Coevolution of Technology and Society:
How Digital Technology is Creating Digital Society

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Abstract

The report, based on extensive research into relationship between Homo and their Tools, follows a story:

Coevolution of society and technology is irreversible and unstoppable. In the latest stage of this process, digital technology is creating a highly connected and therefore *complex* digital economy and digital society.

To prosper under conditions of complexity, traditional businesses, healthcare service and administrations should develop a capacity for rapidly *adapting* to unpredictable changes in social, political and economic conditions. For this to happen, batch-mode resource allocation systems and manual dispatching must be replaced with Artificial Intelligence based *real-time* schedulers.

Globalization, as conceived when industrial economy was dominant, has several critical flows – (1) outsourcing manufacturing to faraway countries created intercontinental supply chains and excessive business travel, which generate pollution and waste energy; (2) excessive transportation of goods and business travel increased the “butterfly effect” and, consequently, provided a conduct for rapid spread of pandemics; (3) Excessively connected global financial network enabled a “drift into failure” and, consequently caused a global financial crisis of 2008.

New digital technology enables building small, cost-effective factories capable of producing a variety of products, which can be located close to points of demand, rendering nations largely self-contained in terms of goods.

Globalization in the digital age should be concerned primarily with trading in knowledge-based services.

Judging by what happened during agricultural and industrial revolutions, digital technology will dramatically change current society, which is still in industrial age.

Introduction

> *“In recorded history there have perhaps been three pulses of change powerful enough to alter Man in basic ways. The introduction of agriculture… The Industrial Revolution… (and) the revolution in information processing technology of the computer…”*
>
> Herbert A. Simon

Since times immemorial tools changed those who invent them. The discovery of fire and the invention of stirrups are good examples of the power of technology.

Approximately two million years ago, homo erectus learned how to control fire and, as a result, improved their diet. Proteins helped the human brain to grow and human race was propelled to the top of the food chain by the newly developed supremacy of human intelligence; and gathering around the fire, created cohesive communities [1].

The second example is less dramatic but still very impressive. The invention of stirrups, first used in France around the 8th Century and England in the 10th Century, helped mounted warriors keep their balance when fighting on horseback and consequently contributed to the creation of the medieval social class of knights, significantly affecting social evolution [2]. A simple invention – dramatic consequences.

Coevolution of society and technology

Social order and technology are closely interlinked as illustrated by the diagram below. Society affects the evolution of technology and technology, in turn, affects the evolution of society, the process known as *coevolution of society and technology* [3].

Like natural evolution, socio-technological coevolution has no goal and no objectives. Technology changes society in an unpredictable and irreversible manner and the process is difficult to recognise and impossible to influence by participants. By the time individual participants realise what are the consequences of the massive use of new technology, it is too late to stop or modify the process. And, of course, changes are always resisted by those who enjoyed their status under the disappearing order, but the process is unstoppable. The interaction of society and technology is quite logical:

1. Society invest into creative minds that invent new tools (technology).
2. New technology creates new jobs and destroys many old ones.
3. New jobs create new businesses (and from time to time, new economy).
4. New businesses change social order.

