Ecosystems of breakthrough technologies: Railways and artificial intelligence

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Is not the human mind a form of such a virus
that invents something, for example, artificial intelligence,
to bring about its self-destruction?

Slavoj Žižek[1]

Railways (*chemin de fer* / *железная дорога* / *Eisenbahn*) and (AI) are solutions that contemporary language defines as disruptive innovations. The implementation of both required cooperation between multiple business partners and social forces, as well as the involvement of public authorities, and resulted in the creation of discrete ecosystems.

Ecosystem a system or network of mutually connected entities (biological organisms, notably *Homo sapiens*, busi ess enterprises, public bodies, non-governmental organisations, etc.) **objects present both in the physical** (whether real estate or movables, together with the know-how of their creation, use, and disposal) **and the virtual** (objects that are created in the digital world, as well as independent entities and those that reflect objects in the physical world, known as "digital twins", together with the know-how of their creation and use) **worlds.**

[1] S. Žižek, *Das Virus befällt den Menschen, aber auch und vor allem: Der Geist des Menschen ist selbst ein Virus*, (article published on the 250th anniversary of birth of G.F.W. Hegel, English version of the quotation based on Polish translation from German), "Neue Zürcher Zeitung" 27.08.2020, www.nzz.ch, (accessed on 27.08.2020).

The railway ecosystem started in the second half of the 19th century and reached the peak of its development at the close of the Industrial Age in the second half of the 20th century. After 1917 that ecosystem was assigned special attributes in the centrally-planned economy, which found the analogue technology that met the requirement of physical resilience highly useful. The advantages of the simplicity of the technical and organisational solutions that laid the foundations for the railway ecosystem, and the possibility of using certain secondary energy carriers, can be seen especially clearly in difficult atmospheric conditions (frosty days and nights, heavy rain and snowfalls, and fog) and also in times of war. Since the 1980s, the ecosystem has been subjected to the process of adaptation to social and economic needs that is typical of the post-industrial period.

The concept of the AI ecosystem follows on from that formulated in the beginning of the second half of the 20th century and fine-tuned and initially implemented early in the 21st century. The period of its development, identified with the process of creating the "Digital Economy 4.0" is ongoing.[2] This ecosystem is directly and totally dependent on the availability of only one secondary energy carrier, namely electricity: once the power supply is compromised, the entire ecosystem immediately loses its capacity to operate. This ecosystem is described in much more detail in science fiction, whether books or film, than in scientific literature. Visions presented by artists in past decades, as well as those being created now, have a powerful impact on the current perception of the process of development of the AI ecosystem.[3] Humanists who observe and comment on the process of its development in a non-partisan way emphasise that the contemporary inhabitants of the Earth will have to adjust to the conditions in the world surrounding them, conditions that are increasingly determined by the proliferation of ever more perfect digital technologies. The challenge becomes the ability of the level

[2]A description of Digital Economy 4.0 is presented in: W. Paprocki, *Transformacja cyfrowa w gospodarce i jej wpływ na funkcjonowanie szkół wyższych*, [in:] *Nowe wyzwania w naukach o gospodarce*, redakcja naukowa R. Bartkowiak, M. Matusewicz, Oficyna Wydawnicza SGH, Warszawa 2020.

[3]J. Nida-Rümelin, N. Weidenfeld, Digitaler Humanismus. Eine Ethik für das Zeitalter der Künstlischen Intelligenz, Piper, Munich 2018.

of human "cleverness" to catch up with its technological achievements.[4]

This work contains references to the solutions called "artificial intelligence" as they are, and not as they were to become. The definition of artificial intelligence formulated by the participants of the seminar in Dartmouth in 1956 remains the point of reference. The descriptions of how individual digital technologies, and the business models developed around them, have been evaluated by representatives of science and business are deliberately not included so as not to repeat what is available in numerous scientific works and reports published in the 2010s.[5] It is the questions that raise doubts and are either treated marginally or altogether omitted in discussions both in the academic and business circles that are important.

In their current form, the ecosystems of the railway and AI determine the functioning of social and economic systems on regional, continental, and global scales. The analysis and comparison of the process of development of both these ecosystems is highly desired so that the results can be used by business owners and managers, and public authorities to modify their development strategies.

What are the similarities and differences between the ecosystems that were developed in the wake of the implementation of both breakthrough innovations? This is the question that I am trying to answer in this work. In my investigation, I use the method of critical paraphrase, that is making references to existing theoretical conclusions in another research discipline, and adjusting these conclusions to such disciplines as economics, finance, and management and quality research that are part of the social sciences. Thanks to the application of this method I seek to identify a new research perspective, formulate new

[4]T. David, *Ian McEwan: "Wir befinden uns im freien Fall – dank unserer eigenen Cleverness*, "Neue Zürcher Zeitung", 7.08.2019, www.nzz.ch, (accessed on 7.08.2019).

[5]They include T. Doligalski, *Internet-Based Customer Value Management. Developing Customer Relationship Online*, Springer-Verlag, Cham 201; A. Husain, *The Sentient Machine. The Coming Age of Artificial Intelligence*, Scribner, New York 2017; *Inteligentne gospodarki: Sztuczna inteligencja zmienia oblicze przemysłu i społeczeństwa*, "The Economist" Whitepaper, 2018.

problems, and present new ideas of how to analyse and describe them.

I note that from the perspective of Polish researchers and young people still in education, as well as adults who are complementing and expanding their knowledge, three foreign languages – French, Russian, and German – were enough to learn about innovation in the 19th century, while the common opinion that that the command of just one foreign language – English – is sufficient in the 21st century is only illusory. With every year we will realise even more clearly that a command of Mandarin Chinese (普通话) is necessary as well.

The progress of civilisation and three industrial revolutions

The permanent pursuit of development in science, the quest for innovation and attempts to employ ever more advanced technologies are natural behavioural features of *Homo sapiens*. In the early development of new solutions, there are still no premises to conclude whether a specific solution will be disseminated and considered useful in the light of evaluation criteria valid at the time, and will therefore be in demand.

There is a belief that at the time of Christ the conditions for the rapid progress of civilisation existed, as 2000 years ago humans already had enough ideas to continue the process of improving the condition of their existence. However, a breakthrough could never occur, as the criteria for evaluating new solutions that would allow the progressive nature and inventive step to be distinguished were missing. Such criteria were still insufficiently developed in the late 15th and early 16th centuries to trigger the process of dissemination of Leonardo da Vinci's inventions. Nonetheless, in his day new ideas in science and technology began to be implemented in daily life.

At the same time, new social practices connected to the extension of the concession for accumulation of capital by private individuals that were granted by royal powers and ecclesiastic institutions (including the Anglican Church, which had been independent of the Vatican since the 16th century) were forming. The manufacturers operating in Flanders and in Italy since the 13th century – and also on the island of Great Britain and in ever more numerous regions of the continent in the following centuries – were being replaced by industrial enterprises. They were managed by citizens with a private entrepreneur mind-set, as defined by Joseph Schumpeter, and with a tendency to seek and implement innovation in commercial activity that they conducted at their own risk and for their own profit.

The development of production and trade became the motor for the developing market economy. Their evolution is described with the help of the method of staging phases of development. Lasting from the early 19th century to the 1870s, the period of popularity of the steam engine is defined as the First Industrial Revolution. Its centre was England.

The Second Industrial Revolution was primarily shaped by the development of technology in Germany and the United States of America, and one of its fundamental technical achievements was the proliferation of devices generating and using electric energy. During that phase, which lasted for approximately a hundred years, the steam rail engine became popular all over the world, and the technical, organisational, and commercial system covering private and state railway enterprises together with their extensive industrial, military, and social environment, developed.

