



Topic: Social and economic impact of technological revolutions in Europe

Time line

- 9500 BC–3600 BC: First crops cultivated and domestication of animals.
- 6th and 5th Century BC: Peak of slavery as a model of work organization.
- Fall of the Roman Empire–end of the Middle Ages: Dominance of paid work based on a relationship of dependence.
- End of the Middle Ages–end of the 18th century: Organization of guilds (*endotecnia*¹).
- 1592–1522: First circumnavigation by Magellan-Elcano
- End of the 18th century to the present: Work organization based on protective labor legislation. Appearance of trade unions.
- End of the 18th century: Invention of the steam engine and power loom.
- Mid-20th century: Development of the internal combustion engine.
- First third of the 20th century: Peak of aviation industry, computing, and atomic energy.
- The present: Smart factories and online production management.

What does 'technological revolution' mean in the context of history? From the Neolithic to Digital Revolutions

What is meant by technological revolution in the context of history?

Technological revolution can be understood as a state of common social and economic transformation for the majority of the population that result from the implementation of technological advances. What characterizes a *technological revolution*, that is, what allows us to speak about the emergence of a new phase in the historical development of societies is not just a confluence of a series of processes tied to technological ingenuity but also the economic, political, and cultural consequences that come about as a result of the use of new technology. To cite an expert in the field, Lewis Mumford (1934), what completely changed the system of established social relationships until that point was the central nature that machines took on in the lives of Europeans at the end of the 18th century.

The use of the term *technological revolution* has become a category of analysis that helps us to understand the evolution of societies, particularly, those that have taken shape in the West since the end of the 6th century. Although the use of this term has also been criticized for its purpose driven and vanguardist nature (Cameron and Neal, 2005),

1 . Neologism adopted from Spanish: *endotecnia*. From Ancient Greek ἔνδον (éndon, “inner; internal”) and τέχνη (tékhne, “craft, skill, art”) + -ia.



the fact remains that it has become a category of social analysis that has grown as an explanatory framework from which the economic, cultural, and political changes that affect western societies since the end of the Modern era can be further analyzed.

The paradigm typically employed has been the British model, whose time lines, causes, and consequences have been exported as the only valid tenet to explain other European contexts. Nevertheless, while the British model stood out for its advanced nature and its characteristics of entry, development, and exit in the intense process of industrialization and modernization starting at the end of the 17th century, it can scarcely help to explain the regional and even local characteristics and variations present in other places such as France, Italy, Holland, or Spain.

Despite the diversity of situations, circumstances, and even disparate time lines, what allows us to speak about technological revolution to the English, French, Norwegians, or Spanish is the new relationship that would be established between societies and technology. This new link is based on a series of characteristics that can be found in neighboring countries, among which we can highlight: the fact that technology has become a phenomenon of global dimensions that affects an increasing number of human beings, the support that modern science continually provides to technological advances, and an astonishing capacity to control the environment.

Time lines of technological revolutions

Historians that have studied the development of technological revolutions normally distinguish three identifiable stages from the second half of the 18th century to the present:

The first technological revolution

This takes place at the end of the 18th century in the context of implementing specific technological advances such as the steam engine or the power loom in the textile and communication industries.

This first stage is characterized by the abundant use of coal and iron as the main sources of energy, which were key elements to sustaining the upward trend of these new systems of manufacture and communication.

The second technological revolution

The effects of the first Industrial Revolution would be felt across the entire western world throughout the first half of the 19th century. Indeed, the second major stage of the technological revolution, defined primarily by the electrification of industry, came to a close in the mid-18th century. In this new phase, other advances that stand out are the development and fine-tuning of the internal combustion engine, which would later be essential to the invention of the first automobiles, as well as the increasing importance of steel-related industries. One of the most important consequences of this





second stage was the impetus to internationalize domestic economies and their increasing interconnectedness.

The third technological revolution

This third stage is typically considered to start in the first third of the 20th century. Its defining characteristics are the peak of the aviation and aerospace industries, the emergence of atomic energy, and the incipient computing industry.

There are other classifications based on varied criteria that emphasize not only technological innovation but also the social and economic consequences that derive from them. Still others, in contrast, rely on much later historical periods beyond the late 18th century or the first few decades of the 19th century to date prior periods in the evolutionary development of a process that would have started practically at the time man appeared on this planet. With the help of the systematic approach that Álvaro Carvajal Villaplana developed (<http://www.circulodecartago.org/columnas/nuevas-perspectivas/etapas-de-la-evolucion-de-la-tecnologia/#>) we will refer to other potential classifications different authors have contributed:

a) Tomás Buch establishes four phases based on four criteria: the type of specialist, learning, knowledge, and machines that appear in each stage.

b) Lewis Mumford bases his approach on an evolution of the complexity of technology based on the energy and materials used in each time period. Mumford suggests the following stages:

The Eotechnic, the main sources of energy are water and wind, intuitive technologies.

The Paleotechnic combines the technology of iron and steam and is an empirical phase.

In the Neotechnic, technology is based on the development of electricity, metal alloys, and information processing systems, and scientific knowledge is incorporated in this stage.

c) Maurice Daumas classifies technological evolution based on the type of knowledge used in each time period and the total number of innovations. It sets out five stages:

Primitive: from prehistory to protohistory

Ancient: refers to human conquests in the era of ancient civilizations

Traditional: from the Middle Ages till the 17th century

Classic: the 18th and 19th centuries

Scientific: from the 20th century to the present day.

Into the future, a new era?

Salvador Salort i Vives (2012), pondered almost a decade ago, “Where are we headed?” (p. 305). He was conscious of the series of changes that western societies are undergoing on a technological level, “a swarm of discoveries and innovations that seem to attest to





the coming of a new system. In this new system (...) there is a new shining star: information" (p. 306).

