INTRODUCTION: DESIGNING THE FUTURE

HANNES ANDROSCH Austrian Council for Research & Technology Development, AT
JOHANNES GADNER Austrian Council for Research & Technology Development, AT

The Council for Research and Technology Development is the central advisory body of the Austrian Government for education, science, research and innovation policy affairs. On a legal basis, it works out precise, implementation-oriented recommendations for specific policy areas in its scope of responsibility, and, as commissioned by the Austrian Council of Ministers, compiles an annual report on Austria's scientific and technological performance. The Council, however, does not see its role merely as an incentive provider for the specified policy fields. Far more to the point it also wishes to deal with topics and issues from its work area that transcend daily policy requirements, which increase the understanding of historical developments, current processes, and future requirements. This aim was also the background basis for the genesis of this book.

The book is entitled *Designing the Future: Economic, Societal and Political Dimensions of Innovation*. It is designed as a collected volume and its objective is to illustrate 'innovation' from the most diverse perspectives. The key role in particular of technical innovations for the constitution of human societies – as outlined by the technology researcher Ernest Braun in his essay, 'From Need to Greed' (2010) – is expressed to this day by the fact that entire ages and eras of the history of humanity are defined by the prevailing technologies applied in them (Braun, 2010, 6).

These *General Purpose Technologies* not only dominate the economy at a national or global level, but also influence social and political structures in particular (Lipsey et al., 2006, 93ff.). According to the economist Richard Lipsey (2006, 85ff.), 24 of these *General Purpose Technologies* can be defined over the course of history. The list ranges from the emergence of writing to printing and the steam engine through to electricity, computer technology or the internet.[1] It is not always entirely clear here whether technical innovations cause social changes, or whether social innovations are first required so that technical innovations can succeed. In most cases, both are arguably conditional on each other. The individual contributions of this book aim to discuss the different dimensions of innovation in the past, the present and their relevance for the world in the 21st century. The first part of the book begins with the Enlightenment in Europe, the 'invention' of invention and progress, and the development of the key institutions of the knowledge society, and consequently the 'Unbound Prometheus' (Landes, 1986). The second part focuses on the modern development conditions of innovations as we know them today. And in the third part an attempt is made to hazard a look into the future and sound out possibilities, and to examine what role research and innovation might have in the future for the economy and society, and how the future can be rethought and restructured.

The objective of the book is to provide food for thought and promote debate on the topic of innovation beyond the strict boundaries of the politics of the day. The fact that this is not merely a purpose-free, intellectual discussion is evidenced by the specific implications for RTI issues included in all contributions. Secondly, it is also illustrated here that only a sound examination of the emergence conditions of innovation in history and in today's world will provide the basis for future-oriented political decision-making. The focus of a large part of these contributions is therefore on the future requirements of and for innovation. Let us begin with a brief look back at history.

[1] Not mentioned here are the innumerable small innovations used every day, from needles and screws through zips to paper clips or punchers. Small innovations find their way into everyday life not through dramatic and spectacular events, but mostly through gradual and inconspicuous processes (see also Glatzer, 1999, 178ff.).

BRIEF OUTLINE OF THE HISTORY OF INNOVATION, FROM THE DAWN OF HUMANITY TO THE MODERN AGE

In his essay 'All Life is Problem Solving' (1991), the British-Austrian philosopher Sir Karl Popper argues that inventions and technical aids are an essential feature of living organisms – for humans and animals alike. Different organisms are, of course, better or worse at this and more successful or less successful. At any rate, in its attempt to meet challenges and solve problems with the invention of technical aids, humankind has achieved a certain perfection. This is why the history of human civilisation is at the same time the history of a chain of ever quicker successive and mostly technical innovations, which also have social, economic or political consequences (see Braun, 2010; Harari, 2013).

Necessity and want are responsible for this on one hand. 'Necessity is the mother of invention', as we say with good reason. Already at the dawn of the *Homo sapiens,* the need to satisfy basic human requirements – such as food, protection against the cold or security and therefore ultimately the assurance of survival – led to the discovery of the usefulness of simple technical aids and tools (Braun 2010, 9ff.). In all probability, coincidence and the trial-and-error principle played an important role here (Diamond, 1997, 245ff.).

On the other hand, there is a basic instinct of humankind, which has characterised and defined it from the very beginning, and which drives the innovation spirals further and further – curiosity. Astonishment of the unknown or amazement 'of the closest unexplained' as Aristotle describes it in his *Metaphysics* (see Liessmann, 1997, 25ff.), has spurred the human on since time immemorial. Eagerness for knowledge and striving to achieve the 'new' are therefore at the root of humankind's cultural development (see Nowotny, 2005, 35ff.).

This striving has accompanied humanity since, as related to us in Greek mythology, Prometheus brought fire from Olympus, although forbidden to do so, and taught man how to use it. As we know, Zeus severely punished Prometheus for his actions.[2] Along with curiosity, another basic constant of human behaviour also played a significant role in the emergence of innovations: aggression and violent confrontations (see Harari, 2013, 80ff.; Lorenz, 1981, 30ff.). Since day one, war has clearly been part of human societies, as proven by archaeological and anthropological findings (Harris, 1990, 46ff., Morris, 2013, 14ff.). Whether or not war is truly the 'father of all things', as related by Heraclitus, is anyone's guess. The fact is, however, that a plethora of technical innovations have been developed for the purpose of waging war, or used after their development for military purposes (Diamond, 1997; 250f.; Harris, 1990, 107; Morris, 2013, 105ff.). And as we will see, it was the 'scientific-military-industrial complex' (Harari, 2013, 342) which ultimately brought about the industrial revolution and its consequences in a significant way. Little wonder then that the emergence of Silicon Valley, which today stands as a global, model region for innovation culture, was and is immediately connected with military-technological research (Leslie, 2000; 48ff.; Sturgeon, 2000, 15ff.), or that the Pentagon continues to be by far the greatest promoter of research and development in the USA (see AAAS, 2015, 61).

