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A Comparative Study of the Impact of Technological Policymaking on Environmental Security in the United States and the European Union

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Abstract

In the era of the Fourth Industrial Revolution, new technologies have developed with unprecedented speed, efficiency, and convergence, bridging the digital, physical, and biological boundaries. At the same time, environmental crises have become a serious threat to global security. The United States and the European Union have been designing and implementing policies to protect the environment since the 1960s. Using a documentary study method and a descriptive-analytical approach, this article seeks to find out what impact the technological policies of the European Union and the United States have had on environmental security. The results of the research indicate that alignment between technological policies and environmental goals is a prerequisite for achieving sustainable development and ensuring environmental security. The European Union has been able to create effective synergies between technology and environmental goals by developing comprehensive policies such as the Lisbon Strategy, Europe 2020, and Horizon Europe, as well as implementing programs such as the Green Deal, the circular economy, and the clean energy transition. In contrast, the United States, despite political fluctuations in the environmental field, has been developing clean technologies and optimizing energy consumption through technological innovations in the private sector. However, recent geopolitical challenges, such as the Ukraine war, have disrupted environmental policies in both regions, such as budget cuts, a partial return to fossil fuels, and a focus on short-term energy security.

Keywords: *European Union; Environmental Security; Sustainable Development; Technological Policymaking; United States*

Introduction

The advent of the Fourth Industrial Revolution has brought about a fundamental change in the field of technology and innovation; today, technologies are not only developing more rapidly and more widely, but are also increasingly merging and intertwining with each other. Meanwhile, the integration of digital, physical, and biological dimensions has led to profound changes in the economic, social, and environmental structures of societies. In such circumstances, new technologies play a decisive role in facilitating or exacerbating

environmental crises, a crisis that has become one of the main challenges of human life today. The environment, as one of the fundamental pillars of global security, is directly linked to the quality of human life, natural resources, and the future of future generations. Disruption of the balance between vital elements such as land, water, and humans can undermine the ecological foundations and philosophy of human life. Since the 1960s, the European Union and the United States, as two major global powers, have made efforts to develop policies and manage technology to protect the environment. However, differences in governance structures, technological approaches, and geopolitical circumstances have led to different paths in policymaking between these two actors.

The present study, with a descriptive-analytical approach and documentary study method, seeks to answer the fundamental question of what impact technological policies in the European Union and the United States have had on environmental security. In response to this question, a hypothesis is put forward that the European Union has been able to create effective synergy between innovation and environmental goals through technological policies, while the United States, despite political fluctuations, has highlighted the role of the private sector and technological innovations in optimizing energy consumption and developing clean technologies. The importance of this study is that by comparative analysis of the experiences of the two global powers in the field of technological policies, a deeper understanding of the role of technology in strengthening environmental security can be achieved, and effective models for localizing policies in other countries can be presented. Furthermore, examining the impact of recent geopolitical developments, including the Russia-Ukraine war, on technological and environmental policies allows for a more dynamic and realistic analysis of the interaction between politics, technology, and the environment.

Finally, this research attempts to scientifically explain the link between technology and environmental security, using theoretical frameworks of technological policymaking such as “mission-based policies,” “responsible innovation,” and “sustainable transition,” and to propose solutions for sustainable development at the national and international levels.

Research Background

In recent decades, new technologies have become a key tool for addressing environmental challenges in the context of the Fourth Industrial Revolution. The United States and the European Union have adopted policies to reduce environmental damage since the 1960s. The United States relies on private sector innovation and environmental legislation, while Europe pursues a structured approach, comprehensive strategies, and public investment. These differences reflect different approaches to linking technology with environmental security.

Several studies have examined separate dimensions of technological policymaking and its impact on the environment. For example, Falkner (2023) points to the role of new energies in post-crisis Ukrainian policies, while Reillon (2017) and Kok (2004) have analyzed the European research and innovation policy framework for sustainable development. Also, studies such as Roth & Thum (2010) and Lawn (2002) have emphasized the importance of intangible capital and strategic planning in sustainable economic and environmental growth. However, few studies have examined the impact of technological policies on environmental security between these two global powers in a comparative manner. Aiming to fill this gap, this article provides a comparative analysis of the technological policies of the United States and the European Union in achieving environmental security and attempts to clarify the role of institutional, economic, and geopolitical factors in this direction.

Theoretical Framework

In scientific research, theoretical foundations serve as the foundation that shapes the intellectual and scientific framework of the research and helps to accurately analyze the concepts, theories, and models related

to the subject. Technology policy, as one of the new and important areas in public policy, plays a key role in guiding the development of technology, innovation, and solving macro-social, economic, and environmental problems. Given the complexities and rapid changes of today's world, a deep understanding of the various theories and models of technology policy and their developments is essential in order to design smart, effective, and forward-looking policies. In recent years, technology policy has entered a new phase characterized by approaches such as mission-oriented policymaking, responsible innovation, and the transition to sustainability. In this phase, the goal of technological policymaking is not simply economic growth, but solving global macro issues such as climate change, public health, food security, and social justice is prioritized (Sadeghikia, 1400: 4).