The truth is that the unanswered questions that Salort i Vives posed reflect a state of concern that many specialists have tried to resolve by making reference to a new stage in the technological revolution, which is taking place before our eyes. This is a reference to the Fourth Industrial Revolution, a term coined by the founder of the World Economic Forum, K. Schwab, in 2016 to refer to the new situation dominated by smart factories and online production management. The characteristics of this new phase have been described in a highly schematic fashion in a report by the *Iberdrola Foundation* (<https://www.iberdrola.com/innovacion/cuarta-revolucion-industrial>) whose conclusions are summarized below:

- a) The internet of things: Facilitates the connection between the physical and digital worlds.
- b) *Cobots*: Designed to physically interact with humans in collaborative environments, they help to optimize production and shift employees away from monotonous or dangerous tasks.
- c) Augmented reality and virtual reality: Enrich the visual experience people have, whether users or consumers, by generating immersive experiences.
- d) *Big data*: Big data enables massive amounts of data to be managed and interpreted for business purposes.
- e) 3D and 4D printing: Essential for developing three-dimensional prototypes and products quickly, accurately, and cheaply with a 3D or 4D printer.

2. Who are the winners and losers? The effects of technological revolutions on social inequalities

Controlling the environment and sedentary lifestyles: from villages to cities

One of the most important effects of technological revolutions is related to man controlling the environment. Nature is no longer an adversary for the human species due to the technological solutions that have helped it to dominate all other animal species and settle a territory that can be controlled, measured, protected, and furnished with basic necessities. Man controlling the environment thanks to technological advances (weapons, productivity, etc.) has been a constant since the development of the first recognized forms of agriculture and animal husbandry in the Neolithic period. In this sense, it is known that the first crops cultivated appeared around 9500 BC, thanks in part to a global warming of the Earth and also the dissemination of the most primitive tillage methods. Among others, wheat, barley, peas, and lentils were cultivated in the Levant, and rice and soy in China between 11500 and 6200 BC. Sugar cane and some vegetables were also cultivated in New Guinea around 7000 BC, while remains of the primitive cultivation of cotton from around 3600 BC have been found in Peru.

We also know how certain animals were progressively domesticated over the course of this initial Neolithic stage: for example, pigs and sheep were initially bred in



Mesopotamia around 11000 BC. There is evidence of domestication of camels around 3000 BC in the regions of Somalia and Arabia.

In this sense, we consider the increase in population sedentism to be one of the most important consequences of the technological revolution linked to the appearance of the first forms of agriculture and animal husbandry. Among many other factors, the ability to provide a large group of people with a consistent, daily supply of provisions undoubtedly enabled the progressive concentration of men and women in a specific territory on an ongoing basis, which over time was essential to initiate another one of the key processes in the history of humanity: urbanization, the establishment of population centers in cities.

The process of generalizing urban environments is well-known and amply described. It can be analyzed starting with the incipient agricultural villages of the Neolithic all the way up to the most renowned urban forms of the city-states developed by the Phoenicians on the east coast of the Mediterranean, which were later continued and expanded upon by Greek cities, particularly those founded throughout the Roman Empire. According to Cameron and Neal (2005), in Medieval Europe, despite the increase in urban population, especially in Italy (Venice, Genoa, Pisa, etc.) and the Netherlands (mainly in the south, in Flanders and Brabant), agricultural institutions continued to perform important functions in the identity of the economy and society. However, this trend would revert in the Modern Era, especially as a result of the increase in commerce and exploration of large areas that were inhospitable for Europeans (Africa and the Americas), as well as the growing effects of continental industrialization that began to appear around the middle of the 17th century in Great Britain, initially, and France, Germany, and the Netherlands at the turn of the century.

In the 19th century and the beginning of the 20th, one of the most significant derivatives connected to the process of urbanization was internal migration, which would cause population centers to grow even more in the majority of European countries.

Productive societies vs consumer societies

A second effect of technological revolutions is the apparent differentiation between societies and how they benefit from technological advances; in other words, those that benefit from the technology developed, which can be denominated *consumer societies*, and those that are primarily involved in the production of the materials needed to build the new technology, which can be denominated *producing societies*.

This effect, which appears to be unique to the modern world, can be used to study systems of locating and transferring raw materials, used since antiquity by the Greeks and Romans—consider the numerous sites located outside the Italian Peninsula, such as those in the Iberian Peninsula (Cartagena, Mazarrón, Río Tinto, Las Médulas) or in the southeast of present day France (Collobrières, Fouillouse, Portes, St. Bresson, etc.)

However, this differentiation between societies that benefit from technological advances and those that are dedicated to producing raw materials and final products now seems more alive than ever. A recent example of this is interest in the mineral coltan, highly valued for its tantalum content, which is essential to produce the



capacitors in electronic equipment such as mobile devices and laptops. Several poor countries, like the Democratic Republic of the Congo and Ethiopia, have specialized in the extraction of this raw material. A description from Spanish journalists in Rubaya in the Masisi province of the DRC is sufficient to get an idea of the conditions workers—many of whom are children—face daily in this type of operation: "Thousands of people work in this mine daily, part strip mining, part deep shaft mining. It was public property until the operators assembled in a cooperative to improve the management of its resources. Although huge sums of money are extracted from the mine, Rubaya has neither hospitals nor schools. It does not even have electricity. Eddy explains that in the rainy season, the mountain comes tumbling down and engulfs many of the slaves" (El Mundo, 19/12/2013, by Raquel Villaécija and Alberto Rojas).