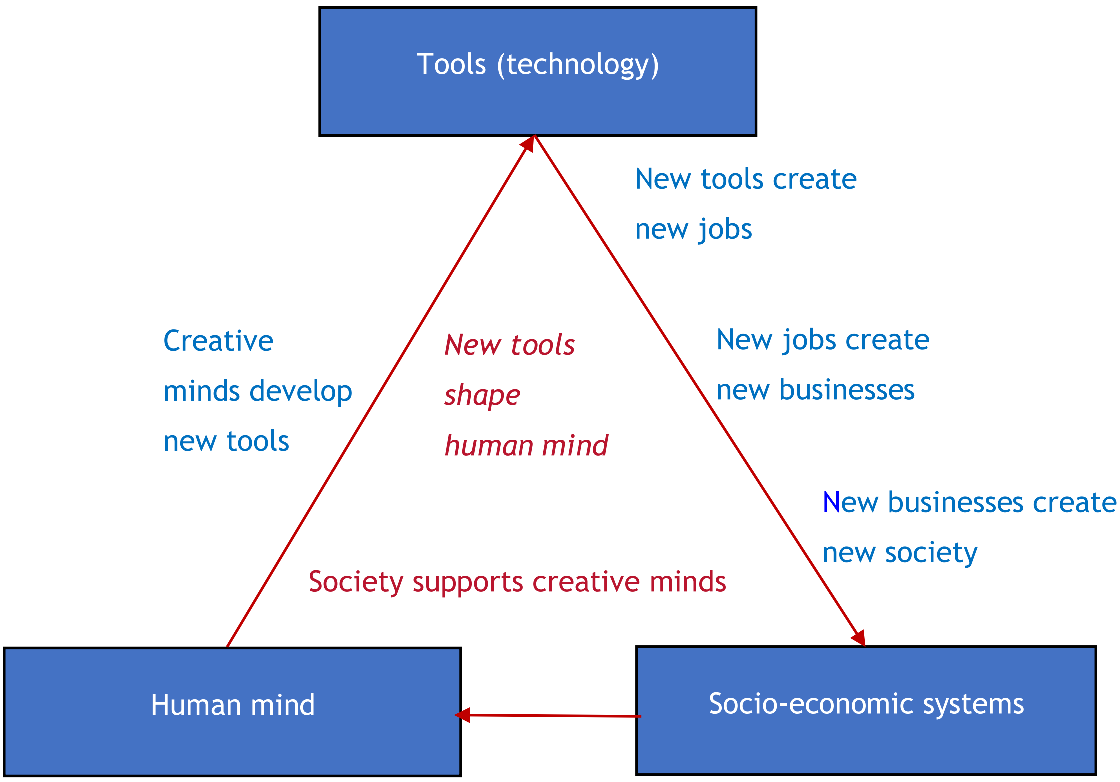

Fig. 1. Irreversible coevolution of technology and society

The diagram in Fig. 2 shows three of the most important stages in social evolution: Agricultural Society, Industrial Society and Digital Society. Society of Hunters and Gatherers, which preceded the Agricultural Society, is not shown.

At every transition the socio-economic *connectivity* has increased significantly, pushing *complexity* to a higher level [4].

Agricultural society

Agricultural technology, which includes all knowledge and tools necessary for cultivating large sections of land, was developed approximately 12,000 years ago in Lebanon and Anatolia and quickly spread around the world, enabled hunters and gatherers to abandon nomadic existence and settle down in permanent dwellings. Transition to agriculture brought a truly radical social change. Loosely organised tribes of hunters and gatherers were replaced by rigidly structured hierarchical society with a relatively small number of landowner families on top and, at the bottom, millions of manual agricultural workers living in poverty [5]. The key economic resource of the agricultural society was land and, consequently, landowners formed social and political elite.

Industrial society

Industrial technology, which enables manufacturing and distribution of goods on a massive scale was invented and developed in England, starting with the invention of steam engine by James Wat and the first steam locomotive by Stephenson. The whole *industrial revolution* lasted approx. 100 years, between 1750 and 1850. Consequential social changes were dramatic. To work in industry, people had to move from villages to towns, where they were paid better but initially lived in overcrowded conditions without proper social security and healthcare [6]. Gradually, living conditions for industrial workers have improved, certainly in the West. As money replaced land as the key economic resource, landowners lost their prominence – bankers, industrialists, lawyers, professional politicians and media personalities took over the establishment.