Mission-Oriented Policymaking: A type of strategic approach in technology policymaking whose main goal is to guide innovations towards solving major issues and macro social, economic, and environmental challenges. These policies mobilize innovation resources and mechanisms in a focused and targeted manner by determining "specific and measurable missions" such as combating climate change, promoting public health, or developing clean energy. These policies can be characterized by features such as focusing on macro and impactful goals, cross-sectoral cooperation and broad stakeholder participation, a long-term and dynamic approach to policymaking, and creating open and flexible innovation frameworks (ibid.).

Responsible Innovation: An approach that guides the development of technologies regarding their ethical, social, and environmental consequences. This approach aims to ensure that innovative technologies are transparent, participatory, and ethical at all stages of their development and application, and to prevent the emergence of unintended negative impacts. This approach is considered through mechanisms such as active participation of society and stakeholders, transparency and accountability in innovation processes, continuous assessment of risks and consequences of technology, and respect for human values and rights (Sadeghikia, 1400: 6).

Transition to Sustainability: Transition to sustainability is a process of systemic and structural changes that are directed towards sustainable economic, social, and environmental development. This process pursues the goal of realizing an environmentally friendly economy and an inclusive society by supporting clean technologies, changing production and consumption patterns, and designing comprehensive policies. In the issue of sustainability transition, features such as emphasis on system-oriented and long-term changes, coordination between different social, economic, and environmental sectors, use of new green technologies and social innovations, and facilitating and motivating policies for the transition to a low-carbon economy can be considered (Sadeghikia, 2014: 7).

Therefore, based on existing discussions, the main goals and mechanisms of these theories can be summarized as follows:

Concept	Brief definition	Main goals	Mechanisms/Features
Mission-oriented policymaking	A strategic approach to driving innovation towards solving macro-social and environmental challenges	Achieving big goals such as climate change, health, and clean energy	Defining clear missions, cross-sector collaboration, and open innovation
Responsible innovation	Developing technology concerning ethical, social, and environmental consequences at all stages of the life cycle	Ensuring transparency, ethics, and preventing negative impacts	Public participation, risk assessment, transparency, respect for values
Transition to sustainability	A process of systemic change to create a sustainable and environmentally friendly economy and society.	Sustainable and low-carbon economic-environmental development	Support for green technologies, Changing production/consumption patterns, and facilitating policies

These three concepts complement each other and play a key role in guiding sustainable and responsible innovation in modern technological policymaking, especially in the European Union, the United States, and advanced countries. Overall, the evolution of technological policies from simple and linear models to interactive, systemic, and mission-oriented models shows that the nature of innovation and technological development is complex, contextual, and requires smart governance. However, the European Union, with an integrated, targeted, and long-term approach, has succeeded in designing and implementing a set of technological policies and programs aligned with environmental goals. In contrast, the United States has adopted a different but complementary approach. This country, especially through its private sector and innovation-oriented market, has played an effective role in the development of clean technologies and energy efficiency, which, according to the theories presented, can be achieved by combining these two approaches.

EU Technology Policies

Recognizing the increasing importance of advanced technologies in economic growth, environmental sustainability, and global competitiveness, the European Union has developed its technology policies in the form of long-term strategies and programs in recent decades. Programs such as the Lisbon Strategy, the Europe 2020 Strategy, and Horizon Europe have been designed and implemented to strengthen innovation, increase the share of research and development in GDP, and achieve smart, sustainable, and inclusive growth (Single European Act, 1987). These policies, focusing on areas such as digital technologies, clean energy, combating climate change, and enhancing Europe's scientific and industrial competitiveness, seek to coordinate research and innovation efforts across member states (Lawn, 2002: p. 2). Instruments such as the Research and Development Framework Programs, the European Research Area, and the European Research Council form the institutional framework for these policies (ibid.). Overall, the EU's technology policies are designed to integrate science, innovation, and socio-environmental benefits to guide the Union towards a knowledge-based and sustainable economy. The EU's long-term strategies and plans for innovation and technological development are as follows:

Lisbon Strategy

One of the main axes of technology policy-making in the European Union is the adoption of decisions that are proposed in the framework of the Lisbon Strategy. This strategy, which is known as a comprehensive plan for economic growth and employment, was formed following the extraordinary meeting of the European Council on 23 and 24 March 2000 in Lisbon. The Lisbon Summit is considered a turning point in the common scientific and technological policies of the European Union, and its key objectives include preparing for the transition to a knowledge-based economy, developing new policies for the information society, and strengthening research and development (R&D) [1]activities (European Parliament, 2000: p. 5).

The Lisbon Strategy emphasizes structural reforms aimed at increasing competitiveness, innovation, completing the internal market, and modernizing the European social model. This strategy uses structural indicators to formulate, monitor, and evaluate development progress. Its main objective is to transform the European Union into the most competitive and dynamic knowledge-based economy in the world, and to promote social cohesion. The policy vision is designed by comparing Europe's economic performance with that of the United States and Japan. Also, allocating at least 3 percent of GDP to research and development is a key goal, although Europe lags behind the United States in some technological and digital indicators (Kok, 2004: p. 42).

