Chapter 4
Analysis of Ground-Breaking Technologies and Their Effect on the Functioning of Enterprises

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Abstract The primary goal of this paper has been an attempt to present breakthrough periods in the functioning of an enterprise, conditioned by ground-breaking technologies. In this study, two approaches to analyzing the notion of technology have been indicated in an original way, and five prisms have been distinguished through which it can be constructed. In addition, key inventions in the history of humanity have been identified together with their effect on the enterprise. Importantly, three main periods of the breakthrough have been indicated in the functioning of an enterprise. The research method used to solve the scientific problem is structural analysis and causal analysis. The first has enabled the identification of ground-breaking technologies, and the second one has identified changes taking place in the functioning of enterprises.

Keywords Technology · Definition of technology · Ground-breaking technologies · Technological change · Innovation · Invention · Enterprise

4.1 Introduction

Technology creates new challenges for enterprises, plays an increasing role in business operations, and over the centuries has often revolutionized their principles of functioning. On the one hand, it allows improvement in operating effectiveness, while on the other hand contributes to hazards and unpredictable events, inhibiting efficient management. Technology can be a result of discoveries, inventions, and innovation, but also often they are just technology themselves, which creates changes, progress, economic growth, or revolutions. It is important to remember that the relation is bilateral and highly correlated, and rigid differentiation of this problem is extremely complex, subject to the context of examination, time and seems unjustified. However, over the centuries technology has undoubtedly undergone massive transformations from a simple method, skill of manufacturing, treating it as a model, influence on

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relations between social, psycho-socio-cultural phenomena, up to its autonomy and possibilities of improvement of an enterprise.

Though these problems are an interesting area of scientific examinations, it seems that it is marginalized by the subject literature. That is why the purpose of this study is to present breakthrough periods in the functioning of an enterprise, conditioned by ground-breaking technologies. In this study, two approaches to analyzing the notion of technology have been indicated in an original way, and five prisms have been distinguished through which it can be construed. In addition, key inventions in the history of humanity have been identified together with their effect on the enterprise. The original analysis included in this study has allowed inventions to be indicated along with identification of a series of various devices and laws of physics, contributing to its creation. This task was particularly difficult, since, along with the degree of complexity of the technologies the difficulty grows in answering the question of how different technologies contributes to creating the subsequent one. Significant is also the fact that changes in technology happen very slowly and, while it is relatively easy to indicate key inventions from a few hundred years ago. Now, due to incomplete knowledge, regarding the development of a particular technology in the future, it is quite difficult. The method allowing achievement of the aforementioned research intentions is analysis and classification.

According to T. Pszczołowski, analysis is a method of action consisting of receiving the output through a division of a certain whole into smaller elements [1]. The use of analysis as a key research process usually can be narrowed down to the implementation of its two basic objectives.

The first one is called structural analysis and consists of determining the structure of the object by indicating the elements constituting it, determining the characteristics of the whole as well as individual parts and identifying and clarifying the relationships that occur between the elements of the whole and describing their nature. This structural analysis enables the identification of technological breakthroughs.

The second one, identified with causal analysis, seeks to understand the mechanisms of functioning of the examined whole by identifying the changes that occur in it, determining the factors affecting the whole, as well as the strength, direction, and intensity of the influence of these factors on the changes of the whole. This sort of analysis identifies the breakthrough changes taking place in the organizations under their influence.

While generally understood classification is a process of dividing and combining, which, through multi-purpose transformation of the structure of an object or a set is to lead to putting the elements of the structure or a set in order [2]. The task of classification itself may assume different forms of grading, taxonomic ranking, and ordering. The pursuit of classificatory solutions is intended to determine the direction and the scope of systematization and hierarchization. Systematization is an "activity consisting in listing—in a single-stage or a multi-stage system—the components of the given whole, basing on the type classificatory criterion." Whereas, hierarchization "is an ordering activity referring to simple elements of single classes of similarity (division) in a given classificatory rank or to classificatory ranks, and it consists of their placement according to the section of validity, the temporal sequence

(chronology of occurrence) or also because of causality relation" [3]. Another name for the multi-level classificatory system is the "hierarchical classification" where the word "hierarchy" indicates superiority from the point of view of the conceptual scope of the set divided in relation to subsets introduced, as a result of classification.