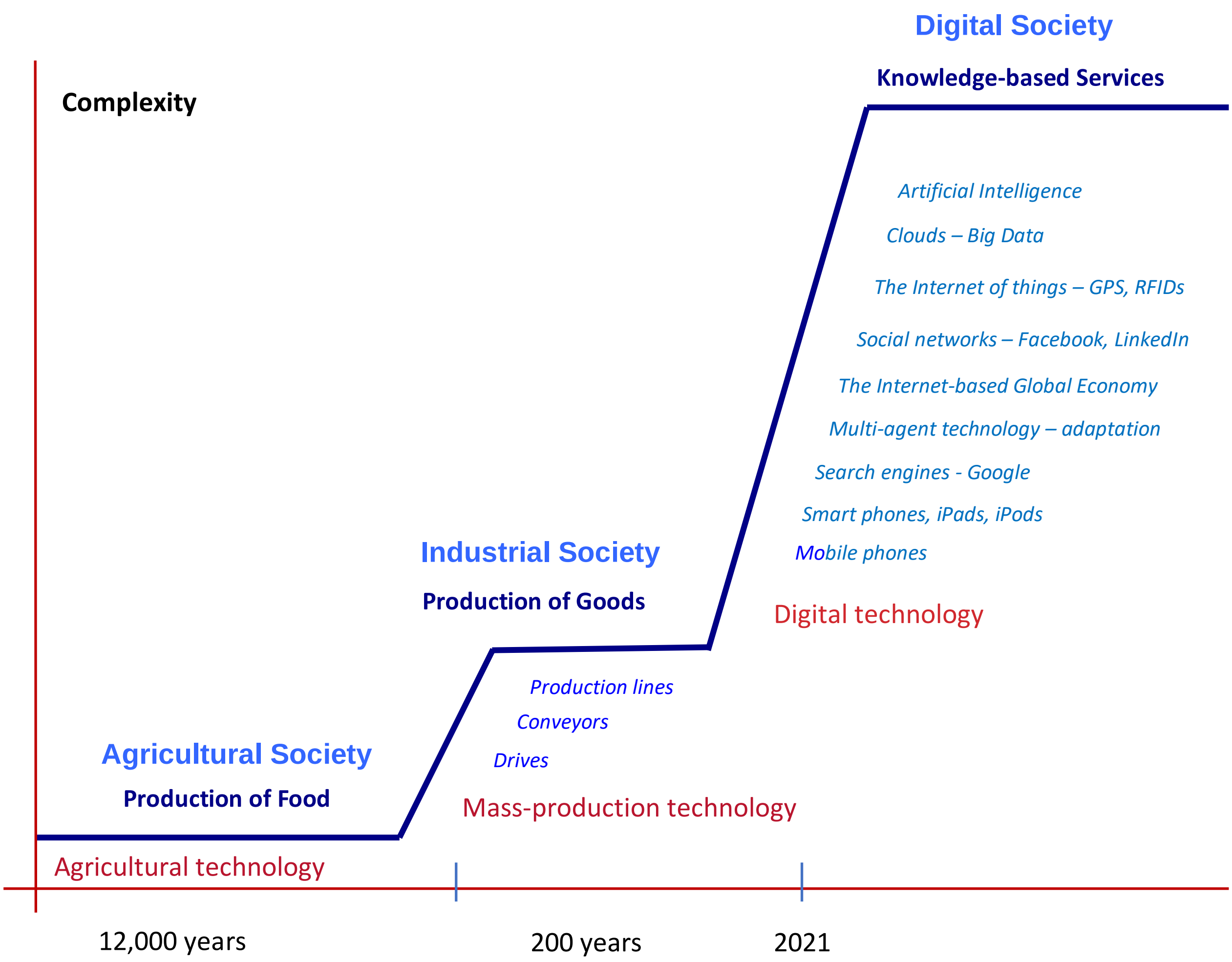

Fig. 2. Social connectivity and complexity increase with every major social paradigm shift

Digital technology

Digital technology, which includes computers, smart phones, tablets, pod music players, digital tags, the internet, worldwide web (www), broadband, Wi-Fi, 4G and 5G networks, AI, multi-agent systems and all software systems and applications, has increased complexity of markets, created knowledge economy and is driving social changes.

Digital connectivity and complexity

The widespread use of *digital communication technology* sharply increased social connectivity and, consequently, social complexity.

The word c*omplex* derives from the Latin word "flex" mining "weave" and it describes a group or, more formally, a system which

- interacts with its environment (open system)
- consists of diverse and *autonomous* members, called *agents*, engaged in intense interaction

The term "autonomous" denotes that agents are not centrally controlled and have freedom of behaviour limited by the rules of group membership and the legal system within which the group operates.

Behaviour of a complex system emerges from the interaction of agents and is therefore uncertain without being random - it follows discernible patterns.

Complexity increases with connectivity – as the number of connections between agents increases, the interaction intensifies and the *uncertainty* of the group behaviour grows [7].

Examples of complex systems include human brain, natural ecosystems (forests, grasslands, rivers, oceans), the internet-based global market and social websites. Democracy is also a complex system and so are many currently unresolved issues – mass immigration, Brexit, terrorist networks, global warming and coronavirus pandemic. These issues are unresolved because they are complex and yet the attempts to resolve them are not informed by complexity science.

During the first 20 years of this century, the increase in complexity of our socio-economic system has been truly staggering [8].

At the beginning of the 21st century only 361 million people used the internet and in 2020, 4.6 billion people are connected (out of the total world population of 7.7 billion). With its 2 billion websites, the internet selforganises and evolves displaying adaptability and resilience to disruptions and cyberattacks. Since 1983, the internet grows and evolves without ever breaking down, precisely because it is complex rather than centrally controlled.

Through the internet, nearly 4 billion people are connected to social digital media, where they are given opportunities to express their views, display details of their life and engage in debates, within constraints imposed by norms, rules and the law – a vast complex system. The internet-based global market is a genuine complex system connecting estimated 3 billion of individuals and almost all businesses. Suppliers, customers, lawyers, accountants, traders, brokers, wholesalers, retailers, consultants, bankers and investors are engaged in creating, modifying and cancelling transactions with unprecedented speed, making forecasting of demand and supply unreliable.

The internet of things interconnects 30 billion physical objects, engaged in competing or cooperating with each other, independently from their users.

Remarkable properties of complex systems

Complex groups, that is, groups whose members have certain autonomy and are highly connected (such as a neural network in a human brain or the internet-based global market), have remarkable properties [9], some of which – selforganisation, butterfly effect, drifting into failure and clustering - are discussed below.

Selforganisation

Selforganisation is the ability of a complex system to autonomously (without external intervention) change its own configuration of resources to reach a *new order* (a new state) [10].

Selforganisation makes complex groups *adaptable, resilient and spontaneously self-improving*.