An assessment of the actions taken within the framework of the Lisbon Strategy and its comparison with the results achieved by the end of 2010 shows that the European Union has failed to achieve most of the objectives of this strategy. One of the reasons for this failure has been the increasing acceleration of technological developments at the global level, as well as the decline in productivity due to the aging population in Europe. These factors have caused the European Union to lose its competitiveness compared to

[1] Research and Development

other global players, especially the United States. According to assessments made by the European Commission, the structure of the Lisbon Strategy has become too complex and multifaceted over time, which has made its effective and coordinated implementation a challenge (European Commission, 2010: p. 18).

Europe 2020 Strategy

Following the relative failure of the Lisbon Strategy due to the 2008 financial crisis, the European Union developed a new strategy in 2010 entitled "Europe 2020". Aiming to boost employment, productivity, and social cohesion, the strategy introduces three main pillars as strategic priorities: smart growth, sustainable growth, and inclusive growth. Smart growth focuses on innovation, education, and digitalization; sustainable growth emphasizes the efficient use of resources and environmental protection; and inclusive growth focuses on job creation and poverty reduction. These three axes provide a comprehensive framework for sustainable development in Europe. Investing in research and development and supporting new ideas play a key role in achieving these goals. Accordingly, innovation is considered a key factor in driving economic growth and enhancing global competitiveness (Roth and Thum, 2010, p. 300). With the publication of the Lisbon Strategy in 2000 and the Europe 2020 Strategy, which was established in 2010, the EU Member States have set the necessary policies for the transition to a production system in which technology, innovation, and research and development are at the forefront.

Framework Programs

Research and development is a key pillar of EU policy, highlighted in strategies such as the Lisbon Strategy and Europe 2020. This approach, in addition to increasing the competitiveness of companies, also helps to create jobs and improve the quality of life. The R&D Framework Programs are designed to align the scientific and innovation policies of the Member States. They strengthen research capacities, transfer technology, and promote innovation with international partnerships through cooperation between universities, industry, and governments, in order to improve Europe's competitive position.

The first Framework Program (1984–1987) was launched in 1984. This program served not only as a planning tool but also as a financial instrument to support the competitiveness of member states and respond to economic crises. (Reillon, 2017)

The second program (1987–1991) was designed with an emphasis on transforming the European Union into a society based on science and technology (European Communities, 1986).

The third program (1990–1994), adopted in 1989, focused on priorities such as supporting basic and applied research, strengthening university-industry relations, encouraging private sector investment, coordinating national strategies, and cooperating with third countries. (Reillon, 2017)

The fourth program (1994–1998) was adopted in April 1994 with a budget of 13.1 billion euros. At this stage, specific programs were implemented in a structured and coordinated manner. (Reillon, 2017)

The Fifth Program (1998–2002), with a budget of 13.7 billion euros in the European Union, was set up based on the principles of "flexibility" and "concentration". (Reillon, 2017)

The Sixth Program (2002–2006) was designed to increase the impact of the programs on scientific development and support advanced technologies, innovation, and the alignment of European research. (Reillon, 2017)

The Seventh Program (2007–2013) sought to consolidate research initiatives to achieve the goals of the Lisbon Strategy (Kim and You, 2019).

The 8th Framework Program (2014–2020) was the EU's research and innovation framework, pursuing three key objectives: scientific excellence, industrial leadership, and responding to societal challenges. In this

framework, a budget of €24 billion was allocated to the area of 'scientific excellence' and €30 billion to the area of 'social change'. Its important objectives include encouraging cooperation between European researchers, investing in key technologies, supporting climate change-related actions, and increasing the productivity of Europe's young population (Kim and You, 2019).

The 9th Framework Program (2021–2027) started in January 2021 and runs until 2027. The main objectives of this program include strengthening the scientific and technological bases of the EU, increasing its innovation capacity and competitiveness, and meeting the priorities of European citizens in line with sustainable economic and social models (Barke and Grammenou, 2020: p. 1).

Horizon Europe

This policy, with a budget of over €95 billion, directs research and innovation funding within and beyond Europe's borders to tackle key global challenges, including climate change, pollution, biodiversity loss, the digital transition, and population ageing. Horizon Europe, through the European Research Council, will continue to strongly support research at the frontiers of knowledge. Created through the Marie Skłodowska-Curie Action to support research in the European Research Area, the program will encourage more young people to pursue research careers and invest in world-class research infrastructure (Horizon Europe Strategic, 2024: p. 1).

The Impact of EU Technology Policies on Environmental Security

The Lisbon Strategy

The environmental impact of this strategy can be said to be significant since it was created in the early 2000s to increase the competitiveness and economic growth of the European Union. Its main goal was to make the European Union "the most dynamic and competitive knowledge-based economy in the world". At that time, attention to sustainable development and environmental protection was introduced as one of the key details. The strategy sought to increase innovation and environmentally friendly technologies that would help improve the environmental situation. However, the strategy has gradually paid more attention to environmental challenges and the need for sustainable development.

Europe 2020 Strategy

The Europe 2020 Strategy, as a comprehensive plan for sustainable and smart growth, includes targets for reducing greenhouse gas emissions, increasing the use of renewable energy, and improving energy efficiency (Falk, 2009: p. 7). The strategy clearly shows how technology policies can help achieve environmental goals. For example, investing in green and innovative technologies can help reduce negative impacts on the environment.

