wave project presented a case for the ACSI. The case addressed the challenges faced by traditional Finnish industries in the next Kondratieff wave. The case was intentionally very loosely formulated so that the group would be able to define the questions for themselves and not be tied to the ideas that the case owner already had in mind. After a week of working the group presented a problem and a suggestion for a solution to the Sixth Wave case owners. The group had decided to focus on forestry, one of the epitomes of Finnish industry, and how it could look like in the next wave. They came up with a model for a participatory forestry portal, and an action plan for realizing it as a service for forest owners.

The envisioned platform is planned to be built around five functionalities: 1) an ideation board for deliberating possible ways to generate value from forests, 2) a map application for identifying other forest owners in the area, or with the same kinds of ideas, 3) an ability to form groups around new opportunities, 4) a start-up incubator for finding funding for viable ideas / companies, and 5) a way to increase (buy) forest ownership or sell existing land. These core functions are likely to evolve as development work continues.

The platform will include an element of gamefication, meaning it should be possible to use the platform as a transmedial portal connecting real life forest use and a virtual, game form forestry application, which would enable us to engage people who happen to own forest but have no longer a real life connection to it. An inspiration for this is the online game *Farm Ville* (a hugely popular Facebook application) where players engage in virtual farming activities to gain points and go further in building a more successful virtual farm. The Forest Infinity platform could take from this example those elements that help illustrate practical work in forestry and link them with real life forest ownership (it could, for example, be imagined that a certain amount of points gained in the course of the game could be transformed into a small piece of real forest). Ultimately, the game could in itself contain all the functions of the platform discussed earlier.

Of course, building an engaging platform is very challenging. In general a platform cannot work if it does not respond to a real need that the potential users have. Although there is not one recipe for success, several important factors that affect it can be identified:

In building a platform that at least in the beginning will rely on volunteer work, it is important to try to identify the one % who are very interested and motivated in the idea (the "true believers") and understand their key values and expectations. Whatever they might be, the aims of the platform cannot be in contradiction with these without alienating these core users. In an effort to build a bottom-up movement, for instance tying the platform to corporate interests or sponsorship has in many cases proved harmful to the cause (this might be reflected in the difference of popularity between the general interest Facebook group "Metsä" (*Forest*) that has 162 000 users and for instance a corporation owned "Metsänomistaja" (*Forest owner*) group with 3120 users, or even the government backed "1001 tapaa tykätä metsästä" (*1001 ways to like the forest*) that has 1292 users).

A very powerful way to create a movement is to find an alignment of interests. In this case, with a very diverse group (forest owners, the forest industry, the government, people with general interest in the forest) this could happen by finding a shared problem or a common mission.

The Sixth Wave project, together with the ACSI group will continue working on the platform during the spring and summer 2013 and hopefully a coalition of interests will consolidate among new, aspiring foresters as a result.

8. RIDING THE 6TH WAVE: SOME CONCLUSIONS FOR FINLAND

Why are we exploring the next 30–50 years through the lens of the Kondratieff wave theory? Simply because we think that understanding the framework within which technological products and services, new business models, but also new cultures and values, operate, will help us innovate. In fact, what we are proposing is a conceptual methodology for innovation: the 6th wave of development is also the 6th wave of innovation. We hope to spark off ideas on how the coming decades will create a society with new needs. At the end of the day, it is all about how successful we are in riding on emerging opportunities while avoiding to continue applying the same recipe. In other words, we must build more intelligence into our systems. Innovation will sweep through all the four sectors we have touched upon in this report:

First, in terms of digitalization, the 6th wave will mean that virtual experience will become much more of a standard experience of our everyday life[201]. Simultaneously, new business models that will dramatically increase the flow of communication between different stakeholders will launch the development of new partnerships, businesses and ecosystems. This is due to ever increasing computing power which is facilitating the build-up of machine-to-machine communication, which in turn is creating a whole new economy, called the second economy, that it going to play a huge role in all of our business. Furthermore, as machines become intelligent, they will perform tasks that are way beyond our wildest imaginings. We will see robots increasingly doing things humans used to do, from sweeping floors to creating art. Observing existing businesses, we can say that ICT technologies will also continue to lower transaction costs dramatically, just as in the 5th wave.