Adaptability is the capacity for selforganising in response to a disruptive event. The adaptive system autonomously identifies a disruptive event and reschedules affected resources to neutralise or, at least, reduce consequences of the disruption (cancellation or modification of a demand, arrival of an unexpected demand, failure of a resource, no-show).

Resilience is the capacity for selforganising in response to a fraudulent or malevolent attack. The resilient system autonomously identifies an attack and reschedules affected resources to neutralise or, at least, reduce consequences of the attack (approval of a toxic loan, illegal transfer of money, hacking, cyberattack).

Spontaneous self-improvement is the capacity for selforganising to improve own performance. A complex system self-improves by trial-and-error, (1) it assumes that certain activity will improve system performance, (2) performs that activity, (3) if necessary, modifies previous assumption, and (4) repeats steps 2 and 3 until the desired performance improvement is achieved or resources available for self-improvement run out.

Butterfly effect

In highly connected complex systems, such as climate, global market or global transportation system, an insignificantly small disturbance, like a movement of a butterfly wing, may cause an extreme event, such as storm, in a far-removed part of the globe.

The most dramatic example of the butterfly effect is the current coronavirus pandemic - a single meal of an infected animal or, possibly, a single mistake in a virus laboratory, which enabled a population of viruses to escape, rapidly propagated through the highly connected "global village", causing worldwide infection, more than a million deaths and economic collapse on a huge scale.

Drifting into failure

When a complex group operates successfully over a long period of time, a tendency may develop among constituent members to neglect some of their duties or engage in small-scale illegal activities, which can be individually easily concealed. However, the consequences of these activities accumulate over time and when the *tipping point* is reached, an *extreme event* (failure) is triggered [11].

Isn't it obvious that the financial crisis of 2008 was caused by a drift into a failure? The accumulation of small toxic loans, approved to gain bonuses, gradually reached tipping point and turned into an unstoppable global crisis.

The evidence gathered from experiments with complex digital systems shows that to prevent drifting into failure, it is necessary to impose strict control on the behaviour of agents when the operation is going smoothly and to allow them considerable freedom of action to encourage creative thinking during the recovery [12] – exactly opposite to what was actually done by the US and UK financial authorities during the build-up to crises and the recovery.

Complexity science provides a strategy for controlling butterfly effects and drifts into failures in large, densely connected man-made complex systems, such as globalization or the internet-based global market. The idea of clustering is at the core of this strategy.

Clustering

Clustering means organising a complex group into sparsely interconnected smaller groups of members with a common purpose, engaged in intense interaction, as depicted on the right-hand side of Fig. 3.

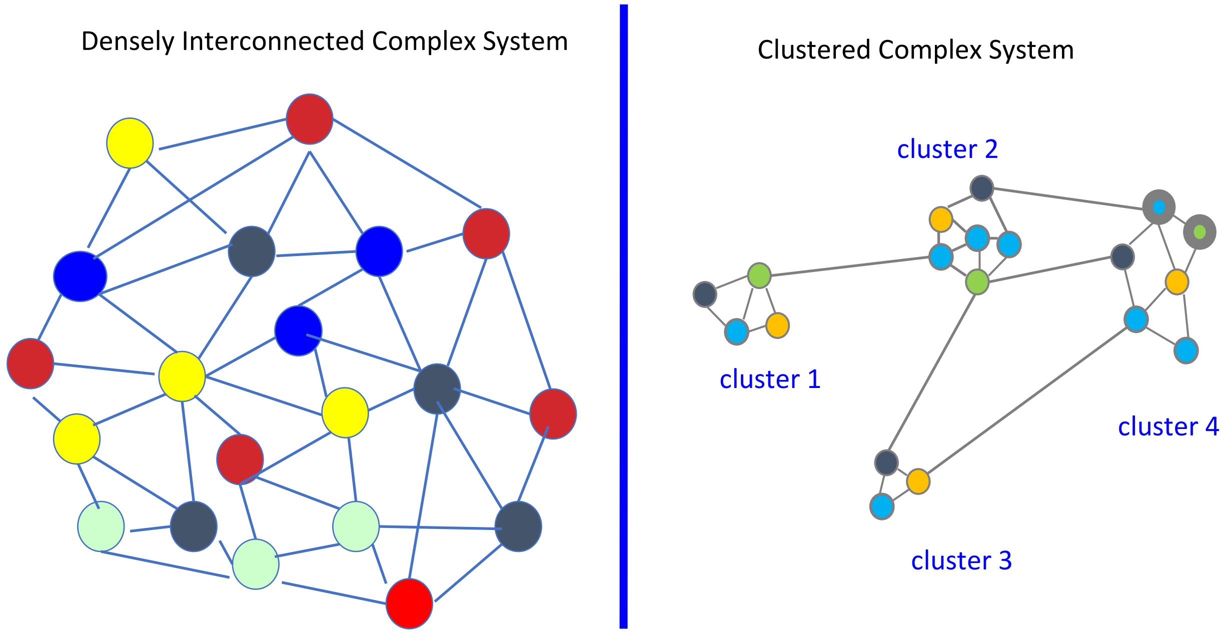

Fig. 3. Two contrasting configurations of complex adaptive systems

Living creatures naturally form clusters – they organise themselves into swarms, colonies, herds, packs, families, tribes or communities. In a group where all participants know each other, it is easier to collectively create and distribute resources for life, grow and age together and experience a feeling of comfort and security.