British historian Ian Morris has another explanation for the motor of history: in his epochal work 'Why the West Rules – for Now' (2010) he argues that technical innovation and accompanying social change have always been and always will be motivated by an essentially lazy human searching for easier and more convenient solutions. The consequences of this were and are still mostly unforeseeable, and occasionally also led to unintended developments, the nuclei of which are installed in every innovation, because the solution of specific problems can release forces that undermine this solution and in turn cause entirely new problems (Morris, 2010,

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[2] See also the detailed illustration in *Reclams Lexikon der antiken Mythologie*, 1991, 455f.

28, 560). At any rate, the sum of all these changes, of the erection and conversion of even more new complex structures, is what we today describe as the history of our global civilisation.

In his work *Eine kurze Geschichte der Menschheit* ('A Brief History of Humanity', 2013), Israeli historian Yuval Harari illustrates the profound changes, revolutions indeed, that (technical) innovations have occasionally effected. Three major revolutions in particular were of eminent importance here (the first of which admittedly was not due to any technical innovation, but rather owed its existence more to a coincidental gene mutation): the cognitive revolution, which around 70,000 years ago led to the development of language and with it the rise of *Homo sapiens,* and ultimately marked the beginning of 'our' history; the agricultural revolution, which approximately 10,000 years ago radically changed mankind's way of life, and the consequences of which are still being felt today – because to date the global calorie requirement can be covered more than ninety per cent by the plant types domesticated at that time (see Harari 2013, 102; Diamond 1997, 128) and, finally, the scientific revolution, whose foundation was laid approximately 500 years ago, and whose continued course through the industrial revolution into the digital revolution has provided us with today's knowledge society.

For some time human inventions were attributed to coincidence or arose from direct needs and requirements. Innovations were therefore quasi by-products of human behaviour, such as the taming of fire, the discovery of bones or stones as technical aids, from which, over time, flints, knives or needles were produced, or the invention of the wheel (see Diamond, 1997, 246f.; Lipsey et al., 2006, 55ff.). The development of the basis for the agricultural revolution in the Neolithic Age (i.e. the domestication of plants and animals) appears to have emerged in all probability in a gradual and coincidental way (see Diamond, 1997, 93ff., 105f.; Harari, 2013, 37; Lipsey et al., 2006, 137ff.). The main factors responsible for this were global climate warming after the end of the Ice Age, the extinction of large animal stocks in the Mesolithic Age and the resulting pressure to adjust, which necessitated a nutritional shift to compensate for the falloff in the production of animal proteins with plant proteins (Harris, 1990, 32ff.; Morris, 2010, 81ff.).

As humanity had lived through the greatest part of its history up to that point in smaller groups of hunters/gatherers, the agricultural revolution effected the most radical transformation in the human way of life with the change in production conditions and the resulting sedentarism. The cultivation of plants meant more calories per surface area, which caused a genuine population explosion. While before the beginning of the Neolithic revolution, over millennia approx. one to maximum five million people lived on the earth, the number rose to some 250 million by the beginning of the modern calendar (Diamond, 1997, 92; see Harari, 2013, 126; Harris, 1990, 26, 45). This swift population growth was, however, also accompanied by a deterioration in nutritional quality and an increase in disease and the emergence of epidemics (see Diamond, 1997, 203f.; Harari, 2013, 104f.; Harris, 1990, 25, 37ff.).[3]

The rise in population numbers led to the gradual formation of larger social structures, which in turn necessitated an entirely new type of information and its dissemination: data and numbers (see Harari, 2013, 155). The old Mesopotamian cultures were the first to begin developing a system to make bookkeeping easier and to document harvest yields (see Lipsey et al., 2006, 144ff.). Over the course of time, this developed into the first known form of writing. At the beginning of the development of writing we consequently see a specific practical benefit as one of the most important

[3] Compared to later eras, Stone Age man obviously enjoyed far better food and living standards (Harari, 2013, 104; Harris, 1990, 18f.; Sahlins, 1972, 35). Archaeological evidence proves that Stone Age hunter/gatherers lived healthier, were ill less and showed higher levels of healthiness than following generations. Clear proof of this is the fact that the average growth of people of the Palaeolithic Age was only reached again in the 1960s (Harris, 1990, 25).

innovations of all time (see Fara, 2010, 10f.; Morris, 2010, 181): The oldest texts of humanity include, as Harari writes, neither profound philosophical knowledge nor poems, legends, laws or heroic epics. Rather, they are entirely everyday recordings of business life, such as tax payments, debt securities and deeds of ownership (Harari, 2013, 158).

With the development of writing, the foundation was laid for the development and organisation of more complex, stratified societies (Diamond, 1997, 234ff.). Once established, this innovation led, however, to an (at first unintended) recording of myths, religious stories, medicinal knowledge or observations of the skies. At the same time, mathematical, astronomical and other knowledge, which defines our worldview right up to the present day, could now also be recorded. Many of our current ways of thinking, and also the sciences, are based – as illustrated by the English science historian Patricia Fara in her book *Science: A Four Thousand Year History* (2010) – on technologies and ideas that have their origin in antiquity and are passed on in writing. Our current division of time into weeks with seven days or hours with sixty minutes, each with sixty seconds originates in Babylon. Mathematical or geometrical principles – such as the idea that a circle has 360 degrees – go back to a millennia-old system developed by Babylonian land surveyors and bookkeepers (see Fara, 2010, 13).