The conditions of near exploitation of the majority of the workers that put their lives at risk for paltry wages, the use of child labor, and the scant or nonexistent risk prevention measures are the price paid, sometimes unwittingly, by consuming societies for goods and services provided at the lowest possible cost. Another example is the textile industry, where women and children work in poor conditions in countries like Bangladesh or India.

3. Technological revolutions and work organization: from slavery and guilds to temporary work agencies and 'false' self-employed people

This section deals with the social impact of technological changes and work organization throughout history, specifically the impact of mechanization, automation, robotization, and digitalization in the world of work. The consequences technological revolutions have had on society, especially issues like social relationships, work relationships, or culture and technology transfer, are addressed, as well as providing a brief mention of the current situation.

By way of an introduction, Ortega y Gasset asserts there have been three key stages to the evolution of technology: "the technology of chance, the technology of craftsmen, the technology of technicians" (Ortega y Gasset, 2004). The latter began to emerge around the 16th century—around 1540 the mechanical arts (*artes mechanicae*) became popular—and indicated the emergence of technology. For other authors who follow the scientific tradition, such as Michel Serres, technology is nothing more than the sixteenth branch of 'industrial science' (Serres, 1998). Theorists of English-speaking societies, where the term *technology* has traditionally been used, include craftsmanship in technology. For example, prehistorians sometimes speak about the technology of stone polishing for one simple reason: this is the only word available to describe it (Bunge, 2006); this allows them to create their own technology time lines and transform technology into an inherent trait of human nature whose origins are inseparable from the origin of man. Another perspective asserts that technology appears when the word emerges in the English-speaking world in the 17–18th centuries (Harvey, 2011).

The human factor and technological revolutions: machines against man?





Industrial and technological revolutions should be analyzed as processes rather than matching them to a specific time period. This way, at least the inequality between countries can be explained as the first Industrial Revolution did not start until late in the 20th century in less developed countries, while the second Industrial Revolution was already well underway in the US and the most important European nations (Chaves, 2004).

An industrial society takes advantage of technological development to replace the energy provided by human and animal efforts or turbines with energy provided by machines. Of course, a change of this magnitude had enormous consequences for different reasons. Humans and animals can only work for a limited number of hours per day, and the wind does not always blow nor is there always a sufficient flow rate to power a turbine, in the summer or the winter, for instance. On the other hand, a machine can operate non-stop and may last for many years when cared for properly. The difference is extraordinary: a machine can produce more energy than any number of animals available could. These changes to equipment and methods also brought about new forms of industrial organization, such that the family work unit was replaced by industrial warehouses, and factories became a production method in itself, based on a clear definition of functions and responsibilities for its key actors: the bourgeoisie and workers. In turn, technological and business developments continued in a convergent direction such that one change generated another (Chaves, 2004).

Factories moved to cities, and that process of urban industrialization caused a shift of labor and resources from agriculture to industry. Cities grew, but this gave rise to problems in the new industrial city: overcrowding, poverty, poor living conditions, factory smokestacks, trash, poor health conditions, and tension between the proletariat working class and the capitalists. Worker opposition to the new machinery and the new business and technological network that had formed was particularly remarkable. In England, these individuals were known as Luddites, in reference to Ned Ludd, a weaver who is credited with the first deliberate destruction of power looms (Chaves, 2004).

Moreover, a present day parallel can be seen in the dependence on machines in the case of mobile telephones, where the South Korean philosopher, Byung-Chul Han, has expressed that mobile devices are instruments of domination. The culmination of this process of technological innovation is a digital world that is increasingly and notoriously mixed with the world we still consider to be real, so much so that both are fast becoming confused and make existence more and more intangible and fleeting (Han, 2021a). Today, a *smartphone* is both a digital workplace and a digital confessional. Every device, every domination technique generates objects of worship that are used for subjugation, thus strengthening the domination. *Smartphones* are objects of worship for digital domination (Han, 2021b) and function as if they were rosaries.

The need to organize work (slavery, paid work, guilds, and trade unions)

The action of governing represents the action of guiding an activity in one specific direction, aiming to fulfill an objective. For others, it is a means for organizing and



distributing functions to achieve specific goals with control and authority. However, briefly, government represents the social and material order with which things are done to benefit someone. From ancient times and among the most primal cultures, everything has been done under the influence of government, including the consolidation of organizations all the way up to the apex represented by globalization; its complexity, size, and evolution go hand in hand with the economic development of societies (Santiago and Silva, 2016).

At the outset, all governments were run according to the idea of might makes right. A leader with a hierarchy (inherited or established by physical strength) took control of a group, which submitted to him, while supported by the wisdom of elders and the strength of his remaining male supporters; the leader then organized and executed a plan to satisfy the most vital needs of the clan. This transformed into a tribe, later changed into a niche, and from there societies were born that formed civilizations. The earliest societies needed to be highly organized to take advantage of the natural resources nature provided, to feed more people, structure jobs, organize services for the city, and above all, provide hierarchy to a religious, military, and political system where power and authority were always present. Examples of this are the Akkadians, the Phoenicians, the Egyptians, the Greeks, and the Romans, not to mention the primal administrations of China and India as well as American civilizations (Santiago and Silva, 2016).

It is worth noting that in the field of human relations in prehistoric contexts, there are many unanswered questions or areas of limited knowledge. Among them is the existence of unequal power relationships between men and women and the degree of implementation of the same according to the context. Another example is the distribution of jobs according to gender and the establishment of differentiated roles in the heart of every society. Nevertheless, there is a long tradition of attributing productive activities to both women and men. In this sense, many jobs stand out because the marked differentiation of roles and activities that have been assumed and established for the period of prehistory stem in large part from the current internalization of gender inequality. Therefore, differentiated roles are justified in the social realm: dominance and masculine leadership and the relationship between women and the domestic realm (Pastor and Mateo, 2019).