There could be no development of a uniform railway ecosystem in the territory of Poland in the 19th century, yet in fact, two of them arose: one was the Russian *железная дорога*, and the other was the Prussian and Austrian *Eisenbahn*. Network infrastructure developed more slowly and in a more modest variant in the Austrian partition than in the Prussian one. The differences are easy to see when you compare the number of bridges and tunnels built in the two regions, and even more so when you measure the

network density (calculated as the ratio of the length of the tracks and the area).

The Third Industrial Revolution has been ongoing since the 1970s. The creation and popularisation of hardware and software for the electronic recording, collection, and processing of data is considered the fundamental feature of the period. A very important doubt sets in here, namely whether the generally-used notion of "a computer" is construed precisely. If you recognise that a computer is a device that contains a microprocessor (the Intel 4004 invented in 1971, and its successive versions marketed by multiple manufacturers all over the world), you should state that the diffusion of progress in computer technology has followed a different track in the Third Industrial Revolution than in the previous two.

Unlike in the case of mechanical devices that make use of steam, electric, and internal combustion engines that are manufactured all over the world with different engineering solutions, the devices known as computers are currently manufactured on the basis of but a handful of ideas and perfected by an ever narrower group of enterprises. Late in the 2010s, the most advanced microprocessors are only produced in Taiwan, which means that the US and China, leaders in the global economy, rely on supplies from TSMC – the only company with the most advanced technology for semiconductor manufacturing. If American misgivings that the Chinese company Huawei is on track to take over the lead in development and use of information and communication technology hardware are valid, the reasons for the US-led initiative to block the global expansion of that particular manufacturer and operator become evident.[6] For these reasons, a change in the assessment criteria of innovative behaviour will occur during the Fourth Industrial Revolution. Americans believe that global economic expansion of innovators can only be tolerated as long as it does not infringe the strategic interests of incumbents based in the US and remaining under the control of the federal public authorities. Thus, the

[6]M. Sander, *Die USA bedrohen die globalen Lieferketten für Chips – und damit die Wirtschaft von morgen*, "Neue Zürcher Zeitung" 2.06.2020, www.nzz.ch (accessed on 2.06.2020).

mechanism of competition in the global market must be unconditionally dependent on the criterion of subjecting long-term objectives of businesses operating from any country in the world to the "America first" US strategic interest.

The Fourth Industrial Revolution in the "juvenile" phase

In a reference to natural sciences, which employ the notion of a "juvenile phase" of an organism's development, the term will be applied to describe the current stage in the development of digital technologies. The purpose is to demonstrate that what is called the "Digital Economy 4.0", in which AI solutions are used, has only gone into the initial stage in the existence of the new ecosystem. It still has no features that are characteristic of an organism capable of independent existence.

The exceptionally spectacular "Dot-com Bubble" crisis of the late 1990s was one of the first symptoms of early childhood diseases. From 1995, many investors were operating in the American capital market naïvely, like juveniles with a limited capacity for assessing the reality surrounding them, invested in what were known as "dot-com companies". Their decision-making was based on barely credible visions of technological development, never accounting for the fact that the companies issuing shares were top marketing experts who were not sufficiently competent to build business models that would assure revenues from the core business activity that would exceed the costs of operation.[7] In this way, the shares were bought from organisms in their juvenile phase that were absolutely incapable of independent existence. Late in the 2010s it became evident that tech innovators had not yet created a

[7] A. Hayes, *Dotcom Bubble*, "Investopedia" 25.06.2019, www.investopedia.com, (accessed on 27.08.2020).

new ecosystem without which the efficient use of isolated applications was impossible.

The view that the process of development of the AI ecosystem is only at a very early stage of development in the late 2010s may apparently seem contrary to the knowledge disseminated by globa[8] and Polish[9] literature that describes a world of the Internet, which has operated since 1991 and has been called "Web 2.0" since 1999, in which nearly everyone encounters highly advanced digital solutions that are called "artificial intelligence" at nearly every step. However, the validity of that view can be seen once you have rejected the uncritical enthusiasm of the authors of some publications containing the descriptions that generate typical hype. All you need is a competent analysis of the prevalence and characteristics of the connections that are only now being shaped between the entities that are developing the innovative solutions, and their social, business, and administrative environments.

The fundamental premise that would allow one to consider the Fourth Industrial Revolution to be in a very preliminary phase is the still marginal, although noticeable, impact of digital technologies on the processes of production, exchange, and consumption. Thus, both facts and the understanding of their significance are important. How to evaluate the claim cited by Michał Kosiński, that according to IBM, every person generated 0.5 GB of data about themselves in 2012?[10] Yet, rather than how much of that data can be, it is far more important who, and to what effect, makes use of it. And the effect cannot be significant if the permanently accumulated datasets, treated as "Big Data", contain gaps whose volume or nature cannot be defined. There is, however, no doubt that such gaps are present and their elimination remains a major challenge.[11] It is known that both distortion and biases, stemming from the lack of integrity of the analysed data, are characteristic of the

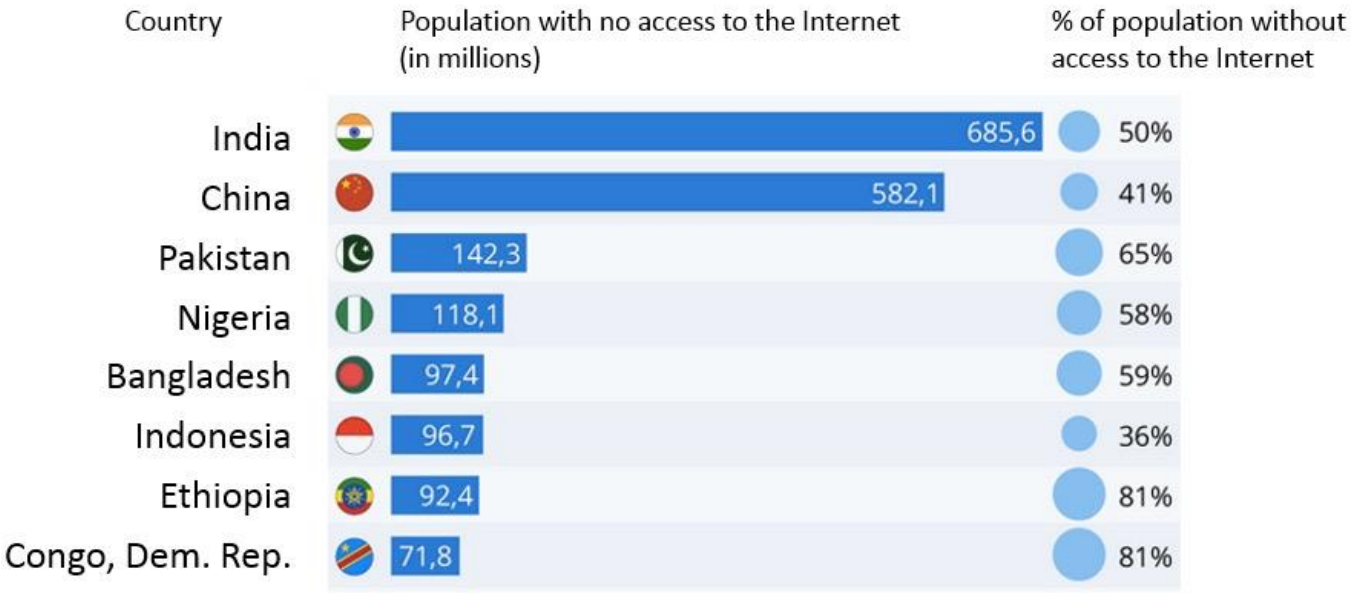
[8]See e.g.: M. Ford, *Rise of the Robots. Technology and the Threat of a Jobless Future*, Basic Books, New York 2015; N. Bostrom, *Superinteligencja. Scenariusze, strategie, zagrożenia*, Helion, Gliwice 2014.
[9]See e.g.: M.R. Wiśniewski, *Wszyscy jesteśmy cyborgami*, Wydawnictwo Czarne, Sękowa 2019; A. Przegalińska, P. Oksanowicz, *Sztuczna inteligencja. Nieludzka, arcyludzka. Fenomen świata nowych technologii*, Znak, Kraków 2020.
[10]M. Kosiński, *HumanTech Meetings*, lecture at the SWPS, 17.12.2019, https://www.youtube.com/watch?v=7M2c_3BYQk0&utm_content=reminder, (accessed on 26.08.2020).
[11]M. Sloane, *Participation-washing could be the next dangerous fad in machine learning*, www.technologyreview.com, 25.08.2020 (accessed on 3.09.2020).