Here are two interesting examples, one from 11th century and another from the 20th. The first English university, Oxford is organised as a system of connected colleges (clusters), where academics and students live and learn in relatively small groups. Cambridge, 100 years younger university, functions in the same way. Now let's move forward in time rapidly to observe how recent immigrants in London tend to form cultural clusters – French in Kensington, Indian in Southall, Polish in Ealing and Russians in Knightsbridge, to mention just a few.

Among biological systems there are many examples of clustering. Human brain, a beautiful creation of natural selection, consists of connected regions (clusters), each focused on performing a particular function. Fig. 4 shows regions of a human brain engaged when people lie and those when they are truthful.

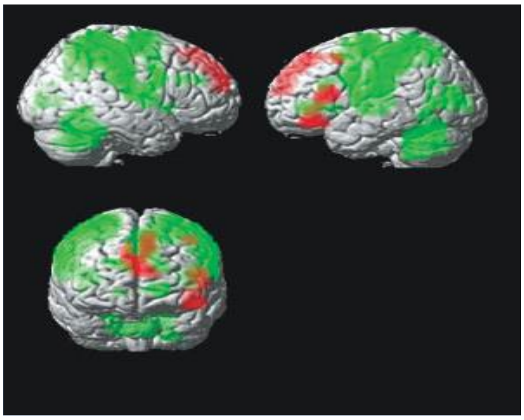

Fig. 4. Green regions are engaged when people are truthful and red regions when they are dishonest

We really should ask ourselves why we ignore the clustered configuration, which emerged from natural selection and is so successful in biological and natural ecosystems. Clustered configuration significantly slows down the transmission of disruptions originated in one cluster to other parts of the system.

Let's build global complex systems as sparsely interconnected national clusters, as depicted on the right-hand side of Fig. 3. The author knows well that national self-sufficiency is a controversial idea because it contradicts the widely held belief that the global market is more efficient than national markets. In digital economy, however, this believe may be no longer valid - thanks to digital technology, manufacturing self-sufficiency is now possible to achieve by building smaller, cost-effective, selforganising manufacturing plants that are "versatile" – capable of rapidly switching from the production of one type of products to another - and therefore can be located close to points of demand.

Economy of scale is harmful

In industrial society, to achieve *economy of scale* the natural propensity to live and work in small groups was ignored. Whenever possible, people were packed into large units - large factories, large corporations, large schools and universities and large unions of states (such as EU) - much too large for the liking of many individuals, who felt frustrated being seen as clogs in a machine, rather than as distinct individuals, as perceptively described by Schumacher in his seminal book Small is Beautiful [13].

Globalization, initiated and realised in industrial era, extended the notion of the economy of scale to the whole planet. Large factories were located in regions with low wages at long distances from centres of demand and, consequently, goods were transported up and down the globe. The world became densely interconnected, as illustrated on the left-hand side of the Fig. 3. It is necessary to admit that the economic success of the idea was considerable, helping both developed and developing countries to rase living standards. In spite of the material improvements, resentment is widespread.

Major fallacies in the concept became obvious only recently.

Firstly, a fully interconnected global complex system is a potential victim of severe butterfly effects. We had recently two rapidly spreading global disasters – the global financial crisis of 2008 and coronavirus pandemic of 2020.

Secondly, outsourcing manufacturing to faraway countries created intercontinental supply chains and excessive business travel, which generated pollution and wasted energy.

And thirdly, the coronavirus pandemic closed national boundaries and prevented normal exchange of critical goods (remember a case of disruption of the supply of protective equipment from one European country to another), which exposed an additional shortcoming in the concept of fully connected global systems – the need for critical national self-sufficiency was ignored.

Just reversing the trend of outsourcing manufacturing to developing countries can substantially reduce long-haul transportation of goods and intercontinental business travel, and also increase national self-sufficiency.

The law of requisite complexity

We have to ask ourselves: can traditional large corporations, the centrally managed healthcare service and rigidly structured administrations prosper in this entirely new volatile and dynamic environment? The answer to this question can be found in the law of requisite complexity:

An organisation can survive and prosper in a complex environment, (such as the internet-based global market) *only if its complexity is appropriate to the complexity of that environment.*

The law of requisite complexity tells us that we have to figure out how to inject some complexity into our businesses, the health service and administrations to make them agile and compatible with our new socio-economic environment.

