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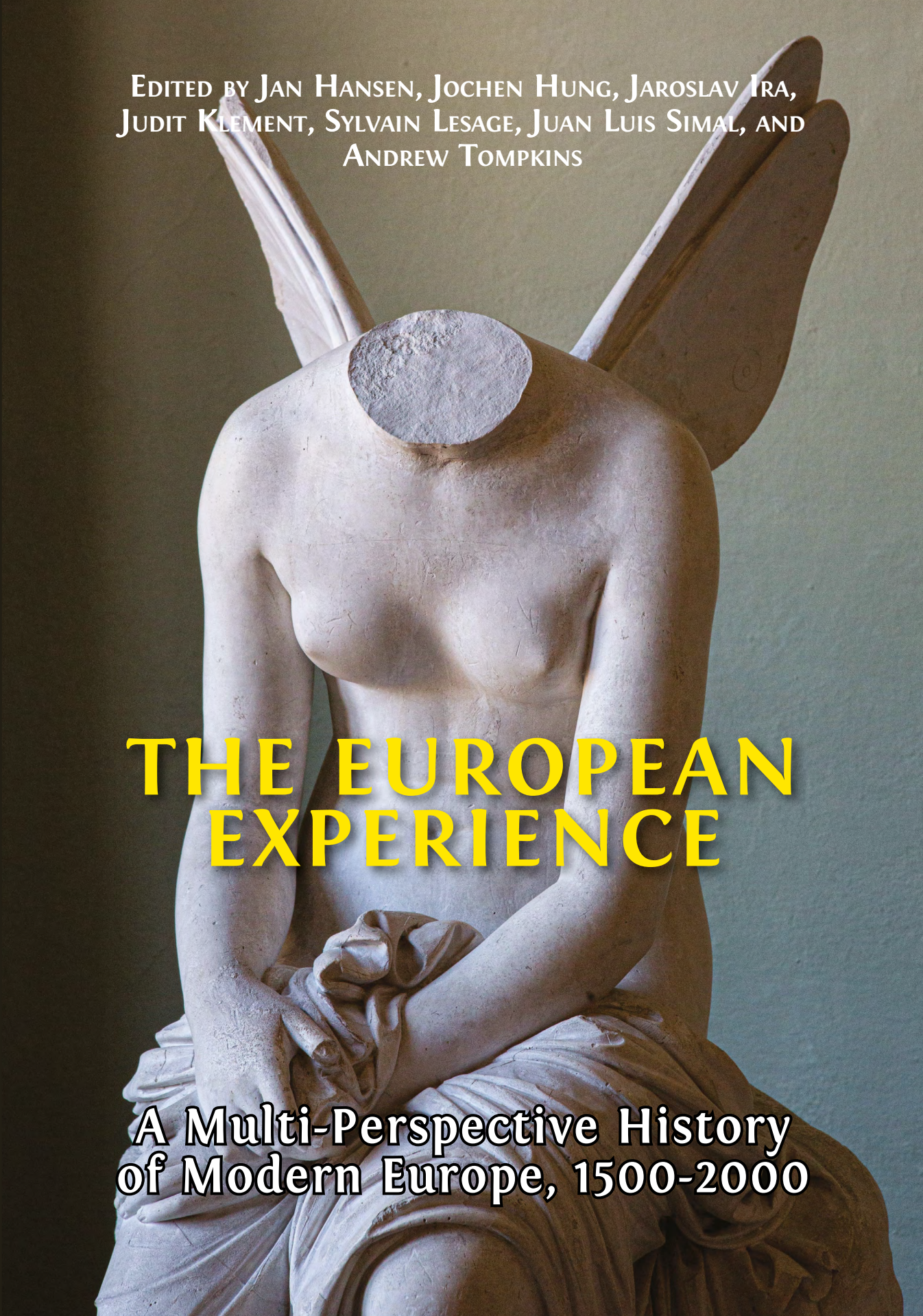

The European Experience

A Multi-Perspective History of Modern Europe, 1500-2000

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Jan Hansen, Jochen Hung, Jaroslav Ira, Judit Klement, Sylvain Lesage, Juan Luis Simal and Andrew Tompkins (eds), *The European Experience: A Multi-Perspective History of Modern Europe*. Cambridge, UK: Open Book Publishers, 2023, https://doi.org/10.11647/OBP.0323

Digital material and resources associated with this volume are available at https://doi.org/10.11647/OBP.0323#resources

This book is one of the outcomes of the Erasmus+ Strategic Partnership "Teaching European History in the 21st Century", which ran from 2019-2022 and was funded by the European Commission under the Erasmus+ Key Action 2 (Cooperation for innovation and the exchange of good practices).