Framework Programs

The Framework Programs are the main research and innovation instruments of the European Union, designed to advance scientific and technological knowledge. They emphasize increasing public awareness and public participation in science and innovation. They focus on clean technologies, resource management, and biodiversity conservation. They also help to solve environmental challenges and reduce pollution by strengthening international cooperation.

Horizon Europe

Horizon Europe, the EU's most important research and innovation program, can play a vital facilitating role, providing funding to support this transition (the green transition). Excellence in Science, the first pillar of Horizon Europe, supports frontier research and valuable scientific ideas by bringing together the best European and non-European researchers and equipping them with world-class research skills and

infrastructure (Reuil, & Others, 2024: p. 2). As the largest EU research and innovation program, it is the main pillar for achieving environmental, climate, and sustainability goals in the EU. Horizon Europe is the scientific, innovative, and implementation arm of the EU's environmental policies. Without this support, achieving goals such as net zero by2050, reducing emissions, preserving biodiversity, and the green transition would not be possible.

Table No. (1) - The impact of European Union technological policies on environmental security

Policy/Program Name	Main Objectives	Impact on Environmental Security	Role of Technology
Lisbon Strategy	Increasing competitiveness and growth of the knowledge-based economy	Primary focus on Sustainable development environmentally friendly technologies	Encouraging innovation And clean technologies
Europe 2020 Strategy	Sustainable and smart growth, reducing greenhouse gas emissions, increasing non-renewable energy	Reducing environmental impact, improving energy efficiency	Investing in green and innovative technologies
EU Framework Programs	Research and innovation in clean technologies, resource management, and biodiversity	Solving environmental challenges, reducing pollution, and preserving resources	Strengthening international cooperation in the field of technology and the environment
EU Green Deal	Transforming Europe into a carbon-neutral continent, a green economy	Reducing negative environmental impacts, sustainable economic transformation	Directing technologies towards the economy, Green, and reducing emissions
Horizon Europe	The largest research and innovation program, budget of 95 billion euros, 2021-2027	Achieving carbon neutrality, preserving biodiversity, and green transition	Financing and implementing a framework for eco-innovations

The Russia-Ukraine War and Its Impact on the Quality of the EU's Technological and Environmental Policies

On February 24, 2022, Russia launched a large-scale war against its western neighbor (Ukraine), and this invasion is considered the largest conventional attack against Europe since World War II. This war, which can be referred to as a new crisis, has made the economic, political, social, and technological realities and weaknesses of the European Union more visible than ever before. The Ukraine war has had many consequences for the European Union, leading to the divergence of the Union and, subsequently, to a decrease in its power in the international system. This issue has been caused by the deepening of the cracks within the Union, the vacuum of strong leadership, and the different positions of the members regarding this war (Kastey and Leonard, 2023: p. 6).

The Russia-Ukraine war has led to a serious review of the EU's energy policies. Europe's traditional dependence on Russian energy resources has faced widespread disruptions and created unprecedented challenges in the supply of gas, oil, and coal. In response, the EU has strengthened cooperation with alternative suppliers such as Norway, the United States, and North African countries by adopting resource diversification policies. Effective measures to improve energy efficiency and reduce consumption are also on the agenda to increase the Union's resilience to future crises (Shoukat & Yaseen, 2023: p. 3).

According to the above description, the Ukrainian war has also had multi-layered effects on the technological and environmental policies of the EU, accelerating some policy processes and sometimes setting

back the process of producing clean technologies. One of the major concerns of the EU before the war was its energy dependence on Russia, which has been important since the war began, and the EU's attention to renewable and clean energies (solar and wind) has increased, and this performance has been in line with the goals of the European Green Deal (Atamanenko and Piddubnvi, 2023: p. 7).

The Russia-Ukraine war was a turning point in the EU's technological and environmental policymaking. It led the EU to move faster towards energy independence, to review and strengthen its environmental and technological policies, to focus on the resilience and security of technology supply chains, and to expand international cooperation in line with environmental and technological goals (Falkner, 2023: p. 9). At the same time, challenges such as the temporary return to fossil fuels and rising energy costs may have temporarily affected the quality and coherence of some policies. However, in the long term, the war has strengthened the EU's sustainable and technological orientation.

Consequences of the War and Policy Disruption (Increasing Arms Spending and Decreasing Environmental Spending)

The Russia-Ukraine war has had a significant impact on changing policy priorities in the EU. As a result of this geopolitical crisis, the focus shifted from long-term goals such as green innovation, digital transformation, and combating climate change to areas such as military security, short-term energy, and humanitarian aid. Programs such as Horizon Europe and the European Green Deal also faced budgetary constraints. This situation reflects a policy shift towards national security and economic resilience to international shocks. (European Commission, 2023).