Here the question is, how will Finnish companies be part of this development in the future? Thanks to Nokia, our engineering-minded culture, as well as some progressive steps taken by the public sector, we have a good number of skills for flourishing in this new generation of digital technologies. What that generation really needs is an ecosystem of inventors, angel capitalists and other sources of finance and marketing know-how to put our intellectual capital to good use. What should be strengthened in particular, is the availability of capital in the early phases of innovation, that is, angel capital. Without the focus it brings, it is hard to imagine how we could effectively build the new generation of digital businesses and services to ride the next wave of digitalization successfully. The model of the Silicon Valley is particularly helpful here: the success story there is built around a close community of entrepreneurs and venture capitalists in which ideas are shared and competences are merged to create ever new success stories[202]. It is really about the collective ability to generate innovative product systems. And for this collective system to become more intelligent, we need more networking, collaboration and partnerships.

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201 See Takatalo, Jari – Nyman, Göte & Laaksonen, Leif (2008): Components of Human Experience in Virtual Environments. Computers in Human Behavior

202 See the revealing interview of Aoki, Masahiko.

THE NEW FUTURE OF NOKIA

A blogpost by Markku Wilenius (25 November 2012)

I always remember reading the article by a Fortune journalist who travelled to Finland in 1999 to explore the "secret code of Nokia". In the course of the expedition, he was at great pains to understand what it really was, because nothing he heard from executives and experts was satisfactory: technology, delivery, etc., all this was in pretty good shape, but didn't reveal the secret. On the very last day of his stay, he went to interview Jorma Ollila, the then CEO of Nokia. The conversation was good but, alas, he didn't find what he was looking for. Until at the end of the session, Ollila suggested they go grab a meal together. So down they went to the canteen where all employees had their lunch. There was no separate canteen for executives, the journalist realized. As they were queuing to get their food, he observed how employees of all ages and ranks said hello to Ollila and made conversation in passing, always starting it with "Jorma..."and then it hit him: this was the secret of Nokia. A corporate culture that allowed anybody to approach the CEO without any pretensions. A culture that provides a fertile soil for interaction between those in the corner room and those on the factory floor. A culture that invites innovation and flow which materialize in new innovative products and services.

Somewhere along the line they must have lost the line and succumbed to what so many companies today succumb to: they lost the potential of internal interaction, and institutional nausea set it.

During the past autumn, there have been signs that the old spirit may have gained new momentum in in a new form. Nokia has come out with a new product family, headed by the flagship phone Lumia 920. Comments have been encouraging: "hottest phone in the market" and other remarks that simply tell Nokia is back giving a cutting-edge customer experience. The US, Singapore, Germany, Australia, we are hearing everywhere about customers rediscovering Nokia. Let alone the surge in stock valuation last week.

Is this sustainable? Is this the great bifurcation point that marks a new rise to the top of this highly competitive industry? Of course, no one can say for sure. But I have an inkling that this might be the case. Nokia is creating its new future as we speak. They still have a positive brand in many countries, such as India, where Nokia continues to mean reliability and durability. And when I visited a few stores here in Silicon Valley to investigate consumer attitudes to the product, the enthusiasm was palpable. Vendors were eager to point out how Lumia's new features simply outperform any other product in the market, including iPhone and Samsung Galaxy.

As a Finn who has lived the past 20 years of so in a mobile-Nokia country, this all makes me very excited. Nokia is back in business, and who knows if it will shoot back to the top, after the very recent moment when most customers and investors had lots their confidence in Nokia.

The future, it seems, always comes up with new surprises. Let's hope this time it means Nokia has regained its momentum, creating a completely new future for itself, and bit of it also for us all.

Second, we address demographic change and its impact on society at large as well as its implications to the health sector. In the course of the 6th wave, our societies will age to the extent that, at the end of the wave, more than ⅓ of our population will be over 65, while an increasing number of senior citizens will want to continue to work far beyond what we consider the standard today. This calls for new kinds of health and pension systems that are much more flexible in adjusting to individual needs. Systemic innovations supported by digital technologies are needed in the public sector, particularly in the public health system. The sad story of the construction of the current digital base of the health service sector is a case in point; it proves that we need much more than new technology in place. If do not change our patterns of behaviour as well, new digital systems may merely evoke another Kafkaesque experience of the digital behemoth. The renewal of the digital structures of the Finnish university system serves as another case of

"when everything goes wrong with ICT implementation." We simply need more intelligent software solutions and the capacity to adapt them to certain conditions. In other words, we need to build more intelligence into the systems so that they operate truly smoothly on the human scale.