Before the Roman Empire in the West, a personal relationship of dependence between the service provider and the object of service was subsumed into the work relationship. This concept of work is intimately related to slave labor, whereby the subject performing the activity had the exact same legal consideration as an object, of which the master was the owner. This manner of harnessing human work was the most common among civilizations in antiquity and constituted the driving force of their economies. In the late Roman Empire, the first notions of paid employment can be detected. According to numerous historical sources, between the 6th and 5th century BC Rome experienced population growth that made the available supply of slave labor insufficient. Free men in difficult economic situations, Romans without property, or slaves that had gained their freedom 'rented' their services in exchange for money. This situation was precisely what Roman jurists tried to address, since the conditions under which free men provided



their services could not be the same as those of slaves. Unlike slaves, free men had a voluntarily assumed legal relationship with those to whom they provided their services since they were considered citizens of the Republic (Boza, 2014).

This regulation of contracting for paid work underwent no significant innovations from the fall of the Roman Empire until the Late Middle Ages (around the 13th century). Towards the end of this transition, the predominant form of political organization in western Europe was feudalism, whereby complex personal relationships existed between the feudal lord and his serfs. They were recognized as subjects of rights, but they also had a status that required them to work the land owned by their feudal lords in exchange for protection. The work performed under this regime of serfdom was rendered in conditions of complete submission: serfs were prohibited from making their services available to others, and their condition of serfdom was hereditary. For these reasons, from a modern perspective, it is currently very difficult to identify substantial differences between the conditions of serfdom and slavery (Boza, 2014). In this time period, the knowledge and practice of a trade was patrimony of the family, where this knowledge was learned and practiced; as a result, the function of family was essential in the passing down of trades. The term *endotecnia* has been used to describe how artisan craftsmanship was replicated in families and guilds, not only because of the learning that takes place in the family workshop but also because of the regulating structure that strengthens the *endotecnia* of trades.

All of this is clearly visible in the organization of artisan workshops where the head of the enterprise was the master craftsman, who was responsible for organizing, directing, and perfecting the work of the employees, called journeymen. The economic relationships established between the workshop and its employees was managed by this figure, who was thus inherently entitled to the economic benefits of the endeavor. Journeymen earned a wage for the work they performed for the master craftsman, which was paid in cash given the growing importance of exchange in regional markets. As a result, their service can be considered a pioneering form of salaried employment. Finally, artisan workshops also had apprentices, who were young workers that were interested in benefiting from the reputation of training for a profession in that workshop. They were supervised by the journeymen in the performance of their tasks (Boza, 2014).

Master craftsmen united with the objective of monopolizing markets, prohibiting non-members from practicing their trade, and granting authority to open new workshops. In this way, the first guilds were formed as organizations that united master craftsmen of artisan workshops. It is in this context that journeymen also begin to create their own organizations, which may be considered the first trade unions. Through these, journeymen tried to establish better working conditions in workshops using negotiation and, eventually, force (Boza, 2014). Another means of technology transfer was the emigration of specialized craftsmen, especially for technological innovations that came with the arrival of foreign craftsmen. In preindustrial technology transfer, human training was the most important thing, even more so than capital investment; as a result, the spread of new technology required, more than anything else, a flow of craftsmen qualified in the new methods (De Vries, 1982).



As feudalism faded and the first large cities arose, European society underwent important transformations: regional markets grew and trade intensified through progressive economic development that irradiated from the cities to the countryside. Consequently, paid work also evolved, adapting to the changing context (Boza, 2014). In this time period, the foundations of modern society were laid since, after this stage, new and important means of governing society were set up with a bourgeoisie that abused and concentrated power for the benefit of its social class; while it was the Renaissance that sparked ideas, art, and science, it was not until the Industrial Revolution that administration was thought of as an intellectual resource to organize processes and reap the benefits the capitalist system had sown (Santiago and Silva, 2016).

This vision of administration places man in a rigid context, to the point of objectification; in sum, man is just another resource in production, and scientific management inherits these basic principles, which are in use to the present day. Thus, the division of labor, organization structure, and mass production or mechanization are topics of analysis, observed through the theory of Frederick Taylor, who asserted that the division of labor caused workers to become specialized. Since workers only performed one operation continuously for extended periods of time, they developed skills and abilities that reduced the costs and time needed for production. Workers with low salaries became the new slaves of capitalism (Santiago and Silva, 2016), and workers lost control of the productive process, which they had previously maintained through artisan workshops. It is important to note that specialists have speculated whether the growing attention of the State to social issues in the 19th century revealed that the true function of labor law was none other than to preserve the capitalist system of production by ensuring the survival of its driving force: manpower. One way or another, protective legislation, and especially the actions of the first trade unions, were able to ensure basic rules were established that limited the abuse of employees (Boza, 2014).

In summary, this capitalist economy was based on two social activities: the market system and the production system. The first regulated economic processes and directed and motivated individuals to obtain utility through consumption, and the second regulated tangible and intangible consumption generated with production. The Industrial Revolution, as the newest success story in human history, had entrusted government with emphasizing the processes performed in factories, that is, thoroughly measuring and supervising activities of transformation. As a result, fulfilling these needs obviously depended on greater production and a progressive increase in the overall economic capacity: economic growth (Santiago and Silva, 2016).