Traditional command-and-control organisations are too rigid and brittle to cope with complexity – they were designed to operate in a stable, predictable market.

Complexity worldview

Our traditional education prepares young to be successful in an orderly and slow changing world in which future is predictable and where source of uncertainty is often ignorance and, therefore, it can be reduced, or even eliminated, by learning. In such *deterministic* word, according to Newton, natural laws are valid independently of time and location. Einstein asserted determinism by stating "God does'nt play dice with universe".

As recently as 1990's, a different worldview was articulated, independently, by Belgian Nobel prize winner, Ilya Prigogine [14], [15] and by the US Santa Fee Institute researchers, Stuart Kaufman [16] and John Holland [17] - a *complexity worldview*. Many other authors made important contributions to the idea of a complex evolving world, among them, Charles Darwin [18], Carl Popper [19], Marvin Minsky [20] and Eric Beinhocker [21].

The essence of complexity worldview is that the world, far from being created by a great design, irreversibly and unpredictably evolves from early beginnings, through a stage of primordial soup to the current state, and will continue to evolve, driven by the accumulation of everyday actions and interactions of all living and non-living constituent components. Every infection, war, scientific discovery, trading transaction, financial crisis, erosion, earthquake, tsunami and procreation, changes the world in an unpredictable way.

Uncertainty is a result of unpredictable evolution and cannot be reduced or eliminated.

In sharp contrast to Einstein' assertion of determinism, Prigogine proclaimed "Future is not given". The idea is, of course, not entirely new, Heraclitus realised, as early as 500 BC, that world is perpetually changing and expressed this notion in a memorable sentence **"**You could not step twice into the same river**".** Karl Popper observed that in a deterministic world creativity would not be possible.

Complexity mindset

Complexity mindset is mindset which ecompases the complexity worldview. Developing complexity mindset is essential for those who live and work under conditions of uncertainty.

Digital intelligence

Digital intelligence, more commonly known as artificial intelligence (AI), is widely used for extracting knowledge from data. It has huge potential to improve operational decision making and enhancing adaptability and resilience.

Author's research shows that at present, it is safe to use AI for decision making associated with low risk, in other words, decisions which do not endanger human life or high-value property [22].

Before we start using AI in anger for applications where there is a high risk for human life or high-value property, we shall have to sort out questions of ethics and legal responsibility of AI.

An estimated 50% of all jobs in industry, commerce, healthcare and administration are low risk decision making jobs, which can be safely replaced by artificial intelligence. The allocation of human, physical, financial and knowledge resources to demands at operational level in businesses, NHS and administrations can be cost-effectively, precisely and rapidly performed by intelligent digital real-time schedulers. In case of a disruption, fraud or electronic attack, AI schedulers can almost instantly reschedule affected resources and minimise the consequences of any disruption.

Digital intelligence plays the key role in the design of digital immunity systems. A digital agent is assigned to each data input and trained to rapidly detect the value that is untypical for the monitored interface. The suspicious input triggers one of several predetermined options – alert, advice to security staff, blocking of the interface or closure of the attacked site, depending on the judged severity of the attack. The system learns to improve performance from an extensive post-event self-analysis.

Digital ecosystems

The author's research shows that socio-technological organisations could be designed as digital ecosystems in which natural and artificial intelligence cooperate or compete depending on circumstances. The aim of digital ecosystems is to *support the connected, sustainable society, which is capable of cost-effectively feeding, watering, housing, educating, keeping in good health, moving and employing its members without endangering our natural environment* [23].

According to Wikipedia, "A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organization, sustainability and scalability inspired from natural ecosystems. Digital ecosystem models are informed by knowledge of natural ecosystems, especially for aspects related to competition and collaboration among diverse entities". From this definition it is clear that digital ecosystems are complex systems and therefore highly suitable for operating in a complex socio-economic environment. A trend to think about business as an ecosystem began as early as 1993, triggered by the James Moore's article in Harvard Review [24].

By now, complexity of the environment in which we live and work, has increased to such a degree that, following the law of requisite complexity, we would be well advised to adopt the ecosystem approach to all aspects of our lives, starting from businesses, healthcare and administration.

Digital economy

Packaging of knowledge in *digital formats*, such as world-wide web, pdf, electronic books, podcasts, posts, videos, webinars, twits, Instagram messages, online lectures and software, enabled cost-effective capture, storage, access and rapid distribution of knowledge on an unprecedented scale. It created knowledge economy.