analyses of various phenomena achieved thanks to the application of AI solutions. Even though digital transformation has ensured the mass accessibility [12] of networked devices and access to vast data sets, it has not yet resulted in the actual proliferation of the application of digital technologies.

Such a state has not yet been achieved if one takes into account the highly limited accessibility to the Internet around the world. This is illustrated by the data in Figure 1, which lists the countries in which tens, if not hundreds of millions of residents have no access to the Internet whatsoever. If, drawing from assorted media, both traditional and digital, and under the influence of commercial promotion and state propaganda, one has become convinced that digital technologies are in general and universal use in the People's Republic of China, one can experience cognitive dissonance on learning that (no fewer than!) 41% of the Chinese population has no access to the Internet. Reports that entire indigenous groups, such as Uyghurs (nearly 10 million people) and Tibetans (approximately 6 million people), are controlled with various AI solutions are not at odds with the news that most of these people have no access to the Internet, and are in line with the intentions of the central powers who deem that they cannot have access to the Internet. If 41% of the entire Chinese population has no access to Internet, this means that that group must include many representatives of the dominant ethnicity, that is the Han, who account for more than 90% of the total Chinese population.

[12]In June 2020, Facebook (including the Instagram and WhatsApp platforms) recorded the activity of 2.4 billion people worldwide, achieving 74% participation in the global market of social media (with the exclusion of continental China). G. Steingart, *Morning Brief*, 2.09.2020, https://news.gaborsteingart.com, (accessed on 2.09.2020).

Fig. 1. Selected Asian and African countries with populations who have limited access to the Internet, as of 2020.



Source: Own research based on R. Bocksch, *Halb Indien ohne Internetzugang*, Statista, www.statista.com (last accessed on 2 August 2020).

During the lockdown introduced in many countries after the start of the Covid-19 pandemic, growth in the value of consumer goods, including food, purchased online (e-commerce) was observed. The data that was supposed to point to the monopolistic position of Amazon, the American leader of the "tech" sector in the global market, proved to be important "news" in some countries. A study of the data suggests that, for example in Germany, Amazon achieved a 48% share in e-commerce in the first half of 2020, that is two percentage points more than in 2018, however, its share barely surpassed 5% of the entire retail sales market.[13] This means that people living in Germany still do nearly 90% of their shopping in traditional retail stores. The takeover of 10% of sales by value by e-commerce does indeed have a huge impact on the operation of shops, with the closing of boutiques in shopping arcades and large department stores in main streets and squares being perhaps especially troublesome for the operation of city centres. However,

[13]M. Janson, *Wo Amazon dem meisten Umsatz macht*, "Statista", 10.08.2020, https://de.statista.com, (accessed on 10.08.2020).

profound structural changes in distribution systems are just only starting, and one can expect that e-commerce will not become the dominant form of retail for many decades to come.

While appreciating the significance of digital technologies whose development is proved by three important events from the first decade of the 21st century, that is the launch of Facebook in 2004, the opening of Amazon's AWS Cloud Compute Service in 2006, and the marketing of the iPhone by Apple in 2007, one cannot say that the process of using unstructured data has already reached maturity. That state will only have been reached at the moment when we see the general dissemination of the concept of "Industrie 4.0" presented by German innovators Wolfgang Wahlster and Henning Kagermann at the Hanover Industrial Trade Fair in 2011.[14]

Even though nearly a whole decade has passed since then, the concept has not yet been successfully introduced in any part of the world in a way that provides a tangible competitive advantage in the market. The Internet of Things is not widespread, as the advantages of recording, gathering, and using structured and unstructured data in datasets large enough to meet the requirements of "Big Data" and that could serve to power machine learning processes still remain unknown in the world of relations between devices, unlike in that of the relations between the human and the machine. It is, however, significant that representatives of Siemens and SAP, Germany's two leading industrial enterprises, only declared that they are beginning to integrate the data recorded in production processes with the data recorded in the processes of distribution of consumer goods in July 2020, that is nine years after the announcement of the "Industry 4.0" concept.[15]

Table 1 presents the results of a comparative analysis of the forecast features of the AI ecosystem, and those that have already been developed. The analysis is based on of the opinion of Raj Reddy, a pioneer of computer science, who

[14] *Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution*, "VDI Nachrichten" No. 13, 2011.
[15] A. Höpner, Ch. Kerkmann, *Siemens und SAP verbünden sich für die Industrie 4.0*, "Handelsblatt" 14.07.2020, www.handelsblatt.com (accessed on 14.07.2020).

started working on AI solutions in the late 1960s. The comparison of the results clearly shows that by 2019, the objective defined in eight tasks using AI had successfully been achieved in two, and in the third, concerning the construction of an autonomous vehicle, the objective has been achieved up to a certain stage. Many experts believe that the production of a vehicle that would meet the level 5 requirements of autonomous driving on public roads is a task that requires not only additional work, but a fundamental change in the concept of the search for the solution. The visible disproportion between the volume of data that the autonomous vehicle obtains in real time from its environment and the data that is useful for making decisions on how to behave is becoming a problem. Steffen Heinrich of Peregrine Technologies claims that with the currently-applied solutions that proportion has achieved a ratio of 1:100, which leads to an absurdly large processing load for the on-board ICT system for the recording and processing of data in comparison to the effects of that effort.[16] If the fear that the path chosen for the construction of the system controlling the autonomous vehicle is misplaced, then it will become evident that the level of advancement of works on the creation of an artificial intelligent ecosystem covering the realm of human mobility must be considered initial.

Table 1. State of AI development in 1988–2019, according to R. Reddy

Task	Solution	Comments *)
AI winning a game of chess.	DeepBlue software produced by IBM beat chess grandmaster Garry Kasparov, who at the time (1997) was the World Chess Champion	The human "stands no chance" when confronted by AI in board games, as confirmed by the victory in 2017 of the AlphaGo software developed by DeepMind (a subsidiary of Google) over 18-time Go world champion Lee Sedol.
Autonomous vehicle (level 5).	It was expected that after the tests of such vehicles in 2019 the solution would be available "in the near future". R. Reddy counts that task	There was a general conviction among experts early in 2019 that development work at Waymo (a subsidiary of Alphabet) is sufficiently advanced to allow this goal to be at-