Policy-making area	Before war	After War
Clean energy	High	Medium (Temporary reduction)
Defense and security	Medium	Very high
Technological innovation	High	Medium or lower
Military/humanitarian help	Low	High
Environment and climate	High	Medium (delayed)

Technological Policy in the United States

Technological policy in the United States has been shaped and evolved significantly since the 1960s, influenced by numerous geopolitical, economic, and social developments. This process, which began with the intense competition of the Cold War and the space race, has been accompanied in the following decades by energy crises, the growth of digital technologies, the emergence of the Internet, and the biological and nanotechnology revolutions. Simultaneously with the development of advanced technologies, attention to environmental security has also been raised as one of the important dimensions of policymaking; so that since the 1970s, with the establishment of environmental institutions and the adoption of environmental protection laws, technology has been used as a tool for reducing pollution and monitoring the environment (Executive Office of the President, 2022). In recent decades, with the growth of artificial intelligence, clean energy, and big data technologies, the United States has moved toward integrating technological competition with China and promoting environmental sustainability (Ansari, 1404: 3). A periodic review of these policies shows that the United States, while advancing national and economic security goals, has also attempted to use technology as a key factor in promoting environmental security and addressing climate challenges, although challenges such as high energy consumption of data centers and unknown risks of emerging technologies remain. On the other hand, the United States, given its position in the international system over the past two decades and the goals and scope of interests it has defined for itself, is always forced to improve its capabilities and always gain a superior position in the assessment of all components of power (Zare et al., 1404: 19). This introduction, with a brief overview of the technological developments of the United States, highlights the importance of harmonizing technology and the environment in the path of sustainable development and national security. We will discuss these policies in chronological order from the 1960s to the present.

The 1960s: The Beginning of Technological Competition Focused on Space and Defense

Historical Context: Intense Cold War Competition with the Soviet Union and the Beginning of the Space Race

The term "Cold War" refers to a period of geopolitical tension and competition between the United States and the Soviet Union. During the Cold War, the US strategy was to contain communism (Ansari, 1404: 3). It lasted from the end of World War II in 1945 until the early 1990s. The conflict involved a widespread arms race in which both countries developed vast arsenals of nuclear weapons, intercontinental ballistic missiles (ICBMs), [2]and nuclear submarines (Gaddis, 2005: p. 12). The fear of Mutually Assured Destruction (MAD)[3] served as a major deterrent to direct military conflict. In the space domain, the two superpowers also competed; The Soviet Union launched the first satellite (Sputnik) and the first human (Yuri Gagarin) into space, while the United States responded by establishing NASA in 1958 and carrying out the Apollo missions, most notably the manned moon landing.

NASA's activities, which were mainly focused on aerospace engineering and space launches, although they resulted in the production of space debris, paved the way for the development of satellite-based environmental technologies. The United States made significant investments in space technologies and satellite communications to enhance global communication capacities and ensure its national security. These efforts, especially in the areas of telecommunications and remote sensing technology, provided the infrastructure for environmental monitoring through satellite data in the following decades. In addition, the US Defense Advanced Research Projects Agency (DARPA) played a key role in the development of strategic technologies, including the Global Positioning System (GPS)[4] and the early Internet. These innovations helped to strengthen the US military, security, and information technology superiority, although they increased the consumption of energy and natural resources (Hafner and Lyon, 1996: p. 9). In the field of education, the United States, with a special focus on STEM[5] programs in science, technology, engineering, and mathematics in schools and universities, trained a skilled workforce to compete with the Soviet Union. These investments laid the foundation for the growth of new green technologies and clean energy and played an important role in advancing sustainable development.

The 1970s: Energy, Environment, and Information Technology

Historical Context: The 1973 Oil Crisis and Growing Environmental Concerns

The 1973 oil crisis began with the oil embargo of the Arab OPEC countries against the West, especially the United States and the Netherlands, in response to their support for Israel, causing the global price of oil to quadruple (Smith and Johnson, 2021: p. 10). This oil shock highlighted the importance of natural resources as a geopolitical tool and shifted power to the oil-producing countries of the Middle East. In the wake of this crisis, governments reconsidered their energy policies; The United States focused on developing domestic resources such as coal, natural gas, and oil exploration in Alaska. European countries such as France also turned to expanding nuclear energy. This period also saw the establishment of organizations such as the Environmental Protection Agency (EPA[6]) and the beginning of widespread government support for applied research in universities and industry. The oil crisis triggered large-scale investments in alternative energy technologies and charted a new course for energy policy and innovation.

The 1980s: Economic Liberalization and the Growth of Commercial Technologies

Historical Context: Ronald Reagan's Presidency and Economic Competition with Japan

[2] Intercontinental Ballistic Missile
[3] Mutually Assured Destruction
[4] Global Positioning System
[5] Science, Technology, Engineering, Mathematics
[6] Environmental Protection Agency

The most important measures in this period were the reduction of government intervention and encouragement of the private sector to innovate, support for the semiconductor industry to compete with Japan, the SBIR[7] program to support small innovative companies, and the rapid growth of the computer and software industry, which are described in the table below (Morwery and Rosenberg, 1998: p. 14).

The 1990s: The Emergence of the Internet and Globalization

Historical context: The End of the Cold War and the beginning of Technological Globalization

One of the most important effects of the Cold War was the enormous scientific and technological advances that occurred as a result of the competition between the United States and the Soviet Union. The space race was only part of this competition, but its effects went far beyond launching satellites and traveling to the moon. Technologies related to computers, satellite communications, and nuclear energy developed rapidly during this period. The governments of both countries allocated huge budgets to scientific research to keep up with their competitors. The most important measures during this period were the liberalization of the Internet for public use, the growth of the knowledge-based economy, and the support of innovation in the fields of information technology, telecommunications, and electronic commerce (Costells, 2000: p. 2).