Unlike the development of writing, the discovery of bronze did not evolve on the basis of a specific problem. It is seen as a coincidental but logical step in a longer history of incremental improvements of a metal already used since the Stone Age (Lipsey et al., 2006, 151). The development of steel and iron, on the other hand, was the result of necessity. Important centres of advanced Bronze Age cultures collapsed during the transition to the Iron Age, which resulted in the collapse of existing trade networks. The very rare tin required for bronze production was therefore no longer available in many places. Iron ore was indeed known earlier, but its processing only became interesting with the absence of tin and the resulting search for alternatives (Morris, 2010, 233; Lipsey et al., 2006, 155). Extremely differentiated work processes were already required for the production of bronze and iron. The establishment of entirely new occupational groups followed, for mining, transport and processing in continuously further developed furnaces. The social, economic or political changes that accompanied the establishment of these new (cultural) technologies were also correspondingly great – even if their dissemination in places ranged across centuries, as in the case of iron (see Lipsey et al., 2006, 151ff.). The rise of the Persian Empire in the 6th century BCE coincides more or less with the consistent use of iron for the development of a superior weaponry technology (Morris, 2010, 245ff.). The swift expansion of the Persian Empire was first arrested by the Greeks at the beginning of the 5th century Before Common Era. They had developed higher performance furnaces and innovatively further developed the skill of iron forging (Lipsey et al., 159f.). Combined with an improved weaponry and war technology (Meier 2009, 184, ff.) and supported by an unprecedented social and political reorientation, the allied Greek city-states defied the far superior Persian forces (Meier 2009, 36ff.) Subsequently it was, among other factors, ever newer, increasingly innovative weapons and accompanying military combat techniques that effected the emergence and the downfall of empires (see Diamond, 1997, 241; Harris, 1990, 45ff.; Morris, 2013, 144ff.). During the last two and a half millennia, the empire that secured its power through military dominance was the dominating system of government, and most people lived in one of these 'global empires' (Harari 2013, 235ff, Morris 2013, 85ff.).

There were also technological innovations in periods which we today usually consider not particularly innovative historical eras. Agrarian production, for example, was innovatively revolutionised in the Middle Ages with the further development of the plough and the introduction of three-field crop rotation (Braun, 2010, 47f.; Lipsey et al., 2006, 161; Landes, 1999, 41). The widespread use of the water wheel, introduced especially for the operation of mills – originally already invented by the Romans, but never used in numbers worth mentioning – was one of the foundation stones for the road to mechanisation and therefore also one of the basic requirements for the later industrial revolution (Diamond, 1997, 359; Landes, 1999, 45f.; Lipsey et al., 2006, 167). These innovations were primarily developed to compensate for the absence of workers, which had been replaced in the Roman Empire by slaves (Braun, 2010, 61; Lipsey et al., 2006, 161, 165).

In addition to a number of other inventions, such as windmills, glasses, the sextant, the compass or three-mast sailing ships, the European Middle Ages also for the first time saw the development of firearms (Braun, 2010, 61; Landes, 1999, 52f.). In the 14th century, an important foundation stone was consequently laid for the conquests of the conquistadors and Europe's later global dominance (Diamond, 1997, 74ff.; Harari, 2013, 340ff.; Landes, 1999, 29ff.). This far-reaching innovation was not a genuine European innovation but merely the further development of an invention that had reached Europe from China on the trade routes across Mongolia and Arabia (see Morris 2010, 396). The Arabs had made use of the Chinese invention of black powder, which in its country of origin had, despite some attempts, never been used for warring purposes until then (Diamond, 1997, 247).

FROM COINCIDENCE TO SYSTEM: THE EMERGENCE OF THE KNOWLEDGE SOCIETY

All these innovations up to this point were all completely pragmatic, based on absolutely no theories and had been developed with trial and error (Braun, 2010, 61). In his scientific manifest entitled *Novum organum scientiarum*, or 'new information or knowledge tool', in 1620 the English philosopher Francis Bacon issued not only the renowned sentence, 'Knowledge is power', but also proposed a then revolutionary concept – the unification of science and technology. The book therefore constitutes a landmark point between medieval thinking and modern systematic research, which is oriented towards scientific and technological progress for the benefit of humanity in general (see Fara, 2010, 149ff.; Fischer, 2001, 52f.; Harari, 2013, 317f.).

While, therefore, earlier innovations were very heavily characterised by the element of coincidence or direct requirements, over the centuries a more systematic approach pushed to the fore (see Fara, 2010, 103ff.; Fischer, 2001, 49; Morris, 2010, 510f.). This 'Invention of Invention' (Landes, 1999, 45) was to have far-reaching consequences for European thinking and action. With the Renaissance and the Enlightenment in Europe came the first individual mind-sets, structures and institutions, whose purpose increasingly served the systematic production of knowledge (Burke, 2001, 45ff.; Fara, 2010, 165ff.; Harari, 2013, 299ff.). In particular the universities that had already existed since the Middle Ages subsequently experienced a massive upsurge, and in the future formed a foundation stone for the scientific and industrial revolutions (Braun, 2006, 64f.; Burke, 2001, 52ff.).

At their core was a new thinking that was committed to progress and steeped in the conviction that certainty cannot be achieved by belief but through reason and systematic trials alone (Fara, 2010, 225ff.; Fischer, 2001, 48ff.).[4] This was a genuinely

[4] The belief in constant progress has been accompanied by criticism since its emergence. Towards the end of the Renaissance, in his *Essays* (1572–1587), Michel de Montaigne was one of the first to doubt the belief in progress that had established itself in Europe. Jean-Jacques Rousseau addresses a key thought of Montaigne, according to which culture continually destroys nature, and in his *Discourse on Inequality* (1755), essentially promotes a call 'back to nature'. In this tradition, Friedrich Nietzsche, who in his, *The Gay Science* (1887) explores the freedom of thinking beyond scientific-methodical constraints, in *The Antichrist* (1888) praises the sceptic as the only decent type in history, and in *Twilight of the Idols* (1889) expresses his mistrust for all systematists. Nietzsche was also a role model for the philosopher of culture Oswald Spengler, whose masterpiece, *The Decline of the West* (1918) formulates a rather pessimistic prognosis of the future development of Europe in light of the experiences of the First World War. With his *Civilisation and Its Discontents* (1930), Sigmund Freud ultimately delivers one of the most influential culture-critical pieces of the 20th century. More recently social and cultural anthropology has questioned the concept of a teleogical progression of history through to a constantly improved future (see Harris, 1990, 7f.; Sahlins, 1972, 1ff.).

European way of thinking; there is no specific place at which it emerged in isolation. Europe itself is this place: Nicolaus Copernicus, for example, was Polish, Francis Bacon and Isaac Newton were English, Paracelsus, Johannes Kepler and Gottfried Wilhelm Leibniz were German, Galileo Galilei and Evangelista Torricelli were Italian and René Descartes and Blaise Pascal were French (see Rossi, 1997).