ISBN Paperback: 978-1-80064-870-8
ISBN Hardback: 978-1-80064-871-5
ISBN Digital (PDF): 978-1-80064-872-2
ISBN Digital ebook (epub): 978-1-80064-873-9
ISBN Digital ebook (azw3): 978-1-80064-874-6
ISBN XML: 978-1-80064-875-3
ISBN HTML: 978-1-80064-876-0
DOI: 10.11647/OBP.0323

Cover image: Wilhelm Gunkel, *Fly Angel Fly* (2019). Cover design by Katy Saunders

4.1.3 Science and Technological Change in Contemporary History (ca. 1900–2000)

Mathias Grote, Jiří Janáč, and Darina Martykánová

Introduction

The 'short' twentieth century, bounded by the outbreak of the First World War (1914) and the end of the Cold War (1989), has been called the "age of extremes" (Eric Hobsbawm). Certainly unique in terms of political history, this period's significant acceleration of technological change would undoubtedly rank high among those extremes. Processes of development and the implementation of new technological innovations became more deeply institutionalised and systematic than ever before, with states playing an increasingly active role. Furthermore, the production of innovations was built upon a growing state involvement with scientific research, which correspondingly became more and more organised. Advances in energy production and long-distance power transmission enabled the electrification of factories and households both in the cities and in rural areas, which sped up in the decades immediately following the Second World War. The rapid development and expansion of infrastructural systems such as central heating, water supply, transportation and the electrical grid significantly transformed people's lives and living environments—urban areas were gradually getting rid of the ubiquitous coal dust, hygiene and housing standards improved, and livestock disappeared, first from urban yards and later from most of the country dwellings. New synthetic materials such as nylon or Bakelite made fashion and various technological gadgets more accessible to everyone. Various electric home appliances introduced on the European markets transformed the organisation of family life. Science and technology, now joined into an inseparable whole, reconfigured their European users who, for their part, started to consciously influence and shape

 https://doi.org/10.11647/OBP.0323.42

the direction of scientific and technological change with a growing intensity, particularly once they became aware of substantial downsides to ever-growing living standards—chiefly environmental degradation, but also increased dependence on complex technological systems.

Science and Engineering

The beginning of the First World War marked a break in the development of the sciences and the humanities. Many researchers on both sides rapidly endorsed nationalist rhetoric, using achievements as well as traditions for propaganda, but it was the physical and the chemical sciences in particular that became actively involved in warfare. While chlorine gas was originally intended for use in the trenches of Belgium and France in 1915 to remedy shortages of ammunition, specific chemical weapons were subsequently developed and have since been used repeatedly.

The Second World War reinforced this picture: the development of airplanes and rocketry should be mentioned alongside secretive projects to develop an atomic bomb, which used the skills and hard work of a great number of physicists, chemists, and engineers. While the American 'Manhattan Project' represented the largest and most consequential of these projects, Nazi Germany and the Soviet Union pursued these goals as well. Where gas warfare relied on the knowledge of organic chemistry and physiology, the atomic bomb was based on the discovery of radioactivity (Marie Skłodowska Curie), insights into the make-up of atoms and quantum mechanics (Niels Bohr) as well as Albert Einstein's relativity theory.

Meanwhile, biology's fall from grace in the period up to 1945 was eugenics. Research to 'improve' humankind's genetic make-up was conceived of as a strategy to cope with the perceived 'degradation' of human beings, due to social problems of industrialisation and urbanisation (alcoholism, neglect, prostitution). It rapidly became fused with racist theories from anthropology, often related to colonialism, as well as long-standing prejudices against Jewish or Roma Europeans, among others. Eugenic thought and practice, including sterilisation programmes, were widespread in many countries and endorsed by various political actors during the 1920s and 1930s, but the field reached a completely different dimension under German National Socialism after 1933. Antisemitic legislation and the murder of asylum inmates display clear continuities with the Holocaust, which many German scientists and medical doctors approved of, carried out actively, or used as an opportunity for their research.

After 1918 and 1945, the active enrolment of science in discrimination, war, and genocide provoked widespread disillusionment and doubt over its

civilising role—which had previously been firmly linked to Enlightenment ideals of rationality, cosmopolitanism, and benefit for humankind. Following Friedrich Nietzsche, Sigmund Freud, and other critics from the humanities, the scientific pursuit has been understood as a display of power over others and nature. This downfall of the sciences from the pinnacle of optimism they had reached in the long nineteenth century, however, should not obscure the fact that the sciences have also remained an agent of cooperation, pacifism, and increasing human welfare, not least through international organisations such as the World Health Organization or Paris-based UNESCO.