The 2000s: Security, Digital and Biotechnologies

Historical Context: September 11, 2001 Attacks, Growth of Biotechnology and Nanotechnology, and the Beginning of the Global Debate on Climate Change

In the 2000s, US technology policymaking underwent a fundamental transformation in the wake of the September 11 attacks, and with the passage of the Patriot Act, a focus on cybersecurity and surveillance technologies increased (Bush, 2010: p. 13). Extensive investments were made in areas such as biotechnology, nanotechnology, and advanced defense systems. In addition, attention began to be paid to environmentally related technologies such as climate modeling and satellite sensors (PCAST, 2005). Despite advances in environmental data collection, pollution reduction efforts remained ineffective and lacked coherence. The spread of new technologies also created new environmental risks that lacked a regulatory framework. Overall, this period can be seen as the beginning of the convergence of technological security and environmental concerns. This process laid the groundwork for integrated policymaking in the decades that followed.

The 2010s: Open Innovation, Artificial Intelligence, and Big Data

Historical Background: The Rise of the Digital Economy and Technological Competition with China

The United States and China have one of the most important and complex bilateral relationships in the world. After establishing diplomatic relations in 1979, Washington and Beijing have experienced periods of cooperation, competition, tension, and confrontation on various issues, which were based on interaction and cooperation until 2010 and have since undergone transformation (Ghafarizadeh et al., 1404: 10). In the digital age, artificial intelligence (AI) has become one of the most important strategic technologies. This technology has not only created huge changes in various industries but also acts as a key factor in the economic, military, and geopolitical power of countries. Meanwhile, the two global superpowers, the United States and China, are in a tight competition for dominance in artificial intelligence technology. This competition, which some call the "technological cold war," has far-reaching implications for the future of the world (Brookings Institution, 2023). The US-China competition in the field of artificial intelligence will intensify in the coming years and will have consequences beyond technology, including the economy, security, and global order. This competition is geopolitical in nature and could determine the global position of each country in the 21st century. Along with this competition, the development of international regulations, technological ethics, and limited cooperation for risk management is essential. The responsible use of artificial intelligence will be a

[7] Small Business Innovation Research

criterion for future global leadership. The US considers the convergence of the artificial intelligence revolution and the rise of China in the technological dimension to be its main conflict, and the US strategy to deal with this challenge is to selectively isolate and disrupt China's global value supply chain in the field of technology (Ghafarizadeh et al., 1404: 19). Currently, the United States is the largest leader in artificial intelligence technology, which is currently being used by US cybersecurity policymakers to increase awareness, respond in real time, and increase its effectiveness (Azin et al., 1403: 13). In the 2010s, focusing on open innovation, AI policymaking, and promoting digital skills are key actions (DOE, 2023; IEA, 2022. The table below also mentions its environmental dimensions.

The 2020s to Now: Focus on Competition with China, Sustainability, and Future Technologies

Historical Background: Intense Competition with China in Technology, Environmental Crises, and the COVID-19 Pandemic

At the end of the second decade of the 21st century, China successfully emerged from the COVID-19 recession and continued its economic growth path based on the scientific and technological revolution. The country moved towards intensive and sustainable development within the framework of the 13th Five-Year Plan (2016–2020) and set ambitious goals until 2035. Technological advances and the expansion of China's international role have caused concern in the United States and have been predicted geopolitical tensions. This situation is described in Graham Allison's book with the concept of "Tele Thucydides," which refers to the possibility of confrontation between emerging and established powers (Alison, 2017: p. 23). China is trying to pursue its development path independently of Western structures. At the same time, technological competition has become the axis of tension between the two powers. The United States and its Asian allies argue that China has become an economic superpower over time, and that this economic power strengthens the country's national self-confidence, which is why Washington, along with its regional allies, is working to weaken and isolate the country globally (Darj and Hamid, 1403: 27). In the 2020s, the United States made extensive investments in key areas such as semiconductors, clean energy, artificial intelligence, and biotechnology by passing laws such as the CHIPS and Science Act [8]and the Inflation Reduction Act. These measures aimed to strengthen technological competition with China, reduce supply chain dependence, and move towards a green economy. National strategies for artificial intelligence and cybersecurity were also developed. Overall, these policies demonstrate the combination of technological innovation with environmental and geopolitical goals (Congress.gov, 2022).

The Impact of US Technology Policies on Environmental Security

The 1960s: The Onset of Technological Competition Centered on Space and Defense

Policies in this decade reflect the dual impacts of space and defense technologies. On the one hand, the production of space debris and the increased energy consumption resulting from the development of these technologies have created significant environmental challenges. On the other hand, advances in satellite and remote sensing technologies have enabled more accurate monitoring and better management of natural resources and the environment. Also, investments in STEM education have paved the way for the development of clean and sustainable technologies in the future.