Apart from the above, this study is based on a literature review, in particular, the principles of a classical review and a narrative review method which was used as a subsidiary method. Moreover, it was the starting point for further analysis.

4.2 Characteristics of the Notion of Technology

Technology plays a significant role for the man, organization, world economy as well as is a significant element of the society's culture. Often it is the reason for radical changes, contributes to the pace and directions of development, shapes competitiveness and according to J. A. Schumpeter, is a source of economic growth; however, it can be noted that this increase contributes to the development of technology. As justifiably noted by A. Zakrzewska-Bielawska today, technology is a key factor in building value for the client, investors and other stakeholders [4]. It should also be noted that it brings along a number of hazards, both macroeconomic and microeconomic ones.

We can note that there is no unified approach to determining the term technology (see [5–10]) and unambiguous opinions about its essence. The diversity in interpretation results among others from its complexity [11], the context of examination of the given problem area, or passage of time. This proves do the omnipresence of technology and challenges related to understanding it. Already at the very beginning, we come across the problem related to distinguishing the notions' technique and technology. The authors, such as P. Lowe or E. Agazzi, justifiably remark that there is a certain type of continuity between these terms, consisting in that technology remains within technique and is in a way its new branch, which can be understood as "applied science" [12, 13].

On the other hand, other distinguished scientists W. E. Bijker, T. P. Hughes, and T. J. Pinch believe that "technology" is a sensitive term, and the notions such as "technological change" and "technological development" often carry vast interpretational burdens along and devotion of too much effort does not pay off [14].[1]

Analysis of the subject literature has made it possible for us to distinguish two approaches to the examined problem area:

[1] In the subject literature one can observe replacement application of the terms technique and technology, with the prevailing use of the latter one. This disproportion results, among others, from incorrect translation from English as well as suggesting the scientific nature or at least the theoretical dimension of the particle -logy in the word 'technology' which is typical of names of various scientific disciplines. It also seems that this kind of neosemantism is very difficult to overcome and with time these terms will become increasingly equivalent. That is why, taking account of the above, both the notions are treated interchangeably in this paper.

- **narrow** (traditional)—focusing on technology as hardware, machines, and devices (the so-called hardware) used by people in the work process.
- **wide**—including general tasks, material assets as well as manufacturing methods and techniques used in business operations or even social-technological phenomena.

The representatives of the first approach are, among others: Bain [15], Woodward [16], Blau et al. [17], and Barley [18]. However, limitations related to such perception of technology have induced researchers to propose a broader approach, undoubtedly being a supplement of the first one. This allows treating technology as an important variable in different types of organizations as well as pays attention to its non-organizational aspect. Key researchers involved in this problem area are Thompson [19], Pierow [20], Eveland [21], Pearson and Young [22], and Szatkowski and Mitchem [23] it should be noted that the latter approach, unfortunately, creates interpretational ambiguity.

Additionally, technology can be perceived through the prism of:

- **knowledge, science**—this approach interprets technology as a scientific discipline, independent from other disciplines, perceived more broadly than just theoretical knowledge [24]. Other known researchers who have seen technology in this way were Burgelman et al. [25], Gudanowska [26];
- **product**—shows that technology is a specific product of the man, to create which technical knowledge has been used in the first place [27], inseparably related to the functioning of the man. Researchers such as Smitha and Sharif [28], Hatch [29], and W. B. Arthur define technology in a similar manner.
- **resources of an enterprise**—being its key, strategic element. This has been indicated among others by Stonehouse et al. [30] or A. Zakrzewska-Bielawska.
- **methods and technique**—it is probably the most frequent method of defining technology, pointing to a set of methods and techniques used by the man for manufacturing and action. In this meaning, technology is also a general tool for improving competitiveness, depending on many other factors [31, 32]
- **process**—within which technology is a focused process of manufacturing products based on theoretical and practical knowledge, incorporating various activities, performed in a strictly defined way and in proper order. The researchers seeing the problem in this way are among others C. Christensen, Raynor [33], Karpiński [34], Santarek [35].

In connection with the above, for the purpose of this study the following definition has been adopted:

> collection of mutually supplementary methods, tools and algorithms for preparation, performance, maintenance and assessment (analysis) of the process of processing or manufacturing a specific material good, energy or information that uses available knowledge, machines and equipment.