Digital knowledge (e.g., research results) can be also packaged as a highly sophisticated product, such as a potential driverless car, in which digital knowledge component is of greater value than the physical object. Therefore, the physical component of the product can be considered (from valuation point of view), as just the packaging of knowledge. A good example is the car manufacturer of allelectric and, potentially, driverless cars, Tesla, which is currently (August 2020) the most valuable car producer in the world, although its output in terms of numbers of cars per year is only average. Knowledge packaged in physical objects requires physical transport for the first sale; the updates, performance tuning, diagnosis of faults and a good deal of maintenance are then done online.

The valuation of the new knowledge-based businesses, exemplified by Apple, Amazon, Google, Microsoft and Facebook, is exceeding anything we saw in the past. In contrast, producers of goods (General Motors, Ford) or energy (Shell, Exon), highly valued by industrial society, are now pushed to the B list.

This valuation may be excessive and may be drastically reduced in a panic reaction of the market makers to an economic crisis, and yet, it will persist and it does represent a long-term trend. Please remember, socio-technological coevolution is irreversible.

In the knowledge economy, the key economic resource is knowledge, replacing capital, which was the most important resource in industrial economy. This shift becomes obvious, when you recall that in industrial economy those who had money could buy any knowledge they needed, whilst in knowledge economy, the opposite is true - those who have unique knowledge, can choose where and how to obtain required capital. Peter Drucker named the new digital society, the *post-capitalist society* [25].

The production of food is, undeniably, very important, and yet, no one in their right mind would describe current society as agricultural society. Similarly, capital is very important for our life, and yet, knowledge is gradually taking over as the key economic resource, reducing the role of capital to supporting knowledge.

We are leaving capitalist economy gradually, imperceptibly and irreversibly and entering knowledge economy.

Digital Society

We don’t know how exactly digital technology will change the current society. However, it is rather naïve to believe that the transition from industrial to digital society will be less revolutionary than the preceding two major transitions. Certain trends are already discernible. Here are some of them.

Social trends

Selecting your own lifestyle

The most exciting new development is that workers in knowledge economy can *choose the lifestyle that suites them best* – they can choose where to live, because they can work from any location, including home, and they can adjust their working hours to fit into their general life pattern.

There is little doubt that working from home and in offices near home, will be a norm. Businesses will save by closing expensive city centre offices, office workers will avoid long commuting and reduced travel will have a positive impact on energy saving and global warming.

As online working, shopping, banking, socialising and entertainment increases in popularity, plans are being drawn to remodel town centres by converting office blocks, large department stores and even some small shops into flats and replacing empty retail outlets by spaces for entertainment, sport, healthcare services and restaurants, which will enable those of us who prefer to live in a city centre, rather than in the country, to do so.

Wherever one chooses to live, it is likely that there will be opportunities to live and work in small, connected communities. Schumacher was, almost, right - S*mall is Beautiful, if Connected.*

Digital care of seniors
Our aging population, contrary to general belief, is not a burden for the young – it is an opportunity for them to design and produce a variety of AI-enabled *care systems*, from self-driving trolleys to intelligent housekeeping, heating, cooling, ventilation, lighting, healthcare, communication and security systems. Japan has a comprehensive strategy for converting savings of their retired population into investments for the development of digital caring technology, which they call Society 5.0 [26].

New establishment
As knowledge economy develops, knowledge workers will gradually broaden their interests and socio-political awareness and will aspire to participate in democratic processes.

New personalities in the news are Bill Gates, Tim Cook, Jeff Bezos, Mark Zuckerberg and Elon Musk. They acquired their eminence and unprecedented wealth in a very short time by creating early digital businesses through invention (and without much capital), clearly demonstrating the notion that knowledge is today more important as economic resource than money.

They and their successors will be the new social and political elite - it is not possible to lead a nation into the digital future with an industrial-era mindset. The current establishment will, of course, resist the takeover and the struggle may last many years but, in the end, digital society will prevail and digital leaders will take over the establishment.

New political system
In a fast-changing new world, it is hardly possible for rigid political parties, based on a division valid in industrial society - rich bosses versus poor manual workers - to survive much longer. After all, knowledge-based service industry, when fully developed will require hardly any manual worker.

Nobody can say now what shape the new political system will have. The author's guess is that it will be issue-oriented and will evolve as issues change. We have recently experienced the serious issue-based national division, Brexiters versus Remainers, which went across two main political parties. The global warming is another major issue, which is not aligned to the old-fashion party division.

Education

Online and face-to-face synergy
Education at all levels, from primary to university, will change. Online learning, modelled on the Open University, and face to face tutorials, as offered at present by Oxbridge colleges, will provide a high-value learning experience.

Creating your own curriculum
At universities and possibly in later stages of secondary education, students will be able, with the help by their tutors, to *design their own personal curricula* by selecting educational material from a vast library of high-quality online lectures, presentations, documentaries, electronic books and educational videos. In addition to working in laboratories of their own university, students will be able to remotely access and conduct experiments online in laboratories belonging to other universities or research centres.