Third, we should focus on key technologies and innovations in resource efficiency. The great race during the 5th wave towards more flexible and useful technologies to lower transaction costs, to which digital technologies was the solution, will become a race towards less material-intensive products and processes. In this, various clean technologies (some of which we have not seen yet) and natural fibre-based products will replace the current resource-intensive, non-renewable solutions. For Finland, here we have both good and bad news: The good news is that we are well equipped to become a major player in the field of clean tech and biobusiness: we already have 20 billion euro turnover in clean tech, with a target of raising it to 50 billion by 2020[203], generating 40,000 new jobs. Also, out of the 10 largest forest companies in the world, two are Finnish. The bad news is that Finland is one of the most resource-intensive countries in the world. Moreover, our progress in putting in place new renewable-based energy technologies (apart from those installed by pulp and paper plants that use their side-products as energy source) has been very modest by any standards. The old recipe of building large-scale energy plants that preferably run on nuclear power has probably not been very helpful in building those markets. As we have learned from the experiences of the mobile phone industry, having an active home market is a great support factor for companies also in times of flat and globalized economy.

For the next wave, we have some great expanding companies and technologies that are showing way for the 6th wave. Vacon, for instance, is a great venture that rides the energy efficiency wave by supplying world-class AC drives and inverters for optimum process control and energy efficiency for electric motors – a perfect example of the kind of intelligent technologies that can take us towards sustainability by leaps and bounds in a smart way.

Fourth, ever since we began exporting tar extensively from 17th century onwards, forests have been for Finns not only a source of inspiration, but also of income. More recently, the production of pulp and paper and various wood products has formed the core business of our forest industry. In all these areas, the amount of production is expected to fall in the coming decade, with pulp and paper production decreasing down to 40% according to estimates by METLA, Finnish Forest Research Institute[204].

This means a massive challenge to these industries to boost innovation and renew their product portfolio. Fortunately, there are growing needs in the emerging 6th-wave marketplace that can be exploited: Packaging and construction industries need more wood-fibre based solutions that are strong, light, cheap and completely recyclable. In the future, wooden structures will be used in buildings much more intensively than at present due to aesthetic, economic and ecological values. We need new innovations in the field of biofuels: for instance, in the future, Finland could be self-sufficient in its fuel production, with decentralized

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[203] See Pantsar-Kallio, Mari (2012): Finnish Cleantech industry and its opportunities within mining sector.

[204] See Hetemäki, Lauri & Hänninen, Riikka (2009): Outlook for Finnish Forest Industry Production and Wood Consumption for 2015 and 2020.

production providing new sources of income to people living in urban settings. And we need more value-added wood and fibre based design products to whet the appetite into a growing interest in eco-design products and services.

SILICON VALLEY CULTURE
A Blogpost by Markku Wilenius (1 June 2012)

My recent visit to Silicon Valley and San Francisco brought interesting results. After listening to insights from people who have spent considerable time living there, I was totally engrossed by the fact that the single most important thing to drive Silicon Valley to ever new feats in terms of groundbreaking technologies and – increasingly – services, is the creative culture that has been cultivated in this area since the late sixties.

It recalled to me the French anthropologist and market guru Clotaire Rapaille, who some years ago wrote an excellent book on cultural codes. When I was working at the insurance giant Allianz, I had the good fortune to work with him, and his fresh account of how our subconscious mind ultimately makes the decisions we then rationalize, really gave me new lenses to understand collective behaviour.

Rapaille insists that American culture, in its essence, is a culture of adolescence. That is why all types of behaviour we associate with those years are acceptable, and individual decisions are always supported. Nowhere is this more visible than in Silicon Valley. Everybody is entitled to have his/her own dream and go for it. But in addition to that, they have also created a culture of sharing which really brings the whole thing onto another level.

This sharing culture, supported by the freedom to fully express yourself, is ultimately what has made Silicon Valley so unique. And it is exactly the kind of sphere we need to nourish here in Finland, where the fruits of human creativity are often suffocated by envy and excessive control.

Eventually, the 6th wave needs a culture of experimentation. This is probably the hardest part for us Finns. It calls for testing and probing, it calls for acceptance of failure and for continuous learning. It requires us to reverse the order in which we usually do things: first we create a concept and then we implement it. This time around, we need to involve our intuition and go for what **feels** good and right, without shooting everything down with our analysis. Only with this type of experimental spirit can we ultimately make our society more intelligent in terms of its functioning.