The Cold War led to an ideological polarisation of the sciences across the Iron Curtain that split Europe along a line from the Baltic Sea to the Adriatic. The best-known and most infamous example of this divergence relates to the inheritance of acquired characteristics championed by the Soviet agronomist Trofim Lysenko, which was at odds with Mendelian genetics, but matched well with the premises of Marxism-Leninism under Stalin. 'Lysenkoism' was considered as 'pseudoscience' in Western Europe and America. Ideological fault lines divided researchers and accelerated superpower competition, such as the development of aeronautics (with the launch of the first satellite, Sputnik, by the Soviet Union in 1957, followed by NASA's moon landing in 1969), or advancements in automatisation, information science and early computing (grouped under cybernetics, the science of steering and control). Yet, the sciences also developed tendencies to overcome division: first, through international organisations such as the Geneva-based Conseil Européen pour la Recherche Nucléaire (European Council for Nuclear Research, CERN) or the European Molecular Biology Laboratory (EMBL, Heidelberg/Cambridge, UK). Second, researchers began to actively reflect on their involvement in the "military-industrial complex" (Eisenhower). They shifted, for example, from nuclear research to ecology, formed civil society associations or became politically active on both sides of the Iron Curtain, for issues like disarmament, gender and economic equality, or the environment.

Needless to say, the fall of the Berlin Wall in 1989 and the disintegration of the Soviet Union in 1991 introduced another turn for the development of the sciences in Europe. Large-scale institutional changes in Central and Eastern European countries, along with shortages of public finances, led to migrations of highly skilled personnel westwards, where computing, genomics, and biotechnology became the most prominent fields. Since the 1980s, these fields have focussed on the persona of the scientific entrepreneur and business models such as the 'start-up'.

Conceptually, the scientific twentieth century has often been characterised by its discontinuous and dramatic changes, or 'scientific revolutions'. While this concept clearly draws on the early modern study of nature, associated

with names such as Bacon, Copernicus, Descartes or Huygens, the model of scientific revolutions put forward by physicist-philosopher Thomas Kuhn took inspiration instead from the rupture of classical Newtonian physics with the early-twentieth-century theories of quantum mechanics and relativity. For the life sciences, the mid-century surge of molecular biology tied to the DNA double helix discovered by James Crick, Rosalind Franklin, and James Watson, has also been evoked as a scientific revolution.

Fig. 1.: Aleksandr Nevezhin, "A family standing in front of the Monument to the Conquerors of Space in Moscow" (1964), CC BY 3.0, Wikimedia, https://commons.wikimedia.org/wiki/File:RIAN_archive_557655_Second_Moscow_Watch_Factory_locksmith%27s_family.jpg.

Politics of Technology

Growing dependence on technology in all spheres of human activity, together with prevailing enthusiasm for its power to improve the world, opened space for the knowledge and ideologies of science and technology to be broadly applied in the management of human affairs. Building on the argument that technology and innovation bring progress and prosperity—and that engineers with their technical expertise are uniquely equipped to manage such a change (framed as 'development')—governments across Europe started to contemplate and implement designs to run the state and

social affairs as a problem of engineering, rather than politics, in the interwar period. The technification of administering social affairs, emphasising ideas of rationalisation, standardisation, and de-politisation, resulted in a large-scale proliferation of 'scientific planning'. In response to the Great Depression of the 1930s, technocratic forms of governance grew in relevance and popularity. The atmosphere of post-war reconstruction gave further urgency to such attitudes, peaking in the 1950s and 1960s—a period often characterised as 'high modernism'. In the name of 'national development' for all, and not of profit for a few, technologies were employed in the construction of large public works, predominantly various types of technical infrastructures, which secured general improvements in living standards. Consider large dams and flushing toilets, cold chain logistics and home freezers, to name a few. Particularly under the authoritarian regimes of Eastern Europe during the Cold War, state authorities and their expert bureaucracies acquired substantial administrative powers with which grand designs to transform and order nature and society could be developed. That said, Soviet attempts at planned industrialisation and the transformation of nature (in Stalin's Great Plan of the late 1940s) and even human beings (the "New Soviet Man") differed only in scale rather than in quality from Western European proposals for rational housing and urbanism (see Le Corbusier, for example), or for river-improvement schemes designed as blueprints for large-scale social transformation through technology.