Digital skills
Complexity mindset and digital skills (communicating, conferencing, searching, accounting and banking digitally as well as using skilfully a wide variety of application packages) will be required in all sectors for all employment opportunities and will be learned and practiced at all educational levels.

Who is who in the digital world

Leaders in digital transformation, August 2020

Nations that complete digital transformation of their businesses, healthcare and administrations without delay, will prosper under new complex economic conditions. The leading nation in digital transformation is the USA, which has well-established digital business elite: Apple, Amazon, Google, Microsoft, Facebook, Intel, Instagram, Twitter, Zoom, Tesla. South Korea is well represented by Samsung and China by Alibaba and Huawei.

In contrast, Europe has not a single high-value digital business. The UK digital strength is in a large number of small to medium digital businesses.

The most valuable digital businesses in the world by stock market valuation, August 2020

USA

Apple – $2 trillion valuation generated by 137,000 employees.
Microsoft – $1.7 trillion valuation generated by 160,000 employees.
Amazon – $1 trillion valuation generated by 840,000 employees.
Facebook – $840 billion valuation generated by 53,000 employees.
Google – $632 billion valuation generated by 129,000 employees.
Tesla - $341 billion valuation generated by 50,000 employees.

China

Alibaba – $790 billion valuation; 118,000 employees.
Huawei – $65 billion valuation; 200,000 employees.

South Korea

Samsung – $320 billion value; 310,000 employees.

What happened to industrial giants?

In comparison, manufacturers of cars (the elite of industrial economy) are considerably less effective in terms of value generated per employee, as demonstrated by Volkswagen – $70 billion valuation generated by 670,000 employees.

Experimental complexity science

The author and his co-workers are engaged in experimental complexity science. They design and build large-scale complex adaptive systems for commercial clients, observe how these systems work and deduce from observations principles of complexity science.

For the last 20 years, we have designed and delivered to businesses in the UK, US, Germany and Russia complex adaptive systems, which exhibited adaptability, resilience and spontaneous self-improvement. Examples include: adaptive real-time schedulers for minicabs in London and for distribution of coca cola bottles across Germany; managing large seagoing tankers transporting crude oil from Middle East to the North America; a swarm of real-time schedulers delivering astronauts and cargo to the International Space Station; a digital translator from Singhalese to English; a complex adaptive data and text mining system for insurers and intelligent controller for ventilation, cooling and heating of large building in subtropical regions for a client in Florida. More information is available in [27].

Acknowledgement

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Conclusion

Complexity

Driven by digital technology, complexity of our social and economic environments is increasing exponentially. It is essential therefore to improve adaptability and resilience of our businesses, the healthcare and administrations to enable them to function under conditions of complexity. Adaptability and resilience can be improved by injecting some complexity into organisations, which basically means,

- Replacing command-and-control hierarchies with distributed decision making.
- Recasting the role of the chief executive from the chief decision maker to decision coordinator.
- Releasing and making use of natural intelligence of employees by introducing teamwork whenever possible.
- Introducing complex adaptive schedulers, which exhibit artificial intelligence and are capable of rapidly neutralising disruptions, fraud and cyberattacks, to carry out the allocation of human, physical, financial and knowledge resources to demands in real time.
- Ensuring that natural and artificial intelligence cooperate.

Complexity creates uncertainty and knowledge workers should learn to feel comfortable with uncertainty.

Complexity is not going to go away and it is beautiful - it offers new opportunities.

Globalization

Globalization, as conceived when industrial economy dominated the world, has a serious flow - long supply chains and excessive business intercontinental travel waste energy and are harmful to the environment; they also speed up transmission of infections, as demonstrated by current pandemic. Complexity science offers a strategy and digital science provides technology for redesigning globalization into a network of connected national clusters, protected from external disruptions, cyberattacks, fraud, hacking and pandemics. It is now feasible to build small, cost-effective, selforganising *versatile factories*, which can produce a variety of products, rescheduling rapidly manufacturing resources whenever the demand changes. Versatile factories can be located close to the demand to reduce transportation.

The current excessively connected global village is a dangerous space, as dangerous as a medieval village where armed robbers were lurking behind the bushes.

Digital economy

Digitised knowledge is creating new global knowledge economy where knowledge is traded instead of goods. Globalization of knowledge can help raise living standards in developing countries and improve self-sufficiency of all nations without affecting negatively our natural environment. Exporting knowledge how to manufacture goods instead of transporting manufactured goods across the continents will be a priority.

Digital society

We can expect dramatic changes in many aspects of our socio-political life and education, including new freedom to choose your own lifestyle, create your own educational programme and contribute to resolving critical socio-political issues using digital tools. A new political establishment is likely to emerge dominated by digitally minded.

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