[8] The CHIPS and Science Act is an important law in the United States that was passed in 2022

Table (3). Key US policies regarding technology in the 1960s and their impact on environmental security

Numbers	Policy/Action	Detailed explanation	Main goals	Sphere of influence	Impact on the environment
1	The founding expansion of NASA[9] since 1958	NASA was founded to lead the American space program and expanded in the1960s with projects such as Apollo.	Space competition with the Soviet Union, and the advancement of space technology	Aerospace, engineering, space launches	Producing space debris, but helping to develop uture satellite environmental technologies
2	Investing in space technologies and satellite communications	The US government made a huge investment in the development of communication and remote sensing satellites.	Develop in global communications, national security	Telecommunications, remote sensing	Laying the groundwork for environmental monitoring with satellites in the coming decades
3	Development of defense and electronic technologies	As the research arm of the Department of Defense, DARPA implemented projects such as GPS and the early Internet.	Promoting military superiority, information security	Military, telecommunications, computing	It had no direct environmental impacts, but it did increase energy and resource consumption.
4	Focus on STEM education.	Science, technology, engineering, and mathematics education programs were strengthened in schools and universities.	Cultivating specialized human resources to compete with the Soviet Union	Education, University, R&D	Huma Capital provided for the development of green technologies and clean energy in the future.

The 1970s: Energy, Environment, and Information Technology

The 1970s in the United States marked a turning point in reducing air and water pollution with the establishment of the Environmental Protection Agency (EPA) and the passage of important laws such as Clean Air and Clean Water. Government support for alternative energy and purification technologies greatly contributed to the development of pollution control technologies. Also, a modern environmental monitoring system and industrial standardization were formed, and attention to the environmental effects of technology began to be paid seriously in policymaking. This period marked the first steps in the convergence of technology with environmental protection.

Table (4). Key US policies regarding technology in the 1970s and their impact on environmental security

Axis	Brief description
Key technolog policies	Establishment of the Environmental Protection Agency (EPA) in 1970 - Passage of the Clean Air and Clean Water Acts - Government support for alternative energy and purification technologies - Beginning of development of information technology (personal computers, semiconductors) - Beginning of support for technological research in universities and industry.
Impact on environment	Reducing air and water pollution, developing pollutant control technologies (such as smoke filters and treatment plants), establishing a modern environmental monitoring system and industrial standardization, and paying attention to the environmental impacts of technology in policymaking began.
Key result	The 1970s were a turning point in the convergence of technology policy with environmental protection. Structured environmental policymaking began, and the United States, for the first time, recognized technology as a tool for mitigating environmental crises.

(Writer)

[9] National Aeronautics and Space Administration

The 1980s: Economic Liberalization and the Expansion of Commercial Technologies

This period saw a decline in environmental protection and an increase in the production of industrial waste and electronic waste. Although the EPA continued to enforce environmental laws of the 1970s, there was no significant development in environmental technologies. The focus was on market growth and the competitiveness of commercial technologies, and environmental protection was not a high priority. However, a technological infrastructure was created that later became the basis for green policies.

Table (5). Key US policies regarding technology in the 1980s and their impact on environmental security

Axis	Brief description
Key technological policies	Reducing government intervention in the economy and focusing on the market, establishing the SEMATECH[10] consortium to support the semiconductor industry, implementing the SBIR program to support small innovative companies, and growing the computer, software, and electronics industries.
Impact on environment	Increasing industrial waste and electronic waste, decreasing policymakers' attention to environmental technologies, EPA's continued enforcement of 1970s environmental laws without significant expansion
Key result	The main focus was on competitiveness and the growth of commercial technologies. Environmental protection was not a priority, but the technological platform was provided for the development of green policies in the following decades.

The 2000s: Security, Digital Technologies, and Biotechnology

This period included significant progress in the development of environmental monitoring technologies such as satellites and advanced sensors, which enabled increased data collection and public awareness of climate change. The use of digital technologies in climate modeling helped improve pollution predictions, but enforcement efforts to reduce emissions remained weak. Also, the environmental risks posed by nanotechnology and biotechnology are not yet fully understood, which requires further attention.

Table (6). Key US policies regarding technology in the 2000s and their impact on environmental security

Axis	Brief description
Key policies	Passing the Patriot Act [11]to strengthen digital surveillance, increase funding for cybersecurity and military technologies like drones, government investment in biotechnology, the Human Genome Project, and nanotechnology, and expand international cooperation on climate change
Technological policies related to the environment	Developing advanced satellites and sensors for pollution monitoring, starting to use digital technologies for climate modeling and pollution forecasting
Impact on environment	Increased monitoring capacity and environmental data, growing public awareness about global warming, weak enforcement actions in truly reducing pollutants, and unknown environmental risks in nanotechnology and biotechnology
Key result	The 2000s were the crossroads of security and environmental technologies, but despite technological advances, executive policies to address the environmental crisis remained weak and reactive.

The 2010s: Open Innovation, Artificial Intelligence, and Big Data

This decade has seen two global superpowers, the United States and China, locked in a fierce competition for dominance in artificial intelligence technology. This competition, which some have called a "technological cold war," has far-reaching implications for the future of the world. The use of artificial intelligence technology in the United States and China represents a complex balance between technological

[10] Semiconductor Manufacturing Technology
[11] (Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act.

progress and environmental challenges. While the United States is trying to make AI a sustainable tool by focusing on green innovation and ethical standards, China is putting significant pressure on the environment with its rapid industrial growth and high energy consumption, especially from fossil fuels. Both countries are contributing to increased greenhouse gas emissions through their high energy consumption of data centers, although AI has been able to help monitor and manage natural resources and predict environmental disasters. Ultimately, without regulatory frameworks and international cooperation, the environmental risks of these technologies will not be fully controlled.