Indicative of this development is also the increasing promotion of the sciences by the European royal houses, ambitious patrons or scientific societies (see Burke, 2001, 55f., 58ff, 149ff.). International trade was also extremely important for the progress of the sciences. On one hand, it stimulated the global exchange of raw materials, products, animals and plants, as well as technical skills and knowledge; on the other hand, it financed international voyages of discovery, whose findings were invaluable for scientific research (Fara, 2010, 103).

A key innovation that marked the beginning of the developing knowledge society was printing (Burke, 2001, 20; Landes, 1999, 51f.; Lipsey et al., 2006, 175ff.). This revolutionised the way knowledge could be documented and diversified. However, it also changed the ability to spread knowledge (Burke, 2001, 96f.). And this was one of the fundamental requirements for the 'explosion of knowledge' in our time (Burke, 2014) and the establishment of today's scientific knowledge system. It is based on previously acquired knowledge, on which it can build and further develop. This principle leads to a more consistent progress than the earlier unsystematic approach and to this day forms one of the key requirements of the modern sciences and the knowledge society (see Acemoğlu/Robinson, 2012, 215; Burke, 2001, 20ff.; Lipsey et al., 2006, 181).

The interdependencies between innovations and political power and the use and control of knowledge can be seen clearly when we use printing as our example (see Burke, 2001, 139ff.). It also illustrates the interdependence between sciences, economy and government, which ultimately resulted in an all-out contest for the promotion of scientific knowledge and technological innovation between the European nation states (see Harari, 2013, 330ff.). The interactions between the sciences, capitalistic economy structures and the European systems of rule were the motor of history in the centuries that followed (Harari, 2013, 334). The successful colonial empires of the 19th century in particular supported scientific research in massive and specific ways in the hope of producing useful technological innovations (Harari, 2013, 432).

Today the sciences form the backbone of the modern world, but they could only fully exercise their role in the interaction with industry, economy, the military, government and healthcare system, as Fara writes (Fara, 2010, 165). She goes on to argue that decisive for this was the transition period from the private experiments of some wealthy and distinguished men, to the public research institutes, the state financing and industrialisation of the 19th century (ib.).

The scientific and subsequently the industrial revolution changed the life of humankind in a way previously unknown. With the use of fossil fuels, muscle power was gradually replaced by machine power (Braun, 2010, 63). The social transformations that resulted from the invention of the steam engine in an increasing mechanisation of all production processes, the enabling of mass production in factories, increased goods transport with the railroad and ultimately electrification, are, in the dynamics of their development, unique in the history of humanity, and at best comparable with the radical changes of living conditions after the Neolithic Revolution (see Hobsbawm, 1996, 38ff.; Landes, 1999, 186ff.).

In particular the replacement of the old energy systems based on human and animal muscle power with new fossil, later nuclear and today increasingly renewable ones, effected an energy landmark and a fundamental restructuring of economy and society. Our civilisation today is entirely based on the use of energy. From agriculture through the manufacturing sector or mobility to appliances for daily requirements, such as fridges, washing machines or dishwashers, we depend on 'energy slaves' (Dürr, 2010, 72ff.), which convert energy fed from outside in order to reduce our workload. While the energy use of pre-industrial agrarian societies was approximately 600 watts per person annually, today it has risen in our industrial countries to 4,750 watts (Glaser, 2013, 33). As Glaser writes, the global energy requirement of humankind today is more or less a million times higher than 10,000 years ago. Sixty per cent of this colossal rise took place here in the last fifty years. Its historical origins can be found in the industrial revolution (Glaser, 2013, 33).

Overcoming the Malthusian Crisis – the idea that Thomas Robert Malthus formulated in his essay 'The Principle of Population' (1798) – postulates a quasi nomological cycle, in which population numbers without fail grow faster than the available offering of foodstuffs, which in turn must result in a progressive suffering of the population through disease and epidemics, and therefore ultimately reduces population numbers again. The gradual and continuous rise in life expectancy and the, at that time scarcely believable possible increase in prosperity, are the most prominent features of this development (see Braun 2006, 63ff; Landes, 1999, 186ff.). While in 1500, approximately 500 million people populated the earth, and circa 1800, it was a billion, today there are already more than seven billion people on the planet. In 1500, in the entire world goods and services valued at USD 250 billion in current terms were produced, today the figure is almost USD 60 trillion. Energy consumption in the same period rose from 13 trillion calories per day to 1,500 trillion. Harari estimates that fourteen times more people produce 240 times more and consume 115 times more energy (Harari, 2013, 301).

Industrialisation and population growth started a process of urbanisation that continues today. Circa 1800, the world still consisted of a collection of rural-agricultural societies in which the greater part of the population worked in agriculture (see Reiterer, 2010, 90). On a global level at that time, only about three per cent of the population lived in towns (see Bähr, 1997, 9ff.). The efficiency increases of agriculture made it possible to free more and more people from their subsistence economy and to use their labour in the developing industrial and urban centres. An end to this development is not foreseeable. Circa 1950, some 28.8 % of the world's population lived in towns; currently it is already more than fifty per cent and by 2050, according to UNO estimates (2013) it will have risen to just under seventy per cent.

With urbanisation, however, also came a relocation of poverty from the country to the city, and the newly developed wageworker proletariat concentrated in the rising factories, for which ever more workers were required (Hobsbawm, 1996, 47ff.; Ziegler, 2005, 46). This resulted in continuous social problems with recurring worker revolts and social reform reactions, which cannot be addressed further here. The fact is, however, that the industrial revolution and its socio-political problems led to the creation of the European welfare states, with the result that the average citizens of today's industrial states live better and have a far higher standard of living than monarchs of two hundred years ago, as defined by historian Eric Hobsbawm (2000; 1996, 297f.; see Harris, 1990, 9).