[16]G. Steingart, *Datenhunger autonomous vehicle*, April 2020, www.gaborsteingart,com (accessed on 2.05.2020)

	as "completed" due to the fact that five unmanned vehicles covered 212 km in the Mojave Desert in 2005.	tained quickly. However, an increasing number of statements made in the following months suggest that the task remained unsolved. Some specialists began to suggest that perhaps machine learning technology may not be useful for finding the desired solution.
Organisation of own work to achieve a goal.	In 2019, the Aristo software autonomously selected questions from the physics curriculum for eighth-grade students, and formulated and applied correct answers to 90% of test questions.	One of the areas in which such software is more frequently applied is the content analysis of legal documents (regulations and contracts) and presentation of results of such analyses according to predefined criteria, including formulation of proposals for (short) excerpts from the texts that can be used in a report drafted by a qualified lawyer (a judge, a barrister, etc.).
Development of own mathematical concepts.	No such solution exists as yet.	Software's capacity to perform a task by applying brute force, that is finding the sequence of digits forming a code, cannot be considered such a skill. Software is expected to operate creatively in the sense defined for AI by the participants in the seminar in Dartmouth in 1956.
Compression and selection of information.	No such solution exists as yet.	Software collects data from which it can generate information. However recognition and identification of unstructured data, as well as "decomposition" of information and its repeated generation in accordance with the set goal, still pose problems. A user cannot acquire a summary of scanned video recordings "shaped to individual expectations".
"Smart", i.e. automatic and autonomous search for content on the Internet.	No such solution exists as yet.	Wikipedia is developed by volunteers and not via software. The advantage of using online browsers is still highly limited for individual users.
Telephone as a simultaneous interpreter.	No such solution exists as yet.	The available and popular versions of software for analysing voice messages and generating speech are still highly fallible when used for automatic translation.

Automatic inspection of analogue mechanisms in an autonomous robot.	No such solution exists as yet.	

*) Comments from the author.

Source: Own study based on G. Szpiro, *Ein KI-Pionier zieht Bilanz*, "Neue Zürcher Zeitung" 30.10.2019, www.nzz.ch (last accessed on 30 October 2019).

The observation that the Fourth Industrial Revolution is only in a very preliminary phase provides a convincing justification to continue work on the development of visions for its further direction. To be able to draft potential scenarios properly, it is justified to conduct a consciously defined case study investigating the functioning of the railway ecosystem. The establishment of such a system began in the first half of the 19th century, and its development continues to our time. It will certainly continue into the coming decades of the 21st century.

The phenomenon of the railway ecosystem

On 21 February 1804, the first steam vehicle (locomotive) entered regular operation. The machine was constructed by Richard Trevithick and covered a distance of 16 km (10 miles) between Merthyr Tydfil and Abercynon in Wales. That modest journey was a harbinger of a new era in the history of civilisation: the era of steel, steam, and speed.[17] Neither the participants nor the observers of the event could have realised that they had witnessed the birth of the First Industrial Revolution, and that rail, a new branch of land

[17] B. Makowski, Parowóz, pociąg, lokomotywa, rewolucja. Jak kolej odmieniła świat, Polskie Radio, 21.02.2020, https://www.polskieradio.pl/39/156/Artykul/2267098,Parowoz-pociag-lokomotywa-rewolucja-Jak-kolej-odmienila-swiat (4.08.2020).

transport, was an innovation that would result in the development of a separate railway ecosystem.

Its functioning still determines the economic development in many regions of the world, even though it has ceased to function in some regions, for example in the northern part of Chile that runs for nearly 2500 km along the Pacific.

The attitude of Otto von Bismarck, Chancellor in 1862–90 (originally of Prussia, and from 1871 of the German Reich), had a strong influence on the features of the railway ecosystem developing in continental Europe. He considered the development of the state-owned national network of modern technical infrastructure an element for building an economic and military advantage over other countries.

Nationalisation of railway societies established in the 1850s, 1860s, and 1870s by buyout was justified not only by strategic considerations, but also by the growing concern of the public authorities of many European states for the need to retain the resources of these large organisations operating in the rail industry during recurring economic crises and wars. This was the case as the contemporary monarchs sought solutions to the new economic phenomena that on the one hand included the expansion driven by railway enthusiasts, which included both talented innovators and financial investors with high appetite for economic risk, and – on the other – the lack of resilience of the railway societies to cyclical dips in demand and sudden plunges of revenues from customers, both passenger and freight. After nationalisation of that important branch of transport by the state, the owner's responsibilities could be subsidised from its budget without limitations: a practice that has not only been retained, but has even been creatively expanded in contemporary times.

It is significant that the presentation of successive concepts for developing the physical resources of the railways financed from public (EU and state) funds in Europe over at least three decades has emphasised only the nominal value of the investments, with an absolute absence or just a peripheral mention of the nominal value of effects that these projects are expected to bring. The low economic

efficiency of the process of management in rail transport results from multiple factors, the most important of which is currently the over-involvement of state authorities in the functioning of rail companies, the servility of boards in the face of claims from strong trade unions, and the lack of transparency in decision-making processes inside such enterprises.[18]

In many states, including the territory of Poland during the partitions, the railways were developed as the foundation for an autarkic social and economic system. One of the important measures was to render transport between the states impossible, or at least to tightly restrict it. In the eastern section of Europe (tsarist Russia), the system of wide-gauge track (with rails set 1520 mm apart) developed, while the broad-gauge track system on the western side (the Iberian Peninsula) had rails set 1688 mm apart. In Germany, France, Austria-Hungary, and the remaining countries of Central and Western Europe, the constructors of national railway networks used a distance of 1435 mm, which was defined as "standard gauge". That was complemented by local "narrow-gauge" tracks, with different distances between the rails (however, no greater than 1435 mm) which were tasked with handling freight and passenger traffic between individual industrial facilities and the surrounding estate and the nearest standard-gauge railway hub.

The existence of railway networks with different track gauges is an important barrier in the operational processes conducted in pan-European supply chains in the 21st century. The removal of that highly annoying barrier, despite the availability of various technical solutions, has proved to be near-impossible. Construction of a network of standard-gauge tracks alongside traditional wide-gauge tracks started on the Iberian Peninsula to handle passenger traffic in high-speed trains but this hybrid solution is not operationally efficient and remains deeply ineffective in economic terms.

[18]A more extensive description of a railway enterprise and a study of its functioning can be found in: W. Paprocki, *Nowoczesne przedsiębiorstwo kolejowe CARGO*, TOR, Warszawa 2003.

Another cumbersome and ineffective solution applied by the European railways is connecting the carriages into a train by hooking the link of one carriage (or engine) to the pin of another. As far back as in 1873, the Union of German Railway Boards announced a competition for the preparation of a standardised automatic coupler: the prize of 3000 thalers offered at the time has never been awarded and manual coupling is still in use in standard-gauge railways.[19] The number of contradictory interests of individual companies operating within a single ecosystem proved so large that it has been impossible to introduce an innovative solution jointly, even though one had been widespread in the Soviet system from the early second half of the 20th century.

The railway ecosystem developed in parallel to the development of network infrastructure and industry. In locations where the development of railway lines first required the construction of bridges, steel industry facilities developed in the 19th century that were subsequently surrounded by new economic centres.[20] In the first half of that century the railways found an important economic partner, namely the postal service. A manifestation of close cooperation was the construction of railway stations in close vicinity to (main) post offices. Such structures were developed in city centres (e.g. in Kraków in 1844–47 and in Breslau/Wrocław in 1855–57) as crossing stations, or in different parts of large metropolitan centres as terminal stations, where lines coming from different regions of the country terminated. The terminus at Gare Saint-Lazare was built in Paris in 1837, and five more from the group of "seven grand stations" followed in 1837–1901. The latest addition is Gare de Bercy, commissioned for use in 1977.[21]

The passenger train rolling stock that served regular routes included mail cars used to transport letters and parcels. In

[19]D. Fockenbrock, *Wie der Güterzug eine grüne Altervantive zum Lkw werden soll,* "Handelsblatt" 2.09.2020, www.handelsblatt.com (accessed on 2.09.2020).