It seems that the proposed definition fulfills the assumptions adopted in this part of the study. However, it should be emphasized that to understand the essence of the

contemporary technology, one should also take account of the external conditions the complex nature of which requires the technologies to also be complex in this area.

4.3 Identification of Ground-Breaking Technologies

The above-made characterization of the technology notion shows that this term is highly diversified and difficult to be unambiguously determined. That is why in this part, we would like to focus on showing the evolution of technology and indicating the primary, ground-breaking technologies which had an effect on business functioning and were the basis for identification of breakthroughs characterized in the last part of the study.

The basic question allowing for specifying the technological breakthroughs was the problem of indicating the causes for their formation which we see in the evolution of technology and breakthrough inventions, originating from one or many scientific achievements in the past. Those being the foundation for further solutions, and innovations which established changes in agriculture, industry and services, triggering further variations in economy and business, culture, society, and technology. It can be noted that an invention replaces a recognized technology, a product which contributes to creating a totally new product. It is revolutionary enough to allow for ceasing the application of the previous ways of conduct and replace a recognized technology. Simultaneously, being flexible enough, it gives new opportunities for its use. Passage from one to the second method of manufacturing, functioning in the world, also results in revaluing, changing the standards, principles of action in science, practice, with particular focus on changes in the functioning of the enterprise. The process of evolutionary-revolutionary technological changes does not proceed in a linear way but is characterized by non-continuous technological changes, related to a single moment of discoveries and significant development over the period from the Industrial Revolution with the peak in the period of the scientific and technical revolution from the 1950s until the end of the twentieth century. A summary has been presented in Table 4.1.

A basic problem we have encountered in our research was identification of the mere primary inventions (e.g., practical application of electricity or telecommunication infrastructure was possible by inventing a series of various devices and laws of physics), as well as specifying the date of key effect (not always the moment of inventing, patenting or the first definition meant this significant effect on the humanity, organization. It should be treated rather as an estimate than unambiguous decision) and the discoverer. However, it seems that from the point of view of the development of science, the pursuit of the answer seems unfounded. In addition, technological changes happen very slowly. Sometimes slowly enough to be difficult for their contemporary observers to notice.

In the paper, an attempt has been made to indicate significant inventions, innovations, which contributed to the formation of breakthrough technologies, or were

Table 4.1 Historical evolution of ground-breaking technologies

Period	Dates and general characteristics	Meaning
Antiquity (approx. mid thirty-fifth century BCE to 476)	9000 BCE–7000 BCE—agrarian and agricultural revolution—domesticating plants and animals	*Process—cultivation of plants and animal breeding* Revolutionary economic and social changes, settled life and creation of more complex social forms, development of culture as well as adjusting nature to the needs of the man
Neolithic revolution (10,000–40,000 BCE)	4000 BCE—inventing the wheel is an undoubtful breakthrough in the history of humanity also having a great symbolic meaning	*Product—wheel* Development of civilization and culture, transport, trade, and industry
	3500 BCE–3300 BCE inventing the letter is one of the most important inventions of the humanity making it possible to record information	*Process—writing* Possibility of recording, using symbols, possibility of coding, keeping documentation, cooperation, trade
	3300 BCE—480/450 years BCE—smelted ore, bronze and iron	*Process—smelting metals* Possibility of obtaining tools, weapons, machines and equipment, development of civilization
Middle Ages (476–1453)	approx. 1439—development of print (J. Gutenberg)	*Process—print* Possibility of making faithful copies in shorter time, spreading information, development of knowledge, education, science and technology, social, cultural, political transformations

(continued)

Table 4.1 (continued)