Underlying the cultural development and evolution of our values in the 6th wave, it is urgent that we focus on the concept of wellbeing. At the core of wellbeing, there is our natural capacity to care for others and be successful. There are three quintessential aspects of care:

1. Care as minding my objects of care – focus and attention
2. Care as caring about my objects of care – emotion
3. Care as tending my objects of care – proactivity

This concept of care is based on technology entrepreneur Paul Suni's findings in Silicon Valley[205]. Having been a highly successful entrepreneur for almost 40 years, Suni has discovered a recipe for success in the Silicon Valley business environment. Time and again, he has observed that in order to be sustainably successful with their innovation, entrepreneurs need to possess these three qualities of care. In other words, innovation thrives in a cultural environment of care. This means that we have to blend creativity with conscientiousness, which is what we in Finland have a natural capacity for.

As we enter the 6th wave of our socio-economic cycles, we may observe a trend of increasing inequality in the kind of politics of capitalism prevalent in Western countries[206]. The current public debt crisis has in fact partly hidden this development from view which is a much deeper and enduring aspect of societal development.

We think that the real reason for this development is not primarily economic, it refers instead to a more psychological, even spiritual crisis in our societies. The overwhelming emphasis on the economy at the expense of mental wellbeing has shadowed our value systems and brought about mental alienation. The problems we observe in our economy are nothing but a reflection of this alienation, magnified by the hazy vision of the future.

The snake oil recipes proposed for these problems tend to be based on the idea of building more efficient markets and control. While these measures may be a partial solution, more than that is needed. Simply speaking, we need more than efficient economic systems, we need a Renaissance of our mental and spiritual capital. The quintessential precondition for this Renaissance to happen is that we steer our professional life with a mission – we need justice and wellbeing.

Only thus equipped can we spark off the innovations needed to take Finland into the forefront of 6th wave development. We have all the premises to do so: our track record shows an astonishing ability to reach out for the next step. In this historical situation, we have to overcome the inertia caused by the amazing successes off the last 30 years, in the previous Kondratieff wave. And we can do this by relentlessly focusing our interest and investments on those fields of business that are in the forefront of 6th wave development: creating innovations for improved material and energy productivity, creating new natural fibre based products and services to replace non-renewable materials, upscaling our digital technology applications for all spheres of life, and creating new means for the building of health and welfare. In other words, endorsing intelligent technologies for human good.

Ultimately, to get it right: the 6th wave is about a race against the ticking time bomb of the global input-output problem: as input, we have grossly overshot material consumption with highly underdeveloped circular systems. On the output side, we have massive pollution, intolerable rates of greenhouse gas emissions, and devastating and scandalous destruction of our natural resources. The implications are already all too obvious, from the increasing intensity of extreme weather events and sustained droughts to trendlike increases of

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[205] Suni, Paul: Technology and Well-Being. The Role of University. Unpublished manuscript. Sitra, Helsinki.

[206] See Economist, Oct 13: The New Politics of Capitalism and Inequality.

commodity prices in the markets. Thus, we should gear ourselves towards building ecologically sound technologies, business models, lifestyles and practices if we wish to find solutions to these predicaments.

Another timetomb ticking away is growing inequality within societies. In this report, we have already referred to the evidence that most of our societies seem to be almost in an inevitable road towards growing inequality. However, this is essentially a policy issue, and we can do something about it. We need to build more intelligence into our taxation systems and establish institutions that support the inclusive measures. We also need to create more intelligence into our welfare state model so that it adequately resonates with the realities of our aging societies. In essence, this implies a renewal of our pension systems as well as tearing down of old fences between active working life and the time after that.

To put it in another way, there are three essential underlying questions we need to consider: How can social and environmental needs become business goals? How can human needs become social goals? How can planetary needs become technological goals?

For all this, we need to upgrade Finland into a society equipped with resilience and proactivity. All antique structures that do not serve our purpose in the mission ahead must be discarded. Finland can be transformed into a pioneering nation for the 6th wave of development, but this can only happen if we deliberately choose that path to the future.

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SURFING THE SIXTH WAVE

Exploring the next 40 years of global change

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Kondratieff waves – as described by a Russian economist Nikolai Kondratieff in early 20th century – are 40–60 year long fluctuations in the economy. Each wave is fuelled by a specific socio-economic paradigm, led by a set of key innovations.

We are now at the threshold, moving from the 5th wave into the next one. The question we seek to answer is: what are the driving forces for the sixth wave during 2010–2050? We believe that the key drivers for the next wave will emerge from the way we are using our resources: raw-materials, energy and human capital. The kind of society we shall find in 2050 depends on the level of intelligence in the systems we build.

This is an interim report of the project The 6th Wave and Systemic Innovations for Finland: Success Factors for the Years 2010–2050. While the scope of our research is global, we ultimately focus on Finland's potential to become a key player in the making of the new wave.