With the scientific and industrial revolution, according to the British historian John Darwin in his book *Imperial Dreams* (2010), began Europe's global dominance. In 1750, Asia was still responsible for eighty per cent of the global economy, whereby China and India together approached two thirds of global economic production (Harari, 2013, 341; Darwin, 2010, 188). Europe's share grew in contrast between 1750 and 1900 to more than sixty per cent. This increase is due in large part to Great Britain, whose share of global production increased almost ten-fold from just under two per cent in 1750 to more than 18 % in 1900. The USA increased even more, with its share in this period rising from 0.1 % to 23 %. As such, the global economy at the end of the 19th century was almost completely dominated by the West and the global power centre shifted increasingly to Europe. In 1900, Europe dominated the global economy and most of the world unchallenged (Darwin, 2010, 156ff.; Harari, 2013, 341).

The military-industrial-scientific complex, which established itself in Europe at this time, is mostly cited as the reason for this (see Fara, 2010, 165; Harari, 2013, 342; Morris, 2010, 498ff.). In his work *The Great Divergence* (2000) historian Kenneth Pomeranz describes the resulting divergent development of Europe, which ultimately – based on the new 'enlightened' and rational worldview, the resulting scientific and industrial revolution and an expansion of the trade volume building on the benefits of industrialised production – lead to a global shift in the power structure. Europe, and somewhat later the USA, experienced an enormous economic upswing, so that the share of global economic production of all other countries fell sharply. China and India in particular were seriously affected by this. China's share of global economic production fell by 1900 to approximately five per cent. India, which had long served as the textile workshop of the world, plummeted to under two per cent (see Darwin 2010, 181ff.).

China had been the greatest economic power in the world for approximately two thousand years (see Kang, 2012). This position was destroyed by the end of the 19th century. In his OECD study 'Chinese Economic Performance in the Long Run' (2007), British economist Angus Maddison sees the reason for this in the increasing isolationist and backward-looking politics of China since the 17th century (see Morris, 2010, 476ff.; Landes, 1999, 335ff.; Diamond, 1997, 411ff.). This brought the cultural and technological exchange with other countries to a halt, which caused a gradual decoupling of technological innovations outside the empire.

Consequently, there are also no signs that the Chinese economy would have developed further at any point in the direction of mechanisation (see Acemoğlu/Robinson, 2012, 231).This meant that agriculture as a key sector of both the Chinese economy and the manufacturing industry remained dependent on human labour. In the long term, the competition disadvantages that this generated compared with Europe could no longer be compensated. The downward economic spiral had far-reaching consequences for Chinese society.

European initiatives to open up the Chinese market for trade were not very successful at first. Still in 1793 Emperor Qianlong decided to inform Britain's envoy, George Macartney, in categorical terms that China had everything it required and had absolutely no interest in importing foreign goods, and so abruptly rejected the British offer of a trade agreement (see Morris, 2010, 484). China consequently remained for quite some time in splendid isolation. This isolationism, however, ultimately revealed the weak ability of China's economic and social structures to adjust. All attempts to resist foreign trade and its free trade policies, made increasingly more successful by industrialisation, failed. In the two Opium Wars (1839 to 1842 and 1856 to 1860), Great Britain aggressively forced the opening, which resulted in the humiliation of the 'Unequal Treaties', which imposed the removal of all trade barriers. China was forced to give up its economic protectionism and open itself to the trade interests of the Europeans. Subsequently, the development this triggered resulted in the collapse of the two-thousand-year-old monarchy, long years of bloody civil wars and occupation of the country by foreign powers such as Great Britain, France, Russia, Germany and Japan (see Darwin, 2010, 260ff., 332ff.).

At the end of this turbulence, which lasted over a century, the Chinese economy lay in ruins. The per capita income plummeted well below the global average. By 1952, it had even fallen below the 1820 level and made China one of the poorest countries in the world (see Acemoğlu/Robinson, 2012, 234; Maddison, 2007, 43). This downward spiral only began to end in the 50s, and in 1978, Deng Xiaoping led the way out of isolation, which initiated an extremely successful resurgence (see Zakaria, 2009). Whereas since the Enlightenment, therefore, Europe had established forward-looking thinking systems and institutions for scientific learning, facilities of this kind such as schools, universities, academies or scholastic societies were largely absent in China (Landes 1999, 343). Instead, the bureaucracy based on the Confucian education system hindered the development of innovations (Maddison, 2007, 17, 27). Moreover, whereas in Europe, gradually the belief in the progress of humanity and a better life in the future based on technological innovations established itself (Fara, 2010, 227ff.; Fischer, 2001, 48ff.), Chinese intellectuals looked for answers in conventions and old texts (Landes, 1999; 343; Morris, 2010; 481). After all, Chinese scientists never set up a scientific knowledge system that could compare with the European one, in which lessons learned or technological innovations are systematically documented and disseminated, in order to develop new lessons learned or technological innovations that built on this – as a result, important inventions in China sank into oblivion time and again (Landes 1999, 343).

So it was not simply technological skills or knowledge that were absent for the Chinese or other non-European peoples. What lacked were innovation-promoting ways and systems of thinking, as well as social, political or economic structures and institutions, which had grown in Europe over centuries and could not be simply copied or internalised at other locations (Acemoğlu/Robinson, 2012, 70ff.; Harari, 2013, 344f.). And these structures were based on an enlightened, scientifically established worldview that had been emerging in Europe since the Modern Age (Fara, 2010, 165ff., 224ff.; Harari, 2013, 345; Landes, 1999, 276ff.)

Austrian economist Joseph Schumpeter described this correlation in his theory of economic development ('Theorie der wirtschaftlichen Entwicklung', 1912) as follows: The triumph of a technical innovation is not based on the advantages of an invention alone. The innovation process is no simple linear sequence of inventions, of finished products or processes, but rather a complex interaction between scientific, technical, economic and social variables. It is therefore not only a technical process, as important as this is, it is also and not least a social process. Reservations, concerns or fears must increasingly be overcome here. The transformation of a technical innovation into a social process, which results in a positive evaluation by users, financiers and political decision-makers, is a challenge which innovations frequently also fail (Bauer, 2006, 316).