Military technologies and military systems-building—themselves products of state-building—were the crucial driving force behind technological innovation in the modern era. In the pre-modern period, military technologies reflected change rather than fuelling it: consider the relative stability of navy ship design from the fifteenth to eighteenth centuries. But by the twentieth century, the combined effect of industrialisation and the state's growing role in society (including its management of technological innovations) had ushered in the state-sponsored development of technological change. This also blurred the threshold between peace and war, as nation-states tended to employ war as a political tool. Particularly since the Second World War, national military-industrial complexes have been driving technological change. Developments of missiles (rocket science, associated especially with pre-war Soviet and German military research programmes) and nuclear technologies (United States) can serve as primary examples here. Computing and the Internet—again, predominantly developed by US actors (ARPANET) and later imported to Europe—clearly document such a tendency. The ideas of automation (the reduction of human factors in processes ranging from factory production to data collection and communications) and digitisation (the conversion of data into a computer-readable format) did indeed receive prominent attention from military strategists, who faced wartime labour shortages at home and

the risk of losses on the warfronts. The dawn of the 'information age', in which machines started to communicate with each other seemingly without human intervention, arrived in the military sphere decades before computation reached individual consumers.

But technologies and technical expertise did not blossom solely under the auspices of the growing power of the state. After the First World War, experts developed pan-European efforts and organisations aiming at the formation of a 'European' technological space, interconnected through common infrastructures, standards and regulatory regimes for the use of technologies. During the Great Depression, pan-European expert organisations developed plans which explicitly tied the building and operation of networks with the idea of Europe (what scholars such as Frank Schipper and Johan Schot call "infrastructural Europeanism"). After the Second World War, the cooperation of European nations in technology development and regulation intensified on both sides of the Iron Curtain. Nuclear technology provides an illustrative example here. In the West, an intergovernmental research organisation called CERN appeared in 1951, soon to be followed by the Joint Institute for Nuclear Research (JINR) in Moscow. Other examples would be the European Space Agency (1975) or the rather less successful case of the Eurofighter Typhoon. Despite the existence of the Iron Curtain, the second half of the twentieth century witnessed a slow and contested process of technological integration across the continent, which contributed to the successful reintegration of both sides after 1989. Europe's international E-road network, the interconnected power grid, and the standardisation of television and radio broadcasting systems represent illustrative examples.

Nonetheless, the overwhelming march of modernity—imagined as the wheels of 'inevitable' progress transforming lives and landscapes across Europe—aroused the suspicion of those who feared, perhaps naturally, the potential of technology to subvert divine, human, or natural orders, variously defined. Envisioning an ultimate clash between man and machine, critics of technology often claimed to defend the cause of humanity against de-humanising mechanisation and the reductive over-rationalisation of life from the position of morals and ethics. With the arrival of the Great Depression such voices became louder, perhaps best captured by Aldous Huxley's dystopian novel *Brave New World* (1931). Technological innovations related to the Second World War, including nuclear power and rocket science with their combined potential to eradicate humanity, added new urgency to the debate. European philosophers and public intellectuals such as Jacques Ellul and Martin Heidegger published radical and penetrating critiques in the mid-1950s, of modern society's domination by technology, thereby echoing the dystopian vision of technology that the Frankfurt School's Theodor W. Adorno

and Max Horkheimer had brought forward a few years earlier in response to genocide and war. These sophisticated arguments challenged the image of technology as a blessing, or as a neutral tool to be employed either for good or evil. Meanwhile, many contemporaries started to observe the visibly harmful effects of technological progress with growing uneasiness. Cataclysmic events such as the 1963 collapse of the Vajont Dam in Northern Italy, leading to 2000 casualties, or the dramatic and pollution-induced forest dieback in Germany during the 1970s and 1980s (*Waldsterben*), continued to fuel popular criticism of technology. This pinnacled in response to the Chernobyl disaster of 1986: the accident at the Soviet nuclear power plant quickly became a symbol of the destructive potential of technology. In the following years, not only did Europeans largely reject further construction of nuclear power plants, they also abandoned various other large technological projects (for example, the construction of multipurpose dams), referring to their problematic impact on the environment and on humanity. Once apostles of techno-optimism and technological progress, Europeans turned techno-cautious.