New forms of communication and employment, new forms of work? (temporary work agencies, 'false' self-employed people)

Starting with the invention of the steam engine at the end of the 18th century, technological innovation has been the key driver of economic and social growth of the most developed countries. Specifically, it is how the average worker in Spain today works a third less hours and at the same time earns ten times more than at the start of the 20th century. It is for this reason that over the last two centuries all social and economic



agents, institutions, and businesses and individuals have learned to coexist and take advantage of the opportunities associated with the constant and gradual pace of technological development. However, the industrial era also resulted in large waves of disruptive innovations that, despite creating a large array of new opportunities and strong economic and social development over the long term, have caused collateral effects that were difficult to understand and manage at the time. We are talking about phenomena ranging from rural unemployment and migration to large cities, to the abandonment of coal mining. Today, once again, we are at the start of one of these waves, baptized as the Fourth Industrial Revolution or, more appropriately, the Digital Revolution, and the impact it will have on the job market must be addressed (Domenech, Neut, Andrés y García, 2019).

Even if we knew for certain that discoveries or inventions would arrive in the 21st century, we could not determine the economic fate of any single country, as there are multiple equilibria that may converge based on how the digital revolution is managed. Two objectives should guide policies to achieve the greatest equilibrium possible. On the one hand, support economic growth, and on the other hand, ensure inclusion and avoid leaving people behind in the process, guaranteeing equal opportunities and redistributing in favor of the less fortunate to reduce the costs of the transition. Governance should not be seen as a dichotomy between progress in one direction at the detriment of the other; there are opportunities to advance towards both objectives simultaneously. This is particularly true in the case of Spain, which has a gap to cover in terms of productivity, unemployment, and equality in comparison with other developed economies. History also shows that developed countries have advanced on these fronts during the years of the Great Leveling. Likewise, emerging markets are full of examples of countries stuck in situations of low growth and high inequality. It is for this reason that understanding the impact of the digital transformation is of vital importance and is the first step to implementing effective policies that bolster solid and inclusive growth at the same time (Domenech, Neut, Andrés and García, 2019).

At present, we are witnessing struggles in certain industries—characterized by extreme flexibility—that are based on online platforms to sell and deliver products and services, such as Amazon or Glovo. Businesses understand that new labor legislation, including its anti-labor provisions, offer an extraordinary opportunity to further deregulate working conditions with the goal of maximizing profits and requiring delivery men or drivers to accept becoming self-employed, a sort of ally of the company. This means they have to relinquish the minimum protection of their labor rights and enter into ruthless competition with each other to earn a pittance per unit, that is, per haul or delivery (Ntavanellos, 2021). Moreover, a notable example is Switzerland, where in 2020 12% of the population aged between 15 and 74 that had worked at least once in their lives affirmed they had suffered health problems caused or worsened by their jobs. These data confirm that a significant proportion of employees end up burned out from their jobs as they age. This brings us to the heart of the debate on the retirement age. Those in favor of increasing the retirement age behave as if working for a longer time were a mere formality, but this is not consistent with the experience of a significant proportion of employees (Blanc, 2021).





4. Social and economic consequences of the transformation of communications

Making up the distance

Reducing distances and time has shaped the development of economies and the exchange of people, ideas, and goods since antiquity. The previous sections cannot be understood without the technological advances that have enabled the modernization of infrastructure and means of transportation. Without a technological revolution, there could not have been any meaningful Industrial Revolution nor modernization.

The first empires dominated the known world based on maritime expansion (Paine, 2021). They relied on commercial trading routes that allowed for exchanging products made from raw materials they lacked and were cheaper, though essential, to produce weapons, coins, or basic foodstuffs. Some examples are Mediterranean cultures such as the Phoenicians and Greeks, reaching a pinnacle with the Romans and the concept of *Mare Nostrum* as indisputable dominance.

The Middle Ages were marked by land-based trading routes of convoys towards China that enabled exchange with Europe. However, the fall of the old Byzantine empire to the Ottomans closed this secular silk route. Europeans, in search of spices and new markets, explored alternative sea routes. The Portuguese and Spanish were the first to take the initiative in an age when authoritarian monarchies and the beginning of absolutism were getting underway (the end of the 15th century). The Indian Ocean and Atlantic Ocean sea routes put the Iberian powers at the vanguard of the West (Todorov, 1987). Nevertheless, a century later they would cause unease among the competing world powers, whose peak naval power would start in the 17th century: the Netherlands, England, and France. Labor for the American colonies came from Africa, consolidating a slave-based system that would remain in place until the 19th century. The acculturation and miscegenation of indigenous American cultures consolidated the white, European, and Christian paradigm. Likewise, it would engender an initial form of capitalism that would nurture the European metropolises with precious metals and raw materials upon which to establish their manufacturing bases. England dominated the high seas and transoceanic routes from the 18th century, and this served as the basis for its pioneering industrial development. The United States would inherit this model starting in 1914 with its emergence as a superpower. It did not establish colonies or protectorates in the traditional sense but rather allied and docile associations with countries dominated by means of economic issues and liberal capitalist ideology instead of effective territorial control. Its rivalry with the Soviet Union caused the remaining powers of the world to align with one side or the other, while some countries that had recently been emancipated from colonial power chose to remain neutral. An arms and space race was set off between the USA and the USSR that would take man into space and to the Moon. This represented war as the driver of technological innovation to the highest extent.

In sum, those powers that have dominated technology have been the first to benefit from increasingly global power. The challenge is now to control new technologies (5G) and other systems of remote power. Not so much to control large swaths of territory



but rather to get ahead of their rivals in order to control information, sources of energy—both traditional and clean—and production methods (Rifkin, 2011).