The invention alone is therefore not yet an innovation. Innovations always require a specific forerun in which ideas or inventions are implemented in new products, services or procedures and successfully applied until they finally penetrate the market and are used in great numbers. An example of this lengthy, often disruptive process can be seen in the seminal inventions and developments of Thomas Alva Edison in the areas of electricity and illumination – from the first beginnings as inventor in the 1860s through the electrification of New York and the introduction of electric lighting in the 1880s to the extensive electrification of the industrialised world circa 1900 (see Baldwin, 2001).

A specific development pattern of technological innovations becomes evident here. Firstly, there is massive investment in a new technology and this produces an upswing. With the increasing establishment of this technology and its acceptance as a general purpose technology, investments fall and there is a medium to long-term downswing. During the downswing, work already starts on alternative technologies and a new paradigm is therefore prepared. Schumpeter defined the term of the Kondratiev waves (Schumpeter, 1939, 172ff.) for this waveform development pattern of technological paradigm changes and their effects on global economy.[5]

Schumpeter used the *The Long Wave Theory* of the Russian economist Nikolai Kon-

[5] The first Kondratiev wave from circa 1780 to 1840 was triggered by the invention of the steam engine and accompanied by the industrial revolution. The second wave from circa 1840 to 1890 is based on the development of the railroad and steam navigation. The third wave from circa 1890 to 1940 was defined by electrification and the internal combustion engine. The fourth wave from circa 1940 to 1990 was defined by the automotive industry, aviation and aerospace technology and the synthetics industry. The current fifth Kondratiev wave since 1990 is characterised by the innovations in information and telecommunication technology and biotechnology (see Duden, 2013). Some analysts have already identified signs of a new, sixth Kondratiev wave, whose engines are the basic innovations in biotechnology and psychosocial health (Nefiodow/Nefiodow, 2014).

dratiev in his explanation model for the evolution process of global business cycles. The basis for the observable cyclical sequence of global economic development is therefore provided by groundbreaking technical innovations – described by Joseph Schumpeter as basic innovations – which result in a radical change in production and organisation. Critically important here, however, is not the discovery of a basic innovation, but rather its massive dissemination, which causes a technological paradigm shift and a correlating economic and social change (Schumpeter, 1939, 213ff.).

Innovation is therefore always also a break with previous paradigms and customs and a process, during which the known or established is replaced by the new. This can happen with incremental improvement processes just as much as it can with radical, disruptive innovations and revolutionary changes. Schumpeter expressed this with the image of the storm of creative destruction (Schumpeter, 1912, 157). This occasionally resulted in desperate races, as established technologies cannot be so easily ousted – mail coaches versus railroads, sail ships versus steamships or oxen versus tractors, paraffin lamps versus electric bulbs, to name but a few examples. This competition is decisive for further economic development and a motor for history.

DESIGNING THE FUTURE: POSSIBLE DEVELOPMENT LINES AND NECESSARY REQUIREMENTS

The history of humanity, as mentioned at the beginning, is also the history of a chain of ever faster successive innovations. This process is neither complete today nor is its continued course foreseeable. Danish physicist and Nobel Prize Winner Niels Bohr is quoted as saying that forecasts are difficult, especially about the future. Futurologists nevertheless increasingly dare to make prognoses. Most of them assume that the recent crisis-related developments illustrate the need for a radical global economic and social change (see Androsch / Gadner, 2013, 256ff.; Morris, 2010, 598ff.).

The next, already incipient basic change, which is described as the 'third industrial revolution' (Rifkin, 2011), is based on the consequences of 'networking the world' (Schmidt/Cohen 2013) through digitalisation and its interfacing with renewable energy systems and intelligent production methods, which are encapsulated with the keyword 'Industry 4.0' (see Bauernhansl et al., 2014; Marsh 2012). The idea of the third industrial revolution does actually indicate that technological innovations will play a key role for the future of humanity. At the same time, however, it also implies social innovations and the necessary reorganisation of a number of correlated political, economic and social processes (see Anderson 2012; Rothkopf 2012).

As a result of these radical changes, American futurologist Jeremy Rifkin (2011) forecasts a new economic and social paradigm, which entails far-reaching social consequences. In addition to the change in social structures, which will be more democratic and less hierarchical, the changed production conditions will have massive effects on working life with increasingly automated processes. The progresses in the area of Artificial Intelligence in particular also play a key role here (see Anderson 2012; Marsh 2012).

The renowned science journal *Science* published a special insert on the topic of 'The social life of robots' at the beginning of October 2014. It summaries the status of current developments in the area of Artificial Intelligence (AI) and derives possible implications of the automation of intelligent behaviour. According to *Science*, robotics have now become so advanced that it is possible to generate a form of manipulative intelligence, which, on the basis of artificial information processing and with the aid of sensors and actuators, enables an almost intelligent interaction with the physical environment. The basic idea here is to create systems that can understand the intelligent behaviour of life forms (Science, 2014, 182f.).

Robots can consequently already flexibly apply basic human senses in the most diverse of contexts: seeing, hearing, smelling, tasting or keeping balance have all been in use for some years now (Science, 2014, 184f.). A more recent event by contrast is the information technology-based ability of 'deep learning', which employs a feedback system that enables robots to learn – to date mostly from visual impressions and experiences and to adjust their behaviour on this basis (Science, 2014, 186f.; see The Economist, 2015, 17f.).

With the help of robots, potentially dangerous activities such as finding leaky gas lines, the removal of rubble from natural disaster areas and rescuing people from collapsed or burning houses, or even processes and manipulations that always run the same, such as welding, painting, etc. can be exceptionally well automated. But even more complex tasks, such as recording data-based short messages, running repetitive lab tests in research or work as a chauffeur, according to Science, are already carried out today by robots (Science, 2014, 190f.).