Technology, Science, and the Global Market

The commercialisation of technology worldwide is no new phenomenon. In the early modern era, for instance, pistols and watches had travelled thousands of kilometres and crossed the ocean to reach their buyers. In the twentieth century, imports and exports of technology grew unprecedentedly. This worldwide trade, heavily dominated by products made in Europe and North America, was at the same time accompanied by a growing consciousness among governing elites that relying on imports could have serious repercussions on their countries' sovereignty. Therefore, nationalist leaders all over the world promoted policies of industrialisation, creating or boosting local industries that were both state-owned and privately owned. In general, the aim was not for complete self-sufficiency but rather to reduce the political and economic dangers of dependence on particular providers. Moreover, this was also part of an effort to join the group of the so-called developed countries, a category linked to infrastructural development and industrial production, among other criteria. For countries emerging from the process of de-colonialisation, but also for independent countries whose economy had long been dominated by European companies and investors, the control of natural resources was a key political issue: nationalising existing infrastructures (refineries, mines) and constructing dams and powerplants were measures implemented by all sorts of regimes, left and right, authoritarian and democratic. During the Cold War, the countries of the so-called Third World skilfully exploited the rivalries between and within the two blocks in order to secure advantageous conditions

for drug licences, to expand and build transport and energy infrastructures, or to get help in training a skilled workforce, including high-level technical experts. Syrian, Egyptian, Indian, Vietnamese, and Latin American youth studied engineering, medicine, physics and other 'useful' degrees in the USA, USSR, France, West and East Germany, Czechoslovakia, and other European countries on both sides of the Iron Curtain. They were sponsored by their home governments, but also by the host countries as a way of expanding their political, economic, and cultural influence.

By 1970, many countries beyond Europe and North America were producing bikes, motorcycles, cars, fridges, radio, televisions, and washing machines. The aviation industry, beyond small aircraft, remained a privilege of few global centres. While some of these national industries were not profitable, as the century progressed many countries beyond Europe and North America found success in producing all kinds of technologies, for export as well as domestic demand. Since the 1970s, the state often retreated from these industries. Many of them flourished under private ownership, but we should not forget that without public intervention they would have never come to exist in the first place. Moreover, in the second half of the century there were several non-European countries able to compete and succeed in development and industrial production at the global level, namely Japan, South Korea and, towards the end of the century, also China and Brazil (Embraer airplanes). Robotics, computers and gaming gadgets such as those produced by Nintendo clearly show that East Asian countries are not merely skilful imitators of a 'Western' technology, but instead that they have contributed on more than equal terms to shape technological development in the twentieth and twenty-first centuries, setting trends in the production and consumption of technology. While the logic of the national economy dominated technological production during the middle decades of the century, the closing decades were marked by a process of globalisation and de-localisation: the actual production of goods moved from rich, industrialised countries, to countries that could provide large firms with human capital and reasonable infrastructures, but without strong efforts to impose environmental and labour regulations. High-tech industries have been impacted less by this trend, while the more optimistic view among economists is that the so-called knowledge economy is now the highest stage of human economic development in a globalised world. However, the issue of how scientific research and technology are shaped by power and identity (including the specific locations of company headquarters and their sites of production; the legal framework that regulates the research, patenting, production, testing, distribution and use of technologies—and even the nationalities of researchers and producers) has been brought back into the

limelight during the Covid-19 pandemic, not only regarding vaccines, but also concerning simple 'technologies' such as facemasks.

Conclusion

The sciences as a stronghold of rationality became disputed in the twentieth century by means of their inextricable involvement with aggression towards and domination of humankind and nature. What is more, reflections on the natural sciences, not least in the humanities, psychology, or the social sciences, have questioned their optimistic pursuit of models of linear progress—increasingly so in the last third of the century. In light of the challenges of the twenty-first century, such as climate change and rising authoritarianism, it may seem that the tide has changed once more, with the sciences again finding frequent association with the cause of democracy and progress. Regarding the development of technology, some authors describe the second half of the twentieth century as the period of Americanisation—a process during which Europeans embraced and internalised the principles of a consumer society. Technological gadgets, such as fancy cars, refrigerators, portable radios, colour television, or more recently mobile phones, all contributed significantly to that process. Living in an affluent society built on the constant production of new innovations provided by technoscientific research, Europeans were slow to realise and admit to the harmful effects of the global extension of their supply networks. Enjoying the fruits of technological 'progress', their longing for new and better instruments and things helped to spin the wheels of global capitalism and significantly contributed to anthropogenic changes in the environment, with potentially hazardous effects on the entire planet. Now, somewhat paradoxically, they are again invoking the capacity of state-organised science and technology to confront global threats and challenges, by redirecting the aims of technological politics from provision of welfare towards sustainability and environmental protection.

Discussion questions

1. What was the role of the Cold War in the development of technological change in Europe?
2. Why did Europeans become "techno-cautious" in the late twentieth century? Do you think they were right?
3. Which of all the inventions mentioned in the text was the most consequential for the twentieth century in your opinion? Why?

Suggested reading

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