[20]MAN metal works in Gustavsburg can serve as an example, as it was established in 1859 to build a bridge over the Rheine for the Hessische Ludwigsbahn (HLB). The bridge was commissioned in 1863. K. Fuchs, *Eisenbahnprojekte und Eisenbahnbau am Mittelrhein 1836–1903*, [in:]: Nassauische Annalen 67 (1956).

[21] U. Lemmin-Woolfrey, *7 grand train stations of Paris*, CNN Trevel 5.08.2015, https://cnn.com (accessed on 20.08.2020).

normal conditions delivery took from several hours to a number of days, or even several weeks for inter-state connections. In many European countries the close cooperation between the post and railway lasted for over 100 years until postal operators decided to use road transport for interregional transport and air freight for longer national routes and international postal traffic. Conditions were created to allow delivery of post on a global scale (and from the 1970s, also courier deliveries) within one or two days, with a maximum timeframe of one week.

Speaking of the cooperation of the railway and postal service, it is worth mentioning that as far as cargo transport is concerned, rail began to lose its dominant position in logistics much quicker than did post in the communication system. The development of analogue technologies in the transport industry ensured the dynamic development of cargo transport by road in the US already by the 1920s and 1930s, and in Europe in the 1960s and 1970s. That was when the process of weakening the position of the railway ecosystem within the whole social and economic system started.

The position of the postal service was challenged only later, that is in the late 20th and early 21st centuries, in the wake of development of digital technologies. For example, the volume of letters sent by post in Norway grew over the centuries to reach a peak in 1999, and the ever deeper decrease resulted from the widespread replacement of paper documents with electronic media.[22] The number of postal letters in Poland has dropped by over 30% since 2007, and the falling tendency was strongly reinforced in 2020.[23]

The period of cooperation between rail and post is over, with a visible symptom being the transfer of postal infrastructure from the vicinity of railway stations to other locations.

[22]M. Różycki, I. Kerr, *One size doesn't fit all: adapting to changes in letter delivery*, www.parcelandpostaltechnologyinternational.com 18.08.2020 (accessed on 19.08.2020).
[23]M. Duszczyk, *Kryzys na rynku listów. Pocztowcy w tarapatach*, "Rzeczpospolita" 18.08.2020 (accessed on 19.08.2020).

An important feature of railway autarchy was the direct cooperation of state railway enterprises with domestic manufacturers who supplied the infrastructure for the construction sites needed to build railway tracks and stations, and also with the manufacturers of engines (powered by steam and electricity, and later also internal combustion) and passenger and freight wagons. The local suppliers of energy, primarily coal mines that supplied fuel for the steam engines, and electric power plants (combined heat-and-power plants that burned coal and lignite, and hydroelectric power stations) were also important partners for the railways. Cooperation with the mines began early in the 19th century at the outset of the age of steam, and with power plants – towards the end of the century, after the electrification of the first tram (light railway) line in Lichterfelde near Berlin in 1881, and of the first railway line connecting Dessau to Bitterfeld in 1911.[24] Opening a railway station at any location required the construction of a local water supply system, as the steam engines that were used at the time required their boilers to be refilled with water while they waited. With comfort in passenger cars (first class, as well as the extremely comfortable private saloon cars) increased, water was also necessary for the sanitary installations consisting of washbasins and toilets, and in special cases also showers.

Communication was also an element of the railway ecosystem, with the first solution being the electric telegraph constructed by Wilhelm Weber in 1832 and installed along the railway line between Dresden and Leipzig. Many famous industrialists who laid the foundations for the electric and electrotechnical industries over the last two centuries started as suppliers for the railway (for example Werner von Siemens, 1816–92). As the state railways required unique solutions, the same manufacturers were forced to build their products to different standards for different European countries. One of the consequences of this intentional avoidance of a uniform standard for the railway are the multiple systems of electric traction and traffic control systems across Europe.

[24] S. Willbrandt, *Die weltweit erste elektrifizierte Fernbahnstrecke*, "Werk-Stadt" No. 1/2011.

Railway societies (joint stock companies) established in the 19th century, which became the state railway companies on nationalisation, were key employers. The needs were unique, as, unlike in industry, rather than creating employment in a single plant situated close to a developed area, jobs were created throughout the country, notably in the direct vicinity of stations, bridges, tunnels and other elements of infrastructure situated along railway lines, some of which ran across sparsely populated areas. That meant that finding employees required two problems to be solved simultaneously; firstly finding appropriately educated personnel, and secondly – creating the appropriate conditions for them to live near where they worked. The latter problem was solved by building residential houses in the direct vicinity of railway infrastructure.

In the 19th century, the railways promoted the establishment of new technical schools in many European countries, also at university level, in which young people were trained to work in numerous occupations that were only being developed. Poles living in the Russian partition could join railway professions having studied at the Institute of Transport Engineers in Petersburg, an institution of higher education, from 1867. It was created after the transformation of the Institute of the Transport Engineers Corps, an institution established in 1810 and initially only offering education in French as the lecturers were specialists hired from France. In the 1870s Poles accounted for 40% of the students, and throughout the 19th century – for 30% of the top grades at that university.[25] Some Poles studied in West European universities, for example Ernest Malinowski (1818–99), who was educated in France and became the constructor of railways in Peru and Ecuador during his stay in South America (1852–99).

The operation of the railways was perfected with the intent of eliminating threats to life and limb and the risk of material damages. This branch of transport managed to achieve very low levels of casualties (compared to the

[25] Z. Tucholski, *Instytut Inżynierów Komunikacji w Petersburgu – polska kadra i studenci*, 21.04.2017, www.polskipetersburg.pl (accessed on 20.08.2020).

volume of operational work). Care for safety lies at the core of the railway worker, honed over decades at each stage of education, training, and development of professional expertise. Yet, this ethos is being visibly eroded in Europe of the 21st century, a result of the reduction in the significance of "service" in the profession and the simultaneous increased pressure on railway companies to concentrate on the microeconomic efficiency of activity, even at the cost of lowering safety and security standards, and the reliability of operational processes in the days of the "gig economy". The drastic reduction in the attractiveness of the profession of the railway worker has resulted in the deformation of employment structures in railway enterprises in the 21st century. On the one hand, the policy of reducing headcount, and on the other the restriction on the employment of the younger generation, has resulted in a situation whereby 75% of current railway employees in Europe will have retired by 2030, while the prospects for hiring new staff to replace them are extremely limited. [26] For demographic reasons, the European railway ecosystem is threatened with an implosion that could occur in just over a decade.

The railways gained a monopolistic position in land transport back in the 19th century, as it proved an efficient and relatively cheap branch of transport, capable of accommodating the increasing volume of travellers and freight. Public authorities noticed the need to diversify the quality of service and the prices of fares. Passenger wagons were divided into comfortable first class, medium standard second class, and the very simple and capacious third-class carriages. Tariffs, being collections of rules regulating the rights and duties of the companies and travellers, were drafted, with ticket price lists appended to them playing an especially important role. The price of the ticket depended on the distance travelled, the class of travel, and – an additional factor introduced late in the 19th century – the effective speed of the train. D-Zug, a fast train, began operating in 1892 and a modification of its standard was not introduced until the 1970s when West Germany began to develop the network of express InterCity trains. A

[26]D. Fockenbrock, *Die Bahn will investieren – doch 86 Prozent der Belegschaft stehen vor der Rente*, "Handelsblatt", 13.08.2020, www.handelsblatt.com, (accessed on 13.08.2020).

distinctive feature of the new offer was ensuring the hourly departures of long distance trains which meant that passengers could choose the time of departure according to their own preferences rather than, as used to be the case, being forced to adjust their travel plans to railway timetables in which many large metropolitan centres were connected by only two or three train services a day.