Period	Dates and general characteristics	Meaning
Modern times (1453–1914	– **1712**—Inventing steam engine and 1732 steam machine to drive rotary machines (T. Newcomen) – 1976—Beginning sale of engines improved by J. Watt, of T. Newcomen. From the point of view of development of the organization, we can not ignore other areas of mechanization of production processes: – 1733—Inventing the mechanical shuttle (J. Kay) – 1764—Inventing the mechanical spinning frame (J. Hargreaves) – 1784—H. Cort, 1797—H. Maudslay—Change in the method of plastic iron processing affecting transformation of metal manufactories into machine factories	*Product—steam engine transition from agriculture-based economy, manufactory or craftsmanlike production to mechanized factory production; it is a process of business, social, economic, technological and cultural changes. Industrial Revolution*
Industrial Revolution 18th century	Practical application of electricity was possible by inventing a series of various devices and laws of physics. We can indicate among others: – approx. 1600—Using the Latin word *electrcus* to refer to the power created as a result of friction of objects (W. Gilbert) – approx. 1600—Using the term electricity for the first time (T. Browne)- approx. – 1663—Flow of electric charge (O. Guericke) – **1753—**Discovery of electric induction (J. Canton) – 1780—Discovery of the presence of electric phenomena (L. Galvani) – 1800—Inventing the galvanic cell (A. Volta)	*Product—electricity electrification, economic, social, economic, technological and cultural changes*
	The invention of electricity meant a new age in telecommunications techniques and resulted in creation and development of telecommunication infrastructure. It is related to a number of inventions but undoubtedly a key role was played by: – **1792–1794**—Inventing the first optical telegraph line (C. Chappe) – 1839—Creating electric telegraph (Ch. Wheatstone, W. Fothergill Cooke) – 1848—Building the first telephone (A. Meucci) – 1876—Patenting the first electromagnetic telephone (G. Bell)	*Product—telegraph, phone* Possibility of distance transmitting of information using means of communication; development of telegraphic telecommunications, business and economic, social, technological and cultural changes
Second Industrial Revolution nineteenth/twentieth century	*Developing the transport infrastructure*: *maritime transport* **– 1783**—Inventing the steamer (M. C. de Jouffroy) *Rail transport* – 1801—Designing diesel engine and 1804 building rail steam locomotive (R. Trevithick) – **1830**—The first railway line (G. Stephenson) *Road transport* – approx. 1859—Inventing the first commercial internal combustion engine (E. Lenoir); – 1876—First modern internal combustion engine (N. Otto) – **1883**—Car with a gasoline engine (G. Daimler, C. Benz) *Air transport* – 1903—Inventing airplane (Wright brothers)	*Product—steam engine, diesel engine, internal combustion engine, steamer, steam locomotive, car, aircraft* Development of economy, transport, trade and national, international tourism, business and economic, social, technological and cultural changes

(continued)

Table 4.1 (continued)

Period	Dates and general characteristics	Meaning
	– 1913—Manufacturing line—mobile vehicle manufacturing line—(H. Ford)	*Product—production line development of the economy, transport, trade and tourism, business and economic, social, technological and cultural changes*
	– 1926—Mass production (the notion popularized in Encyclopedia Britannica, after an article which was written based on correspondence with Ford Motor Company)	*Process—mass production possibility of producing large quantities of standard products, improvement in productivity, economic growth, increase in total production, emergence of a homogeneous group of consumers*
20th century	*Development of communication infrastructure* *Computer* – 1945—Electronic computational machine ENIAC (Electronic Numerical Integrator and Computer), (chief J. P. Eckert and J. W. Mauchly), new era in the development of the civilization and beginning of the digital revolution. Creation is related to such inventions as among others: – 1800—Building the first mechanical logical machine (Ch. Stanhope) – 1854—Creating two-element algebra logic, until now the foundation for operations of computer elements (G. Boole) – 1948—Building the transistor (J. Bardeen)	*Product—computer* Transition from the mechanical and analog technology to digital electronics, digitization, and implementation of IT solutions in the operations of the man, common availability of information, distance transmission of information, changes and economic and commercial, scientific—technological, social, cultural development
Third Industrial Revolution (scientific-technical the 1950s—today)	*Artificial intelligence—demonstration of intelligence by machines such as people's intelligence (Artificial Intelligence)* – **1950—**First artificial intelligence laboratories Carnegie Mellon University, (A. Newella, H. Simona as well as Massachusetts Institute of Technology J. McCarthy – 1956—Computers learning checkers strategy (Dartmouth College)- 1980—expert systems as a form of programming artificial intelligence	*Process—automation of areas of the company's operations. Creation of smart factories and limiting the participation of people in enterprises to a necessary minimum. A new business model will be created, based on flexibility, efficiency, and speed*