Animal traction, steam, hybrid and electric motors

Animal traction influenced human societies from the Neolithic up to the first Industrial Revolution. The great conquests and movements were carried out using horses, not to mention other pack and draft animals essential for agriculture, livestock farming, and the transportation of people and goods. At the same time, rivers and seas have been dominated since ancient times, especially by means of coasting trade. Cartography emerged to guide merchants and explorers on their journeys to far-off lands where the only means of navigation available were the observation of the stars and instrumentation such as the compass and astrolabe. Nor should the painful experience of the first great explorations be forgotten, where very few of those who set out came back alive. This was the case of the Magellan-Elcano circumnavigation (1519–1522) or the return voyage from the Philippines to Mexico, where Fray Andrés de Urdaneta (1565) discovered how to take advantage of the North Pacific Current to get to Acapulco. The opening of this sea route made commercial exchange with China possible (Manila galleon) and ensured the preservation of the Spanish empire for two and a half centuries (Paine, 2021).

The first Industrial Revolution emerged in England with the invention of the Watt steam engine towards the end of the 18th century (Hobsbawm, 1998). It transformed the thermal energy of a specific quantity of water into mechanical energy, which made it possible to power vehicles, boats, and trains. This meant a qualitative leap forward in terms of reducing distances. Together with colonial and maritime dominance, it was the vertex of British power with a colonial empire spread across the Americas, Africa, Asia, and Oceania.

In the 20th century, steam and coal were replaced by fossil fuels such as petroleum and natural gas, and, to a large extent, we still depend on them. Despite causing pollution they are finite. They also generate unrest because their control and trade can destabilize world geopolitics. Numerous wars to control these sources of energy and their means of transportation have turned areas like the Middle East into a powder keg, which determines the impoverishment of countries, despite their wealth in raw materials. Military and defense spending encroaches on the delivery of social services and basic necessities, to which the vast majority of the population lack access, in addition to impeding stable democracy. Western powers turn a blind eye to compliant dictatorships as long as they provide energy and buy weapons.

The West started to take interest in alternative clean energy after the oil crisis of 1973 and the staggering inflation, unemployment, and social problems caused by the increase in energy prices (Hobsbawm, 2014). This is even more relevant in Western Europe, which is dependent on the Near East, North Africa, and Russia for energy. For countries like Spain, the cost of energy conditions its economy and ensures a trade deficit, in addition to its dependence on regimes that are not always stable or friendly. In Europe, nuclear energy is increasingly looked upon negatively due to its danger to the environment,



although it is the cheapest way of avoiding dependence on other countries for energy. Neither is the United States energy independent and tries, by means of its military and diplomatic dominance, to ensure low cost sources of energy. Without this energy it would be impossible to sustain the prosperity of Western powers. As a result, they have been considering solutions such as the use of clean and renewable energy for years. Nonetheless, hybrid motors (electric and fossil fuel-based) as well as pure electric motors have only just begun to slowly gain traction. They are still not sufficiently competitive for industry or end-users, so this represents stagnation in terms of reducing atmospheric pollution. Nevertheless, it is obvious that this is the future, not just for environmental reasons but also due to the enormous cost of energy.

The Asian powers, lead by China, also depend on fossil fuels, which they, too, lack. As a result, together with the West, they compete to produce vehicles that are ever more cost-effective and cleaner. The challenge is both economic and environmental. Meanwhile, wind, solar, and hydroelectric energy seem to be the only viable path to avoid a total collapse of the planet.

The Internet and social networks: a connected world?

Today's hyper-connected world, with the web 3.0, has generated fear of a dystopia where large multinationals are beyond the control of governments, who had been the key actors till this point. Moreover, Chomsky (2021) plays down the importance of these changes, indicating that the arrival of the telegraph in the 19th century was much more relevant at the time than email, even though the latter is instantaneous. In perspective, he asserted that the qualitative leap forward had already occurred.

In any event, the internet has generated a fourth economic sector in addition to the three traditional ones. Without new technology, it is impossible to understand a single iota of our daily lives. It modifies the exchange of ideas and products and accelerates the whole process. This also creates problems, such as fake news, and information saturation make it difficult for citizens to differentiate between real and fake information.

Social networks are also becoming obsolete. Initial variants (Facebook), aimed at exchanging messages, images, or news, now face competition from others where the importance is on streaming content, virtual reality, and immediacy (Twitter, Tik Tok, and Twitch). Young people no longer get information from TV or the press (not even digital formats) but rather from viral news and videos. The paradigm of bookish culture is at stake, in the face of an increasingly sedate worldview based on audiovisual stimulus and entertainment. This goes so far as to affect electoral processes, and it is now impossible to win a race without considering campaigning on social networks.

World powers compete to control the information flowing on the internet. Aside from controlling the dark net and the geolocation of possible suspects, privacy and personal freedoms are restricted in pursuit of greater collective security. China censors Google, Facebook, and Whatsapp and only allows the use of its own web browsers, messaging programs, and social networks because it mistrusts American technology, even though Apple manufactures its *iphones* there. China is more advanced than the West in the build



out of its 5G network, although the US and Europe do not seem likely to install this technology to avoid being surveilled by the competition. However, in Europe, despite judicial sentences, we accept the hegemony of large American companies that spy on the population, businesses, and governments at the same time that they evade taxes by operating from tax havens.

The countries and sectors not connected to this rampant technological growth are marginalized, including poor people and many older people in western countries. The so-called digital gap impedes access to information and leisure but also to basic services: benefits, education, banking, and business. Marginalization of the analog world even affects teaching and learning from an early age. The preeminence of the digital world has not come about to improve an understanding of the world but rather to facilitate the development of capitalism in a new phase. It seeks impersonal entertainment and consumerism with the creation of non-places and non-cities in which everything is the same everywhere in the world: housing, leisure centers, offices, and transportation hubs. This homogenization implies increasing inequality and does not contribute to more balanced or environmentally friendly growth. Sociologists such as Bauman (2016) and Han (2021a) have been warning of this for some time: a system of liquid societies, with increasingly indistinct identities and a process that makes social and work relationships impersonal. A more connected world but with more monitoring and surveillance. A large part of the population accepts this infringement on their rights and freedoms in exchange for more leisure and free technological applications. When the cost is zero, the price is paid in intimacy, but this trend prevails to avoid being left out by family and friends.