The next qualitative leap in the functioning of the ecosystem was the launch of High Speed Rail (trains using modernised lines at a maximum speed of 200 km/h, or lines designed and constructed especially for the purpose that allowed maximum speeds of at least 250 km/h). High Speed Rail started with the test journey of a railcar produced by Siemens, and in 1902 trains exceeded a speed of 200 km/h. Shinkansen trains entered service in Japan in the 1960s, the first Direttissima line in Italy opened in 1977 and covered the 134 km between Rome and Florence, followed by the French TGV trains that went into operation in 1981.

The concept of state railways applying "value tariffs" became widespread in freight transport in the 19th century. It was recognised that the monopolistic railway company should charge a specified fraction of the value of the goods being transported. This resulted in the establishment of classes of goods, with different groups of raw materials, semi-products, and finished products qualified for each. The use of value tariffs meant that the price of the service became detached from the costs of providing it. However, such a solution bore a veneer of rationality as in the railway industry the fixed costs account for a relatively high share in the total costs, and its resources consist of capital-intensive and long-lived infrastructure and rolling stock. Thus, such enterprises may be tempted to adjust their prices to marginal costs that are relatively low. That could result in the risk of reducing revenues to a level that would not cover the costs, notably the fixed costs, which would make it impossible to renew or replace the resources. That risk was present in rail operations for many decades, as the complex nature of the processes of management and the highly developed organisation objectively hampered the precise recording of outlays, both material and labour, and the explicit classification of costs. This means that it is

practically impossible to define the level of cost per unit for the same carrier for which revenue per unit (price) is defined.

The concept of value tariffs illustrates how difficult it has been to manage a monopolistic enterprise, and how difficult it is to regulate its operation in the market. According to that concept, "one mustn't react to the changes on the demand side by lowering or increasing prices". If, however, a railway enterprise acts in that way, the environment begins to treat it as a "government department". Such an opinion about the railways in Europe was brandished in the 1960s and the 1970s when the national railways proved incapable of reacting to the expansion of road transport and the dynamic development of individual road hauliers, which was a direct consequence of the fact that those carriers became classical organisations that perfectly employed the principles of bureaucratic management described by Max Weber, an insightful observer of the operation of the hierarchised structures of vertically integrated railway enterprises in the 19th/20th centuries.[27]

In the last 50 years rail has lost its position, a phenomenon that couldn't have been prevented by the EU's transport policy according to which railways should increase and not decrease their share in freight transport. Enforced debundling intended to serve the development of competition within the sector and motivate railway enterprises to more efficient functioning brought none of the expected results. The quality of services provided by the railways simply deteriorated in many areas, as it turned out that the contractual relationships between the infrastructure managers and the operators do not favour cooperation between individual "services", that is the functional departments of the railways, which was previously ensured in vertically integrated enterprises by

[27]The term "vertically integrated railway enterprise" concerns the organisations that operated all over the world until the 1990s. They covered both infrastructure (railway lines and stations, marshalling yards, infrastructure for power supply and communication and so forth, as well as the staff operating that infrastructure) together with the resources necessary to perform operational tasks, that is transport of people and freight (staff handling passengers and shippers, rolling stock and engines, passenger train sets, and passenger and freight wagons). EU regulations enforced the debundling of two areas of railway operation in member states, which resulted in the establishment of state management of the infrastructure in each EU state, while the operation of passenger and freight transport is conducted by both state and private operators.

the hierarchical relations of reporting to the management. In Poland, like in other European countries, the quality of the services of the railway carrier is declining, both in passenger and freight transport, and even more so as the scope of modernisation works on the railway lines expands. The fundamental reason for this is that infrastructure operators opt for the efficiency of the construction process and the introduction of limitations in railway traffic, which results in a reduction in the efficiency of the operation of companies providing passenger and freight services.

Prospects for the development of the ecosystem of narrow artificial intelligence

The fairly succinct description of the **railway ecosystem** presented in the previous chapter is a point of reference that can be used to conduct a comparative analysis of its known features and the potential features of the AI ecosystem developed in the following decades. The potential features of both the ecosystem of **narrow artificial intelligence** already being developed, and the – as yet only imagined – ecosystem of **artificial general intelligence** (AGI) have been accounted for in Table 2. With the development of the solutions known as artificial general intelligence, the human would function alongside bots,[28] which would achieve an efficiency in solving intellectual tasks that is comparable to or exceeds what (as yet) only *Homo sapiens* has managed to attain.[29] Currently we encounter fundamentally divergent expert opinions as to whether this stage can be attained at all.[30] On the one hand, debates suggest that bots would threaten the human

[28]The notion of a "bot" refers to a device (hardware) and code (software), whose action takes place in the real world but the results of its actions are only found in the virtual world. The notion of a "robot" covers both devices and software, as well as various mechanisms that are driven by a bot. The effects of a robot's operation are present in the real world, and can at the same time be present in the virtual world. Endowed with a physical form, both bots and robots are vulnerable to failures in the real world, which determines that their failure rate is comparable to that of analogue devices.

[29]*Artificial Intelligence – Automotive's New Value-Creating Engine,* McKinsey Center for Future Mobility, Düsseldorf 2018, p. 13.

[30] R. Scheu, *Wir erschaffen eine künstliche Superintelligenz, die selber lernt*, "Neue Zürcher Zeitung" 21.03.2018, www.nzz.ch (accessed on 21.03.2018)

and the civilisation he has created.[31] That danger is pointed out by Slovenian philosopher Slavoj Žižek[32] and American entrepreneur Elon Musk.[33] On the other hand, the view that the human can be a genius, i.e. an individual capable of attaining excellent intellectual achievements in an individual manner, is also encountered. It is emphasised that a bot created by a very talented human can only "learn" what is already extant and is not capable of developing the internal wisdom without which it is impossible to create a projection of the future, and has no capacity for building emotional ties.[34] As long as the controversy concerning the possibility of developing "singularity"[35] remains undecided, forecasting the time horizon within which bots could develop to have artificial general intelligence at their disposal is groundless.[36] In this paper, accounting for the projections of the ecosystem of artificial general intelligence is used to present its potential features or show the absence of features that could be compared to those of the other ecosystems analysed.

[31]T. Jahn, B. Weddeling, "*Künstliche Intelligenz ist gefährlicher als Atomwaffen"*, "Handelsblatt" 11.03.2018, www.handelsblatt.com (accessed on 11.03.2018).

[32]S. Žižek, *Das Virus ..., op. cit.*

[33]M. Matousek, *Elon Musk said people who don't think AI could be smarter than them are 'way dumber than they think they are'*, "Business Insight" 23.07.2020, www.businessinsider.com (accessed on 27.07.2020).

[34]R. Scheu, *Der Professor zu seinem Studenten: «So denkt das Kind – aber nicht der reife Mensch»,* "Neue Zürcher Zeitung" 21.03.2018, www.nzz.ch (accessed on 21.03.2018).

[35]The notion of "singularity", that is a qualitative leap in the development of artificial general intelligence solutions, was introduced by Ray Kurzweil and Vernor Vinge in 2015. M. Lenzen, *Künstlische Intelligenz. Was się kann & was uns erwartet*, C.H. Beck, Monachium 2018, p. 16.

[36]I. Narat, KI-Pionier J, *Der grosse Stresstest ist bestanden: Das ETF-Kapital wird sich in drei Jahren verdoppeln*, "Handelsblatt" 4.08.2020, www.handelsblatt.com (accessed on 4.08.2020).

Table 2. Selected features of the railway ecosystem and potential features of narrow artificial intelligence and artificial general intelligence.