(continued)

Table 4.1 (continued)

Period	Dates and general characteristics	Meaning
	Cellular telephony: – 1917—Patenting a hand-held foldable phone with a very thin carbon microphone (E. Tigerstedt)- – 1947—The idea of cordless telephony based on cells (Bell Labs)-1956—introduction of a mobile terminal (Ericson) – **1973**—Radio telephony system (M. Cooper) – 1965—Sending a commercial telecommunication satellite Early Bird (Intelsat 1) (Space and Communications Group)	*Product—mobile phone* Distance transmission of information *Product—Internet access, electronic mail, mobile device with Internet connectivity* Revolutionary changes in traditional business models, electronic business, development of international trade, revolutionized distribution channels, crowdsourcing, social networks, common access to knowledge and information, exchange of information, information war, "e-revolution" in communication, multimedia connections. Creation of ICT conditioning the functioning of contemporary enterprises, societies
Digital revolution	– 1988—Second-generation cellular systems (2G) system GSM (CEPT); 1997—Third-generation cellular systems (3G) (IMT—2000/UMTS) (ETSI—European Telecommunications Standards Institute); fourth-generation cellular systems LTE standard (Long Term Evolution). New generations are introduced on average every decade – 1992—Smartphone—portable device combining functions of a mobile phone and a portable computer (PDA—Personal Digital Assistant). Introduction to the market in 1993	*Product—instant messenger use of computer network to send instant messages between two or more computers, video conferences*
	Internet – 1955—Inventing the optical fiber—(Kapan) and 1988—placement of transoceanic fiber optic cable TAT-8 (consortium of enterprises led by AT & T Corporation, France Télécom and British Telecom. Laboratories AT & T Bell) – 1960—Design of a global chain of computers (J. Licklider), – **1969**—First connection between computers in ARPANET—DARPA Web (Defense Advanced Research Project Agency) – 1965—Electronic mail, e-mail—(sending information between users of the same computer (L. Pouzin, G. Schroeder, P. Crisman) – 1971—Sending text information between computers (R. Tomlinson) – 1989—Project of creating a network of hypertext documents, named World Wide Web—(T. Berners-Lee, R. Cailliau) – 1990—Creating the basics of HTML and the first Web site (T. Berners-Lee); – 1993—First graphic web browser—Mosaic (NCSA (National Center for Supercomputing Applications)-broadband access to the Internet (Broadband Internet Access) – 1997—Registering google.com domain – 1997—First mobile device with Internet Nokia 9000i Communicator	

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Table 4.1 (continued)

Period	Dates and general characteristics	Meaning
	Instant messenger (Instant Messenger—IM) a program making it possible to send fast text, audio or video messages, based on cloud data processing technology – 1970—Creation of the first instant messenger prototype (UNIX system) – 1988—IRC (Internet Relay Chat) created by J. Oikarin – 1996—ICQ first instant messenger—by Mirabilis	
	Nanotechnology production with the use of technology in order to achieve very high accuracy and exceptionally small dimensions (precision 1 nm). Becomes the carrier of access to and development of technology – *1931—Building the electron microscope-first device making it possible to see nanoparticle structure, at the atomic level—M. Knoll, E.* Ruska – 1959—Vision of engineering at the atomic level R. Feynman – **1974**—introduction of the term "nanotechnology." N. Taniguchi	*Process—incomparable possibilities of achieving revolutionary progress in education, technology, and production, which may also have an enormous social effect.* Leads to new linkages affecting the enterprise, the economy
	Virtual organization – 1980—First use of "virtual office"—P. Littmann, S.A. Jansen or V. E Giuliano?? check!! **– 1986**—Introduction of the term "virtual organisations" A. Mowshowitz – 1993—Ground-breaking publications by W. H. Davidow, M. S. Malone popularizing and harmonizing the term	*Process—virtual organization* Remote use of resources, particular form cooperative networks, flexibility, smaller costs of operations. New business model for enterprises
	Computational clouds (Cloud Computing) – 1996—First application of the term—G. Favaloro – 2006—Presentation of the term on an industry conference—G. E. Schmidt – **2007**—Promoting activities by companies Amazon, Microsoft and IBM	*Process—possibility of using resources remotely.* Complete change in the approach to performing IT infrastructure-based business processes. Possibility to focus on the basic functions of the operations
	Internet of things, objects, (Internet of things–IOT), Internet of Everything (Internet of Everything–IoE) – 1999—First use of the term K. Ashton to describe a network combining objects in the physical world with the Internet – Beginning of 2009—creation of integrated mobile applications	*Process—communication with the Internet and ability to independently broadcast data.* Automatic generation, exchange and use of data with minimum intervention of the man, resulting in change of the model of interaction of things with the Internet. Almost unlimited use of smart devices in the sector, the enterprise. New business model for enterprises