The possible future development of these complex systems can, however, also conjure up horror scenarios, such as, for example, the uncontrollable independence of the artificial intelligence that all these processes are based on (see The Economist, 2015, 9). Physicist Stephen Hawking consequently warns against the further development of AI leading to the emergence of an awareness of the machines and therefore ultimately to the end of humanity (The Guardian, 2014; see Morris, 2010, 617f.). Even if these dangers cannot be entirely relegated to the realm of science fiction and the concerns of the critics must be taken seriously, from today's point of view the most diverse benefit aspects prevail (The Economist, 2015, 9).

At any rate the fusion of new possibilities of information and communication technologies with synthetic biology, as they are already applied in the area of bio-robotics, for example, holds the potential for completely new developments (Science 2014, 196ff.). The fusion of man and machine building on this is referred to in philosophy as transhumanism or technological singularity. In his book *Menschheit 2.0 – Die Singularität naht* ('The Singularity Is Near: When Humans Transcend Biology', 2013), as a realistic possible consequence of this bio-technological evolution, MIT professor Ray Kurzweil forecasts not only a basic change in our image of humanity, but rather also a break in the structure of the history of humanity.

This development will naturally also have implications for the constitution of societies, and in particular for the structures of the working world of the future (see Anderson, 2012; Marsh, 2012). This thesis has also been studied in more detail by the two MIT professors Eric Brynjolfsson and Andrew McAfee in their books *Race Against the Machine* (2011) and *The Second Machine Age* (2014). According to these, technological progress ultimately results in knowledge-based economies being able to increase their productivity detached from human work performance. This causes the number of jobs to stagnate, as can be seen in most OECD countries for some years now. At the same time, the productivity rate increases. Globally successful companies are already today demonstrating how massive turnover can be generated with just a few hundred employees. This therefore not only affects the much-cited cashiers who are being successively pushed from the tills of supermarkets by the use of self-service terminals. In the long-term, it will also affect specialist workers who will be replaced by intelligent industrial robots. The aptly named knowledge workers are not out of the woods here either, as AI systems will also endanger their jobs (see The Economist, 2015, 20). Translation programmes are already competing today with well-trained translators. IT experts or mathematicians with academic algorithm degrees will be replaced by automated data analysis – the latter in particular is a highly topical issue in conjunction with the global 'Big Data' mega trend (Mayer-Schönberger, 2013).[6]

[6] See also President's Council of Advisors for Science and Technology (2014): Big Data: Seizing Opportunities, Preserving Values. Executive Office of the President.

All indications are that the discrepancy in particular between the loss of work and a simultaneous deficit in qualified workers with adjusted and increasingly quicker changing requirement profiles will become a key issue in the near future, because, while in all leading industrial countries the number of jobs stagnates or occasionally even falls dramatically, in others highly qualified workers that satisfy the current requirements profiles of the economy are in demand (see OECD, 2012). In a somewhat more distant future, however, should the apologists of the rise of the robots be proven right, the difference between qualified and unqualified workers and jobs will become increasingly less important. Should this happen, it will result in any case in a further decoupling of productivity and (human) work (see Morris, 2010, 597f.).

If we follow the thoughts of the British economic historian Robert Skidelsky elaborated in his essay 'The Rise of the Robots' (2013), this development inevitably results in a social revolution that necessitates a redefinition of the concept of work. In his book *Bürger, ohne Arbeit* ('Citizens Without Work', 2005), German sociologist Wolfgang Engler also points out that in the age of the third industrial, digital revolution, we will inevitably have to deal with the fact of disappearing work and the resulting implications. Skidelsky and Engler in particular want to ask how societies can function if large parts of the population are not involved in the acquisition process because, on the basis of the changes to be expected in production conditions, full-time employment can no longer be taken seriously as a political goal, and we must bid adieu to the principle of a right to work. In the future, it will be more about thinking about a right to income and discussing possibilities to better use the free time gained through machine progress and automation, and guaranteeing personal self-esteem and social recognition and appreciation outside of classic work processes (see Rifkin, 2004).

Whether or not humanity will actually lose work can, however, be questioned with a look at the past, and in particular at the consequences of the scientific and industrial revolution. The accelerated development of technology, productivity and the sciences since the 18th century may have resulted in a population explosion. At the same time, however, new jobs emerged in previously unprecedented numbers (see Braun, 2010, 63ff.). And although innumerable occupations have disappeared over time (see Pala, 2014), the working society has still never lost its work. This is proven, not least, by the further rise of global labour force participation rates (see OECD, 2014) and also, for example, by the current and acute deficit of IT workers in Germany (Frankfurter Allgemeine Zeitung, 2015).

On the contrary, there will arguably be work in the future. It will be different, and with the accelerated rate of change, it will bring new requirement profiles with it and require different qualifications. According to sociologist Richard Senett (2006), it will be a work world in which there are less and less jobs for life, and more and more flexibility will be needed. This development will require numerous answers in the area of education, training and further training, as well as in the legal system and in the welfare state area. Jeremy Rifkin also sees a similar scenario in his book *The End of Work* (2004). Consequently, the orientation of today's political activities is too structure conserving and too focused on the status quo and outdated conditions. This increasingly produces the danger of splitting societies into modernisation winners and losers and, connected with this, the danger of populist extremism at the edges of the political arena.

Whether the future will bring the end of work or the end of humanity and its replacement by intelligent machines cannot be naturally predicted. At any rate, today we live at the high point of what some scientists refer to as the Anthropocene (see Crutzen/Stroemer, 2000). This is the age since the scientific and industrial revolution in which the human has become one of the most important factors influencing the biological, geological and atmospheric processes on earth (see Glaser, 2013, 33ff.). Humankind has, however, to date only insufficiently appreciated its growing responsibility, which has resulted in a great threat to our planet. The consequences are everywhere: the climate change caused by humankind, the scarcity of resources caused by economic production of previously unknown proportions, the continuing rapid population rise in many regions of the world, the unchecked energy hunger or, in places, the already dramatic pollution of the oceans, the land and the air are just some of the more prominent examples (see SOER, 2015; IEA, 2014; IPCC, 2014; UNO, 2013; UNEP, 2011a; UNEP, 2011b).