Feature	Railway ecosystem	Narrow artificial intelligence: ecosystem being developed	Artificial general intelligence ecosystem being designed
Time of operation of the ecosystem (in decades)	17	2	0
Most significant functionality	quality of mass transport (transporting passengers and freight)	a bot replacing human labour in standardised and routine imitative actions	none
Strategic significance (dual-use technology)	very high usefulness in the 20th century for the development of military potential for defence and offense	potentially high, but yet not fully-investigated applicability in hostile interventions into the functioning of the strategic sectors of another state	the fear that the entire *Homo sapiens* civilisation would be subjected to the control of "singularity"
Emotional attitude of the human	in the era of steam – fascination, later, in the era of electric trains – frustration	(partially unconscious) reliance on social media, and concentration of users on the interpersonal emotional relationships created in the digital space	general fascination aroused by visions from literature and film, and the fear growing among some experts and in some social groups described in dystopian visions
Economic significance in Europe	in 1850–1960 the strong reliance of land transport users on the railways, followed by a phase of weakening of that dependence, and from 1980 of increasingly niche importance	a near complete lack of European solutions and the creation of local applications primarily with the use of technologies offered by global platform operators (nearly solely American, with a growing share of Chinese operators on the market)	insignificant

Involvement of state institutions	nationalisation of railway companies (in the 19th/20th centuries); the deregulation and demonopolisation of the market initiated late in the 20th century disclosed the weakness of public authorities (at the level of both the EU and of individual states) concerning the preparation and implementation of efficient regulation in the rail services market	support for basic research and developmental projects, whose implementation would result in reducing the technological gap between the potential of business entities and state administration (including the special forces) in Europe, and the potential of the US and China as well as smaller states such as Israel	not present
Cost effectiveness (in the 21st century)	very low level of microeconomic effectiveness of operating/operational processes conducted by railway operators, as shown by the negative or very low profit results of those operators; limited macroeconomic effectiveness of the investment financed from public funds	the only digital economy operator from Europe that counts in the world is Spotify (a startup founded Sweden in 2006), which is developing thanks to the acquisition of successive investors and has not as yet achieved a positive result; this classifies it into the group of disruptors "promising profits" (including Uber and Airbnb) who follow operators capable of generating very high profit margins (notably GAFAM*))	not present

*) GAFAM is the acronym from the names of the five platform economy leaders: Google, Apple, Facebook, Amazon, and Microsoft.

Source: own research.

The development efforts devoted to the construction of an autonomous car have as yet not brought the expected, even though repeatedly heralded, results. The current and past failures must be considered a very serious indication that firstly, the already available technical solutions do not meet the defined requirements, and secondly, that the development of an ecosystem of a road vehicle corresponding to the Auto 2.0 concept,[37] a constituent of the narrow AI ecosystem, will require an effort incomparably greater than the amount of work calculated previously. For these reasons it can be anticipated that the development of the extant narrow AI ecosystem will probably take much longer than currently thought, while the creation of an ecosystem of artificial general intelligence can be embarked on in the future but it is still impossible to foresee when the process will begin. For that reason, limiting the scope of this paper to the analysis of the potential development process for the ecosystem of narrow AI is considered justified.

From the perspective of the fundamental questions of humanities and social sciences, two questions will be of fundamental importance in the process of developing the ecosystem of narrow AI:

- the relationship between the human being and an intelligent device,

- the relationship between the human being as a consumer and a participant in the economic and social processes on the one hand, and business entities that make use of narrow AI solutions on the other.

At the time when the railway ecosystem began, that is in the 19th century, pioneering works that laid the theoretical foundations for many sciences were

[37]For a more extensive discussion of the Auto 2.0 concept see: W. Paprocki, *Inwestycje w technologie przyszłości podczas epok integracji Europy w latach 1952 – 2050*, [in:] *Inwestycje i odporność gospodarcza – wyzwanie dla Polski*, ed. by J. Hausner, W. Paprocki, Wydawnictwo CMS, Sopot 2020.

developed. In building the theory of economics, and – from the contemporary point of view – of macroeconomics, the achievements of mass industrial production were analysed to determine whether it is possible for the economy to achieve a state of overproduction. James Mill presented the view that it is impossible, as economic growth, manifested by the qualitative and quantitative increase in production, also includes the process of increasing demand.[38] Should we assume this perspective, an industrial machine, and also the technical facilities of the railway, should not be treated as a threat to the human but as a useful tool for the elevation of the living standards of individual consumers and their households, and, in the macro approach – a tool for the elevation of the living standards of entire societies.

Employee training in the 19th century focused on developing competences in the application of technical sciences, as the improvement and diffusion of technologies was the fundamental task of the professionally active. The Second Industrial Revolution resulted in the weakening of the humanistic ideas proposed by Wilhelm von Humboldt in the continental system of education. More attention was paid to the natural sciences and the seeking of practical solutions, as suggested by his younger brother, Alexander von Humboldt.[39]

Embarking on the search for proper relations between the human and a smart device in the ecosystem of narrow AI, one can refer to a number of quotations from a work by a German philosopher, Richard D. Precht.[40]

[38]D. Drabińska, *Miniwykłady z historii myśli ekonomicznej. Od merkantylizmu do monetaryzmu*, SGH, Warszawa 2007, p. 39.
[39]T. Stadler, *Was heisst es heute, gebildet zu sein? Besitzstandswahrung für unnötige Lehrstühle*, "Neue Zürcher Zeitung" 12.09.2020, www.nzz.ch (accessed on 12.09.2020).
[40]From the Polish translation of R. D. Precht, *Künstliche Intelligenz und der Sinn des Lebens*, Goldmann, Munich 2020.

- Currently, Silicon Valley elites claim that the human is an imperfect version of a machine, glossing over the fact that it is the machine that is an imperfect version of the human (p. 23).
- According to the Swiss psychologist Jean Piaget, human intelligence "is what the human uses when he or she doesn't know what to do." (p. 25)
- Common sense is not synonymous with rationality, as it is an attitude honed by the socially accepted system of values. (p. 25)
- The science of the functioning of IT systems does not lead to the claim that a "computer" will replace the human, but to establishing to what extent the human cannot be replaced by the "computer". (p. 26)
- The emotional nature of the human is not the "irrational weakness" of the human as some representatives of the ancient Greek thought and Emanuel Kant, a philosopher of the Enlightenment, believed. If we had no feelings, our reason would have no foundation. (p. 26)
- A computer will not recognise flights of fancy; it is neither capable of understanding them nor can it create them. (p. 27)

Therefore the fundamental challenge in educating the labour force in the 21st century is the shaping of human competences in the evaluation of t he available achievements of science and technology, and the development of an attitude of responsible application of narrow AI solutions. The contemporary followers of Alexander von Humboldt have been successful, yet that success is insufficient to ensure the well-being of the human in the already-started era of the Fourth Industrial Revolution. After nearly 200 years, one again needs to promote the followers of Wilhelm von Humboldt. This need has been perceived by many universities in the English-speaking world that have reinforced their faculties of humanities so that their achievements could catch up with the level of scientific research and education in their technical faculties.

As far as economic relationships whose features are influenced by the level of technical advancement of available devices (functioning both in the real world, that is machines including robots, and in the virtual world, that is bots) are concerned, the question of dominance of one side of market needs to become the focus of interest.