5. Technology and social improvements. Unlimited growth?

Technology and society

The eminent sociologist Lewis Mumford pointed out decades ago in one of his most important works, *Technics and Civilization* (1934), that every machine or technology has its root in society, that is, neither machines nor technology exist separate from the societies that produce them. In his words, "The machine itself, however, is a product of human ingenuity and effort: hence to understand the machine is not merely a first step toward re-orienting our civilization: it is also a means toward understanding society and toward knowing ourselves."

Every machine, like all literature, history, medicine, or politics responds to the changing social needs at that juncture. Technology is developed in the heart of a society to meet distinct needs or to satisfy specific interests. In itself, there is no *good* or *bad* technology but rather uses that are more appropriate than others. The development of mobile communications technology, to give just one example, has contributed to reducing physical distances and to keeping people in contact; that is, it has solved a problem of modern society, which is increasingly willing to leave its origins behind but not to lose contact with its home environment. When this basic, primary function was largely met, problems began to arise related to excessive time spent in front of mobile device





screens, the image worship we project on networks, or the need to be permanently connected while spewing personal information and data all over the internet, which are difficult to remove later.

5.2. Technological innovations: the social impact

Another problem arising from technological development is related to the consumption of energy and natural resources. Cameron and Neal (2005), not without reason, asserted that presently "there is no doubt that the world—above all rich nations—is consuming resources at an unprecedented pace in history. This in itself provides a measure of its capacity to dominate the environment and solve the economic problem, but it has also given rise to the fear that resources will run out."

Recognizing the risks that every technological development may pose, in recent years an expression has come into use, 'social technology', which underscores the utility of technology to solve social problems while meeting four basic requirements or principals: simplicity, limited environmental impact, low production cost, and ease of application. According to the *Fundacion Iberdrola* report, social technology "uses all of the digital knowledge and tools available to transform society. The term emerged at the end of the 19th century and has evolved to its present use in identifying and solving the key challenges for humanity: inequality, poverty, hunger and the democratization of access to energy, work, education, and health" (<https://www.iberdrola.com/compromiso-social/tecnologia-social>).

From this perspective, technology can be an efficient ally in identifying solutions to environmental problems and even achieving the Sustainable Development Objectives prioritized by international organizations such as the United Nations. In this sense, in line with the previously mentioned report, the social impact of technology could contribute to:

- Promoting access to information;
- Facilitating data collection and analysis;
- Fostering the creation of new business models;
- Increasing online fundraising;
- Developing new models of reality;
- Offering modified products and services;
- Modernizing productive processes.

According to Peter Thomson, president of the United Nations General Assembly in 2017, as cited by Sandra Paniagua (*El Independiente*, 6/10/2018): "all over the world, smartphones are used to provide financial services to those without bank accounts, to diagnose medical conditions, and to remotely manage care for the chronically ill. We can see how solar panels are used to power flood early warning systems as well as to track marine animal migration and populations and combat illegal fishing. The transformative power of science, innovation, and technology is abundant and obvious" (<https://www.elindependiente.com/desarrollo-sostenible/2018/10/06/tecnologia-social-para-mejorar-el-mundo/>).





6. Consequences of the transformation to transportation and communications

Discoveries and acculturation

The prevalence of technology has given Europe and the West primacy in world history in terms of dominating the economy and geopolitics since the end of the Middle Ages, while seeking new markets and areas of influence. In passing, it has imposed its languages, beliefs, and forms of social organization. The test case, at the Euro-Mediterranean level, was the Roman Empire, which became the model for hegemonic political entities. In the age of discoveries, the Spanish and Portuguese established mestizo societies in America with black slave labor. As these were poor civilizations that were less technologically developed (including the Aztecs and Incas), Europeans imposed their religions, languages, and other identity traits (Todorov, 1987). This was even more the case in other areas where the indigenous peoples were more primitive, such as in North America.

As for Africa, Asia, and Oceania, the colonizing experience spread, notably, in the 19th century. There was not as much mixing between the colonizers and the indigenous peoples. In Africa, there were evangelical efforts, especially in the central and southern regions of the continent, though not as much in the north where Islamic beliefs had prevailed since medieval times. In the far east, cultures and religions were older than Christianity, so there were no mass conversions among local populations. The model was similar in Oceania, but given the limited local population, the majority of the present population descends from white Europeans.

This white, Christian, and western hegemony is in crisis. The state of emergency of civil rights and the independence of former colonies have called into question the world system imposed by the rich north. Even after the fall of the Soviet Union, the US cannot police the world nor spread its political system to the remaining world powers, regardless of its military dominance (Rifkin, 2011). Presently, Russia, Turkey, and China are re-emerging as world powers, having previously been dormant due to poverty, the end of their empires, or internal destabilization. The European Union as an actor has increasingly less clout, as evidenced by Brexit. Under the umbrella of NATO, which toes the American line, Europeans attempt to limit military spending while they try to save what remains of their welfare states after subsequent crises and a lack of demographic support, which is only compensated by migrant labor. Only Germany appears to preserve some vitality in its export industry. International dialog is less and less Atlantic and more and more Pacific, and the rivalry between China and the US has become evident through settings and actors befitting a new Cold War: North Korea, Japan, and Taiwan.

Hegemony or dependence?