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Table 4.1 (continued)

Period	Dates and general characteristics	Meaning
	Modern biotechnology—Methods from the scope of the biotechnology are used for thousands of years, but the modern biotechnology uses genetically modified enzymes, proteins, organisms unlike the classic one that uses organisms naturally present in nature or substances produced by them 1919—First use of the word biotechnology (Károly Ereky) 1996—Cloning Dolly lamb—seems to be the largest breakthrough in this domain of science	*Process—provision of goods and services using biological methods.* Implementation of technical and economic solutions, allowing problems of biotechnological processes to be solved on the industrial scale. It is design of devices, technologies, manufacturing possibilities
	Integrated ERP systems (Enterprise Resource Planning) computer system for supporting resources management in an enterprise. It allows performing managerial function in all the functional areas of the company (production, sales, and others), however, the main area for support and the basis for functioning and processing in these systems is the broadly understood area of finance **– 1960s**—First applications supporting business management—IC programs (Inventory Control—inventory control), – First use of ERP abbreviation in the 1990s—Gartner Group	*Process—improvement in operations of areas of the enterprise, higher effectiveness of the processes, better use of resources*
21st 2002 beginning of the digital era	*Big Data—advanced techniques of analysis of large data collections* – late 1920s—IBM redesigns Basile Bouchon's invented perforated card – 1997—First definition (M. Cox M., D. Ellsworth) – 2000—Formulation of the definition of large data collections as three dimensions (D. Laney) **– 2002–2003—**creating Nutch engine used for searching and indexing content of pages (D. Cutting, M. Cafarella)	*Process—parallel processing of large quantities of diverse data from various information sources and departure from the classical data storage scheme*
	Block chain—decentralized transaction platform in scattered network infrastructure – 1991—First works on cryptographically protected block chain were-S. Haber, W. Scott Stornett – **2008**—First blockchain conceptualized by a person (or group of persons) known as Satoshi Nakamoto	
Revolution digital	*Technological singularity (singularity)—alleged point in the development of the civilization, when any human predictions will become invalid due to fast technological progress* – 1958—First use of the term (S. Ulam). – 60. XX—Deliberations on the consequence of creating machines that are more intelligent than men (I. J. Good) – 1980—Popularization of theory of I. J. Good (V. Vernor) – 2045—Final product	

Source prepared by the author

such technologies and on the basis of which further technologies inventions were developed. In addition, from the point of view of the subject of the publication, attention was concentrated on those technologies which had or have a key effect on the development of enterprises and have significantly affected the principles of their functioning.

4.4 An Attempt to Determine the Breakthrough Periods in the Development of Enterprise

Technology development results in the need for changes in business management. On the one hand, they should flexibly adjust their operations, functions and methods of work organization, and management to the radically changing operational conditions. On the other hand, it is often just themselves who are the carrier of technology and determine directions and ways of business operations. The company's development thus depends on both internal and external technological factors determining business functioning. On the other hand, the ability to adjust to the conditions, and in particular, determination of technological trends largely determines the effects of the operations, competitiveness, and development opportunities.

The analysis performed above undoubtedly indicates that under the effect of technological changes conditioned by inventions, innovations over the centuries, enterprises have undergone a number of transformations that we can present in the form of certain breakthrough periods. As justifiably noted by M. Lisiński, M. Szarucki, period of a breakthrough is a specific critical point, a turning point, and a fundamental change, which creates a new, original, and important quality [36]. T. S. Khun, on the contrary, shows that the special achievements, with adequate originality and attractiveness, able to turn the attention of a fixed group of enthusiasts of a given theory and characterized by openness, leaving various problems to be solved, become a revolution [37].