Notable in particular here are the extent and speed of the global change caused by humans. In the last fifty years, humankind's encroachment on nature has been so radical and extensive that it has introduced an unprecedented transformation process, with effects of global dimension (see Diamond, 2005, 486ff.). Glaser remarks that the key question is, to what extent and in which areas the human has overstressed the earth system so much that its primal basis of existence, its 'life assurance system', so to speak, based on clean air and drinking water, fruitful soil, a diverse plant and animal world, healthy and sufficient food, sustainable energy supply and mineral planning, is endangered. In addition to these supply issues there are also urgent disposal issues: rubbish, neglected deposits, devastated swathes of land, *dead zones* in seas and oceans, smog and fine dust pollution rank among the most obvious excesses of the unchecked encroachment and greediness of humankind. Consequently the loss of biodiversity, climate change, landscape degradation, desertification and the change in the material cycles of ozone, carbon and nitrogen have become urgent issues concerning our sustainability (Glaser, 2013, 7).

The fact is that our current ways of life and production are not sustainable and humankind is facing unimagined challenges. History tells us that earlier cultures have always reached growth limits or failed in their production methods and technologies (see Diamond, 2005; Harris, 1990). Humanity has always overcome growth limits and met pending challenges with technical innovations (see Morris, 2010, 144ff.). Failed technologies of earlier cultures were replaced by new ones and existing growth limits were surpassed (Harris, 1990, 8). The big difference between the current challenges and those of earlier cultures is that today we know which problems are involved and which solutions are required (see Morris, 2010, 621). Not least of all the modern sciences are responsible for this, and although this knowledge must also be followed by appropriate actions, cautious optimism appears to be thoroughly justified (see Diamond, 2005, 525). 'The voice of the intellect is a soft one,' Sigmund Freud wrote in *The Future of an Illusion*, 'but it does not rest till it has gained a hearing. Finally, after a countless succession of rebuffs, it succeeds. This is one of the few points on which one may be optimistic about the future of mankind, but it is in itself a point of no small importance' (Freud, 1961, 53).

'The future is open,' agree the Austrian behavioural scientist and Nobel Prize winner Konrad Lorenz and philosopher Karl Popper in their book entitled *Die Zukunft ist offen* ('The Future is Open,' Popper / Lorenz, 1985). While it remains unclear what shape the future will actually take and which of the outlined developments will become this or a similar reality, it is nonetheless clear that we must prepare ourselves for a fundamental change. To be able to meet this change in the right way, we require one thing in particular: education. Well-trained, independently thinking, critical and creative heads are a basic requirement to overcome the grand challenges and find the technological and social innovations required for this. A modern education system that optimally prepares people for the new challenge is therefore required. Energetic and determined state action must be provided to guarantee this.

In her book, *The Entrepreneurial State* (2013), economist Mariana Mazzucato argues that the role of the state is decisive for the formation of a functioning innovation culture. Legal and taxation framework conditions are just as critical here as the education system or research promotion programmes and instruments of intervention. An innovative, entrepreneurial culture cannot establish itself without appropriate state support structures. On the contrary! According to Mazzucato, creative entrepreneurs and risk-ready venture capitalists were not and are not the motor of the development of technological innovations and the resulting economic upturn and wellbeing, but rather it is an active state, which finances the public education institutions, sets up and expands infrastructures, promotes basic research and implements measures to support the market entry of young knowledge-intensive companies. Examples of this range from electrification through to the internet, whose creation and expansion would never have come about without the public sector. Apple's success, for example, is based on technologies that were almost entirely promoted by the public sector (see The Economist, 2013).

The MIT economist Daron Acemoğlu and Harvard political scientist James Robinson also argue similarly in their bestseller *Why Nations Fail* ('Warum Nationen scheitern', (2013). According to this book, the regulations and institutions chosen by the state are responsible for economies realising their innovative potential, and therefore lay the basis for their economic success. Economic growth has always been driven by innovations and by technological and organisational change (but today increasingly so), which are based on the ideas, talents, creativity and energy of the individuals of a society. The basis for this are, on one hand, appropriate incentive systems, and on the other hand structures that promote the abilities and talents of as many members of a society as possible, and therefore specifically utilise the available innovation potential. This requires suitable education institutions, but also promotional framework conditions, such as, for example, strict ownership and contract laws, a functioning justice system and free competition. Only then can the majority of the population productively take part in economic life.

In his book, *The Wealth and Poverty of Nations* (1999), economic historian David Landes illustrates the eminent importance of innovations and the passing on of new knowledge for the prosperous development of economies. Even if this approach is controversial and was the subject of heated debates due to its Eurocentric position, Landes' analysis of the role of scientific and technological innovations is a coherent explanation for the wellbeing or poverty of nations in the past and in the present world. The consequences to be drawn today for political decision-makers were recently addressed by the chief economist of the Bank of England, Andrew Haldane, in a speech entitled 'Growing, Fast and Slow' (2015). The ingredients for economic growth remain as mysterious as they have always been despite centuries of experience. Regardless of all uncertainty, one thing does become evident from the global history of humanity: in addition to sociological factors, education, research, technology and innovation in particular play an important role for the wellbeing of successful states. The most innovative countries in the world – in particular the USA, Germany, the Scandinavian countries, Switzerland, Japan and South Korea – have reacted appropriately to the realisation that the road to overcoming the great challenges of humanity requires increased efforts in the areas of education, research and innovation. In the recent years of crisis, they have massively increased their investments in these elements of the future.

This book intends to help re-ignite the discussion required on the central role of innovation in the past, present and future from new points of view. Both the international comparisons and the different perspectives of the authors will introduce new arguments to the political discourse. The conclusions the reader draws from this remain, necessarily, open. From our point of view, however, the book very clearly shows the following: If it is possible to sustainably establish the key basic requirements for innovation outlined in all contributions, then a self-determined designing of the future that meets the major social challenges is possible. Essential here is that the required steps are not left until tomorrow and the required reforms put off even further. Because everything that is neglected today will have far-reaching consequences tomorrow. We must, therefore, begin to work on tomorrow today – because designing the future begins now!

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Translated from German by Richard Fluskey