A classical form of domination on the supply side is the use of monopolistic practices. The original railway societies developed in the railway ecosystem only operated in a single geographic area. The phenomenon of competition could not occur in the transport corridors handled by 19th-century railways as there were no other branches of transport capable of moving passengers as effectively and efficiently. In freight transport, competition was possible if transport services in the same geographic area were offered by vessels operating on inland and coastal waters. However, due to the highly limited number of navigable rivers and canals, the railways fairly quickly gained a monopolistic position in the freight market in many parts of the continent. With the development of the railway network on a national, and later continental, scale, the monopoly of the railways was reinforced. It continued for over 100 years, which meant that both passengers and shippers had to concede to the diktats of the railways, even throughout their lifetime. After the nationalisation of rail operators and the development of the vertically integrated railway enterprises, one in each country of Europe, the railway ecosystem was entirely dominated by state monopolies which were described as "natural monopolies" to conceal the penchant of public authorities to subjugate citizens and private enterprises. The existence of these monopolies, albeit with strongly weakened position, is still felt in many countries in many sectors of the passenger and freight transport markets.

Therefore it is worth noticing the similarity between the railway ecosystem and the ecosystem that contemporary literature calls the economy of virtual platform operators. Characteristic of the ecosystem of narrow AI is the

domination of the operators, who, at the beginning of the 21st century and over just a few years, managed to attain the goal of "the winners take it all or most".[41] The symbiosis of private entrepreneurs, who built their multi-billion dollar fortunes over a short period of development of the platforms they created, with the world of politics and the administrative apparatus both in the US and in other regions of the world, attracts ever-growing attention. The powerful lobbying by GAFAM has resulted in a situation in which political leaders have lost their liberty to assess the operation of those businesses.[42] The phenomenon of the "revolving door", describing the permanent flows of experts between private businesses applying monopolistic practices and public institutions, gains significance in the 21st century. The know-how in the entities that should be controlled is more advanced than the governmental agencies, which allows the mangers of platforms creating the AI ecosystem today operate with the same feeling of impunity as the highest officials of the state enterprises managing the ecosystem of railways did in the 19th and 20th centuries.

As the history of economic development proves, no one's success is guaranteed forever. Just like the railways began to lose their market position to the expansive road hauliers and in the wake of individual motorised transport, the American giants of the platform economy begin to be ever more efficiently dethroned by key foreign (mostly Chinese) competitors as well as by relatively small local players. Chinese operators also make use of the special circumstances resulting from the construction of the Great Firewall that cuts off foreign, primarily American, competitors from their domestic market. With the liberty to operate in their home country they can focus on expansion into foreign markets, which

[41]M.A. Cusumano, A. Gawer, D.B. Yoffie, *Business of Platforms. Strategy in the Age of Digital Competition, Innovation, and Power*, HarperCollins, New York 2019, p. 31.

[42]In the first half of 2020, Facebook spent USD 10.1 million on lobbying, and Amazon – USD 9.2 million. P. Winkler, *Der Amazon-Chef Jeff Bezos hat das Lobbying in Washington zur Chefsache gemacht*, "Neue Zürcher Zeitung" PRO Global, 9.09.2020, www.nzz.ch (accessed on 9.09.2020).

seemed altogether impossible in 2000, as commented by the then US President, Bill Clinton.[43]

A fundamental role in the process of empowerment of smaller players in the market who use the solutions of narrow AI is played by the opportunity to set up their own virtual realities. The conflict between Epic Games, a startup and developer of the digital game Fortnite, and Apple, the operator of a virtual platform providing access to its iOS operating system, allows us to see the imminent economic weakness of those monopolists who style themselves as the gatekeepers of the virtual world. The source of that weakness is the multi-dimensional nature of the virtual world, which is increasingly well exploited as you can plunge into it and create successive levels yourself. Apple, and also Google in its capacity as the operator of the world's most popular operating system – Android – only guard the "first" dimension of the virtual world. Epic Games used a business subterfuge by introducing their own virtual currency into economic circulation in the world of a digital game, i.e. a virtual world. As it was situated in another dimension of that virtual world than the one controlled by Apple and Google, Epic Games created an opportunity for the flow of funds in an additional, uncontrolled dimension.[44] Using that loophole, the startup achieved independence from the monopolists which meant they could avoid the obligation to pay them licensing fees. It appears then that the ingenuity of entrepreneurs (human beings) can be considered an efficient tool for building competitive advantage in the ecosystem of narrow AI.

[43] J. Kormann, *Chinas beunruhigendes Zukunftsmodell: Wenn Technologien zu Feinden der Demokratie werden*, "Neue Zürcher Zeitung" 6.08.2018, www.nzz.ch (accessed on 6.08.2018).
[44] A. Möthe, *Epic Games' Klag eis eine epische Herausforderung für Apple und Google*, "Handelsblatt" 1.08.2020, www.handelsblatt.com (accessed on 1.08.2020).

Barriers to the integration of ecosystems (instead of closing remarks)

The previous chapters defined the features of railway and artificial intelligence ecosystems. Observing their operation at the end of the second decade of the 21st century, it is hard to perceive their commonalities, the very fact of which suggests the formulation of a new research question concerning the essence of the barriers to their integration. Considerations of that question deserve a separate investigation. However, several suggestions can be already made at this point:

- The creators of an autonomous vehicle show limited interest in the development of a rail or light rail vehicle that would meet the conditions defined for the GoA4 level, [45] even though it seems that constructors of unmanned metro systems (e.g. in Singapore, Copenhagen, and Toulouse) are highly advanced in the work on achieving the highest level of automation of rail traffic.

- Organisers of public transport and (private and state) railway operators, and state operators of railway infrastructure are not determined to create a passenger-friendly system for the flexible servicing of mobility needs.

- Virtual platform operators show no interest in access to large databases that can be created by recording structured and unstructured data developed in the processes of transporting individuals and commodities, while they show major interest in data of this kind concerning road transport.

[45]The GoA4 level of automation in track transport is the counterpart of "Level 5" in road transport, i.e. the degree of fully autonomous motion of the vehicle. More on the subject in: B. Grucza, *Wizje i scenariusze rozwoju autonomicznych systemów transportowych*, [in:] *E-mobiliność: wizje i scenariusze rozwoju*, ed. by J. Gajewski, W. Paprocki, and J. Pieriegud, Publikacja Europejskiego Kongresu Finansowego, Sopot 2017.

- Passengers using the services of railway operators are active participants in the ecosystem of narrow AI and do not see, or at least do not display a need to use integrated solutions of both ecosystems.

- The creators and active service providers in the AI ecosystem are aware that embarking on projects leading to the integration of the two ecosystems requires highly developed competences in various areas of science and technology, and – given the ambition to manage rationally the available, i.e. limited, resources of human and social capital – they prefer exploiting these resources to carry out development projects in areas other than the extensive and complicated railway ecosystem.

An additional aspect to be investigated is the lack of a theoretical model for a microeconomic analysis of the functioning of major business organisations. No complex tool for economic analysis of economic processes in a vertically-integrated railway enterprise has been created in nearly two centuries. Such a model is also lacking for virtual organisations. The Collegium of Management and Finance of the SGH Warsaw School of Economics undertook an attempt to formulate research questions concerning the attributes of such businesses.[46] This could be a fascinating research project whose implementation would create tools for analysing the operation of both ecosystems – railway and AI – accounting not only for the traditional criteria of microeconomic evaluation, but also for others that would, for example, make it possible to assess the impact of the functioning of these ecosystems on the implementation of a circular economy strategy and on the diffusion of zero-emissions technologies.

[46]A. Karmańska, R. Bartkowiak, S. Gregorczyk, P. Wachowiak, *Pomiar dokonań organizacji wirtualnych w gospodarce opartej na wiedzy. Koncepcja badania i jej ewolucja*. [in:] *Rachunkowość w nurcie ekonomiczno-finansowo-zarządczym*. Ed. by A. Karmańska, *Złota Księga dla dr. Zdzisława Fedaka z okazji odnowienia dyplomu doktora nauk ekonomicznych*, Oficyna Wydawnicza Szkoły Głównej Handlowej w Warszawie, 2020, pp. 205–253.