Therefore, an effect of our research approach was distinguishing of breakthrough periods that are not hermetic, unambiguously identified events in the given place and time but are affiliated with each other and function within a certain structure and interdependence over the particular time span. Thus, examining them as independent, isolated beings is a certain artificiality, on the contrary, they should be interpreted as a certainly closed whole after being matched with certain facts. In addition, we will want to solve this complex research approach to the evolution of changes in the functioning of enterprises as a result of technology development, assuming a different research perspective than previously, namely through the prism of considering revolutions identified in science. Indicating their effect on the enterprise as well as a perception of technology over this period. The problem area of revolution is the subject of interest of numerous researchers and can be differently classified. However, our research procedure will be focused around three main periods the boundaries of which are the ground-breaking discoveries or inventions:

- **I—related to the Agrarian Revolution** (duration from 9000 BC–approx. 1700)
- **II—related to the Industrial Revolution** (duration 1732–approx. 1950)
- **III—related to the scientific and technical revolution** (duration 1950–today).

Below we will present a brief analysis of each period, indicating significant, in our opinion, transformations in the functioning of enterprises, determined by primary inventions or innovations.

The first period related to the agrarian revolution longest one, lasting several thousand years, resulted in changing the lifestyle from nomadic to settle. This has contributed to the formation of more complex social forms, development of culture, first communication methods and formation of first non-agrarian professions being a result of increased productivity. Although we can date back the development of a professional enterprise and management to the period of the Industrial Revolution (II period we have distinguished), the following inventions have been intentionally included in the paper—e.g., wheel, writing, printing, or smelted ore, bronze and iron—preceding this period, since we believe that from the very beginning, they have revolutionized the life of humanity throughout the whole period of its duration and had an enormous effect both on the society's culture and the further development of businesses as well as match the assumptions of this study. From the point of view of business operations, this period can be characterized by the presence of manufactories and craft organizations.

In this period, technology is perceived as art, ability, or craft. It is the basis for knowledge about the world and is the man's basic ability. It is also knowledge about the proper implementation and is the source for solving problems of the man and improvement in its life. As professional management or classic forms of business are not present in this period, we can not also speak about technology management.

The second period is linked with the Industrial Revolution and inventing the steam machine, as well as inventing the mechanical shuttle of the mechanical spinning frame, or the production line. They have become the reason for deep business, social, economic, technological, and cultural changes. Physical work automation led to an expansion of business resulting in a concentration of the industrial production processes, improvement in productivity, ability to produce large quantities of standard products, emergence of economy scale, centralization of factories but also demand for professional management. This period is characterized by significant technology development, resulting in the breakthrough discovery of electricity, which allowed the development of telecommunications and its infrastructure, the electric engine, or information technology. This invention meant a new age in the history of humanity and business management. The discovery of telephone and telegraph allowed for distance broadcasting of information using means of communication, thereby shortening time and distance. In addition, inventing internal combustion, diesel engine, or steamer results in a dynamic development of the transport infrastructure. It is possible to travel by sea, air, and railway and is also booming. All this results in new, so far unknown opportunities both for businesses and the whole economy, which, after periods of war, is dynamically developing already not only on the national but also international scale.

Undoubtedly, these factors contribute to very large production growth, but also to the emergence of negative phenomena, e.g., breakdown of public finances, higher inflation, increase in the regulatory role of the state, or creation of financial institutions [38]. This period marks the formation of industrial society and explosion of the Industrial Revolution in England, then in the USA and Western Europe. It also means drastic changes in the mentality of manufacturers, employees, and customers. As justifiably noted by M. Lisiński, M. Szarucki very important become, so far hardly significant, demographic phenomena, for example, the pace of growth of the world's population as well as the phenomenon of migration. The year 1955 is also the unprecedented situation of the number of administrative employees becoming higher than the number of blue-collar workers. Business functioning in this period involves a number of intraorganizational as well as external changes.

Technology of this time is perceived through the prism of tools, methods, machinery, devices and industrial processes. R. J. Tulley even concludes that it almost systematic industrial knowledge, of the most important industrial areas, e.g., spinning, weaving, and metallurgy [39]. To a certain extent, this is a personification due to considering machines and industrial processes (engineer as an example of coding sex). It takes account of many skills, methods of performing the activities. This becomes important from the point of view of competitiveness; however, nevertheless, it is treated more as a factor making intraorganizational development easier, contributing to improvement in productivity, increase in total production, and expansion to international markets.