The end of the Cold War made even the most ardent liberals believe in an ideal world with a single capitalist system and western parliamentary democracies. This has been shown to be unsustainable; despite the enormous military spending of the US, they





cannot win on all fronts, not even with the best technology nor naval and military bases across the planet. After 9-11, the war on international terrorism caused priorities to change after decades battling the Soviets and their satellites (Hobsbawm, 2014). But a unipolar world does not exist.

At the start of the 21st century, the world is witnessing the emergence of world powers that have been sleeping for decades (Russia) or centuries (China) and who view American hegemony negatively. They will not allow Western powers to expand their control to areas they consider within their traditional sphere of influence: the former Soviet bloc or the South China Sea, respectively. They have also begun a new arms race. War is no longer waged only with troops, tanks, and fighter jets but also with drones and satellites. It also means arming allies, even though they might change sides in a blowback effect, as in the case of the Afghan Taliban, who were provided weapons by the US and Persian Gulf Monarchies to expel the Soviets.

The Near East is far from peaceful. The Israeli-Arab conflict, the Arab Spring, and the Syrian and Yemeni wars make governance in this area difficult and alliances fragile. Conflict between Iran and Israel, with nuclear development in the background, as well as Sunni-Shia antagonism are persistent threats. In addition, the failed wars in Afghanistan, Iraq, and Libya may have removed dictators, but they have caused more chaos and misery for the population.

Latin America and Africa both face structural problems of poverty, unemployment, insecurity, young populations without a future, and authoritarian regimes. Migration is seen as a threat to countries in the north. Hence, they seek stopgap solutions that guarantee impervious borders. The role of Mexico and Morocco is just that, to ensure a calm southern border for the US and Europe, respectively, in exchange for million dollar grants. However, walls do not stop migrants nor poverty, especially while wars in North Africa and the Middle East and the growing misery in Latin America push millions of people to find a desperate solution.

The West's reliance on cheap labor and raw materials from the southern hemisphere is evident. The well-being of the West contrasts with the misery in which a large part of the population of the world lives—a lack of rights and freedoms, not to mention the growing inequalities in the heart of rich countries. Neoliberal policies and offshoring industry have caused basic sectors of the economy to be outsourced or performed with ever more modern machinery. One of the biggest challenges in the near future is reconciling those technological advances with massive job losses and social instability. We have gone from the industrial era to the collaborative stage (Rifkin, 2011). The golden age of capitalism, after the Second World War, ended in 1973. In the West, over the last half a century, important progress has been made in regards to the rights of women, children, religious freedom, and racial and sexual tolerance. There is still much to be done, but it is unusual in the rest of the world.

A war, natural disaster, or epidemic affects everyone to a greater or lesser extent in an increasingly interdependent world. China and other Asian countries are the workshop of the world, as well as the financiers of indebted western economies. At a European level, the COVID-19 epidemic has demonstrated the need to strengthen critical sectors of industry and the supply chain, stop cutting the budget for public services, and start





boosting a green and circular economy (Pardo, 2015). This will be difficult to achieve if developing countries or those that pollute the most reject these ideas. Many of the problems of hunger and misery around the world are related to a lack of food and water, in addition to the persecution of dissidents and minorities. Climate change and growing inequalities are the biggest challenges, not just for Europe but for the planet.

Glossary of concepts

Acculturation: the imposition of a hegemonic culture upon others by means of political, economic, and military dominance of the western powers, which have spread their social and cultural models to their colonies in the Americas, Africa, Asia, and Oceania. They are imposed in different manners, according to the extent of cultural development and the era in which each territory is annexed to the metropole. This heritage continues to weigh on the division between rich and poor countries.

Capitalism: a production model based on profit and private initiative. Although it emerged with European colonial expansion in the 16th century, it was entrenched as a hegemonic system starting with the Industrial Revolution. It is based on the free market and exporting manufactured goods. It creates a poor working class (proletariat) that emigrate from rural areas and an elite bourgeoisie that are owners of factories and capital.

Feudalism: a production method based on hierarchical relationships of dependence between lords and vassals. It arose in the European Middle Ages and was based on loyalty and a system of hierarchy including work obligations as well as obedience to and military service on behalf of a Lord (lay or religious).

Industrial Revolution: a process of mechanization of work that increases the profits and production of capital. It started at the end of the 18th century in England and spread to Europe and the United States in the 19th century. It enabled the achievement of technological advances, putting the western capitalist powers at the vanguard of economic development and political hegemony.

Slavery: a production model based on labor provided by bond-servants that submit to masters or slave owners who dictate their work and lives. It arose with the first civilizations in antiquity and was perpetuated in the modern contemporary periods as the basis of production in overseas colonies. It was key to the economic development of European metropolises.

Social networks: these arose as an evolution of the web 3.0 at the start of the 21st century and allow for interaction in real time between large numbers of individuals. They are part of the so-called collaborative and horizontal internet, communities of users that share content thanks to permanent internet connections. They determine the means of



communication, advertising, and personal and work relationships in present day societies.

Social technology: The use of technology to solve social problems by meeting four requirements or principles: simplicity, limited environmental impact, low production costs, and ease of application.

Technological revolution: Technological revolution can be understood as a state of common social and economic transformations for the majority of the population that result from the implementation of technological advances. What characterizes a *technological revolution* is not just a confluence of a series of processes tied to technological ingenuity but also the economic, political, and cultural consequences that come about as a result of the use of new technology.

Urbanization: The establishment of population centers and key socio-economic activities in cities. This process started with the first civilizations in the Middle East and Mediterranean, where writing and a governing elite also emerged, based on religious, legal, and military primacy.

Web resources

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Disclaimer

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.





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HistoryLab for European Civic Engagement 2020-1-ES01-KA226-HE-095430