The third period is linked to the scientific-technological revolution where the main role is played by science and intellectual capital. Epochal achievements of this period can be observed in almost all sciences. From the point of view of our deliberations, particularly essential is the development of IT tools, such as automation of work processes, integrated management systems, development of the communication infrastructure, further improvement in means of transport and communication, and development of nanotechnology. It also means passage from the mechanical and analog technology to digital electronics, digitization and implementation of IT solutions, common availability of information, virtualization and digitization of businesses, or finally artificial intelligence. The inventions of this period and their development contribute to changes in all spheres of life of humanity, and thus also affect enterprises and force a new code of behavior. Undoubtedly the most important invention of this time was the computer, which initiated the digital revolution, development of information and communication technologies (ICT). These technologies are regarded as the main causal factor in the development of the modern world. Virtualization of businesses, computational clouds, Internet of things, use of big data, or blockchain completely changes approaches to performing IT infrastructure-based business processes. Allowing, on the one hand, better focus on the basic functions of the operations, on the other hand, contributing to creation of a new business model. On the other hand, the intensified development of artificial intelligence contributes to the creation of smart factories and limits the participation of people in enterprises to a necessary minimum. A business model based on flexibility, efficiency, and speed is emerging. Scientists', futurologists' theories can be also found, saying

that machines will autonomously make decisions, act concurrently by communicating between themselves, not involving the man. Let's hope that the concept of technological personality (singularity) will never come true since it would mean the last invention of the man in history.

In the third period, technology is treated as an independent and determinist strength shaping the reality, development of which cannot be stopped and it is out of any control. We are approaching a technology being dependent on strength, which we can moderate and which is something more than a collection of machinery, devices, methods, or processes. Perceived broader than the collection of theoretical knowledge, it can be considered as an independent scientific discipline having a significant effect on the formation of social, cultural, and psychological phenomena. On the other hand, these phenomena can form the technology itself, contributing to new inventions, innovations, often being just such an invention or innovation. It gradually becomes adapted to the needs of a particular enterprise. Its new possibilities of application are often discovered and often different from the creators' primary intentions. This also means analysis of mutual linkages between education, technique, and business. More and more often attention is focused on using it as a source of competitive advantage. Enterprises improve ways and methods of technology transfer as well as cooperation going beyond the sector of their operations. New organizational forms are created, e.g., technology transfer centers, broker systems, facilitating an acquisition of technology and cooperation. We can say that such an approach focuses on a mutual improvement of the enterprise and technical solutions correlated with the psycho-socio-cultural aspect from the point of view of the common achieving of the goal. There are opinions that technology becomes too autonomous and is not subject to human control. Its development is spontaneous and cannot be stopped.

The above-made identification of breakthrough periods in the development of enterprises and their synthetic assessment from the point of view of primary inventions, technologies, does not resolve all matters. However, it seems that it indicates a number of material phenomena that determine the development of this research area and must be treated more as problem areas that require further discussion than final determinations.

4.5 Summary and Conclusions

We have underlined above that the problem area related to the definition of technology, as well as identification of the main key inventions for humanity and thus for businesses, is not easy. The definition of technology itself in its complexity is extremely difficult, and this analysis is complicated by the diversity of views on this subject in the literature, its essence, lapse of time as well as the prism of perception. We are also aware that the above-presented summary does not exhaust all possible definitions as technology is connected with almost every aspect of a functioning of the state, enterprise, society, and every activity of the man, and it can be understood both in the context of knowledge, science, methods, tangible items, or processes.

However, it is important, regardless of the context, to take account of its multidimensionality. We have tried to propose a certain way of thinking about technology, technological changes, inventions that are able to or have ground-breaking importance and effect on the principles of functioning of the enterprise. On the contrary, the presented ground-breaking periods, resulting from technology development, or emerging inventions, innovations, should be the starting point for further discussion and broader research in this area. We are aware that the primary inventions we have specified are not the final determinations. They can rather be an inspiration or indications for further research on this complex problem.

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