Table 7. Key US policies regarding technology in the 2010s and their impact on environmental security

Axis	United States	People's Republic of China	Impact on Environmental Security
The Status of Technology	Leading the way in research, innovation in green AI, and large language models	Rapid growth in industrial AI, focus on broad applications	Using AI to monitor the environment, but increasing data center energy consumption
National AI Strategy	Emphasis on innovation, along with ethical values and sustainability	Focus on rapid growth prioritizing technological independence	In the US, environmental regulations are limited; in China, the pace of growth overrides environmental considerations.
AI Applications in the Environmen	Developing AI technologies for clean energy, smart agriculture, air and water quality monitoring	Using AI to monitor pollution, but focusing more on industrial growth	Helping manage natural resources, predict natural disasters, and reduce environmental losses
Energy and Resource Consumption	Huge data centers with high energy consumption, efforts to become carbon neutral	High energy consumption, especially in China, with its dependence on coal	The threat of increased greenhouse gas emissions from AI infrastructure in both countries
AI and Climate	Participation in climate agreements (such as the Paris Agreement) and AI projects in the service of climate modeling	Commitment to reduce emissions by 2060, but high dependence on fossil fuels	AI is a powerful tool to combat climate change, but it is not fully exploited in China.
AI Ethical Environmental Standards	Efforts to develop responsible AI, voluntary standards sustainability	Central oversight, but with weak environmental transparency	Lack of a common global framework leaves the environmental impacts of AI unmonitored
Environmental Conclusions	Leading the way in developing AI for sustainability, but with the challenge of energy consumption.	Rapid growth puts pressure on natural resources and the environment	AI can be a key tool in promoting environmental security, but it requires global regulation and international cooperation.

The 2020s so Far: Focus on Competing with China, Sustainability, and Future Technologies

The technology policies of the 2020s in the United States have taken an important step towards reducing carbon emissions and combating climate change, with extensive investments in renewable energy and clean technologies. The development of smart infrastructure and clean transportation, along with the widespread use of artificial intelligence to monitor pollution and manage natural disasters, indicates a focus on environmental sustainability. However, challenges such as high energy consumption of data centers and the extraction of scarce resources required by technologies remain. These policies promise to create a model of green and smart economic growth based on innovation and global competition.

Table (8). Key US policies on technology in the 2020s so far and their impact on environmental security

axis	Description
Key Policies	Passage of the CHIPS and Science Act (2022) Investing $280 billion to boost semiconductor manufacturing and research and development, the largest investment in clean energy and climate change in history of about $369 billion, restricting exports of sensitive technologies to China, advanced semiconductors, quantum devices, and artificial intelligence, developing and implementing a national strategy for AI, cybersecurity, and biotechnology
Priority Technologies	Semiconductors, clean energy (solar, wind, hydrogen), artificial intelligence and machine learning, biotechnology and advanced medicine, quantum technologies, robotics, and advanced batteries
Approach to Competing with China	Restructuring domestic supply chains to reduce dependency, strengthening national research and development, limiting technology transfer to China, and responding to China's strategic challenges with a focus on sustainable innovation
Impact on Environmental Security	Increased investment in renewable energy and carbon emissions reduction, development of smart infrastructure and clean transportation, increased use of AI to monitor pollution and natural disasters, but there is still the challenge of high energy consumption of data centers and the growth of consumption of scarce resources for technologies (e.g., lithium, cobalt)
Overall Conclusion	In the 2020s, the United States has entered a new era of technological policymaking by combining technological competition with China and planning for environmental sustainability, which can shape a new model of green and smart economic growth.
Priority Technologies	Semiconductors - Clean energy (solar, wind, hydrogen) - Artificial intelligence and machine learning - Biotechnology and advanced medicine - Quantum technologies, robotics, advanced batteries

The United States has consistently aligned its technology policies with domestic and international strategic needs since the 1960s. These policies have included support for research and development, advanced technologies, national security, the environment, and industrial innovation. The impact of U.S. technology policies on environmental security since the 1960s has been a mix of positive and negative impacts. Technology policies in the country have played an important role in preventing, reducing, and in some cases exacerbating environmental damage (U.S. National Science and Technology Council, 2021). Since the 1970s, U.S. technology policy has gradually become more aligned with environmental considerations, and in recent decades, technology has become a major tool for monitoring, preventing, and responding to environmental crises. The United States is transitioning from polluting industrial technology to smart, clean technologies.

Conclusion

Achieving sustainable development in the contemporary world requires a deep and synergistic link between technological policies and environmental goals. In fact, technology is no longer just a tool for economic growth but a key element in addressing environmental challenges, climate change, natural resource management, and improving the quality of life. A comparative study of technological policies in the European Union and the United States of America shows that both major international actors, despite their structural, cultural, and political differences, have recognized the need for convergence between technology and the environment and have made efforts to strengthen this link.

The European Union, with an integrated, targeted, and long-term approach, has succeeded in designing and implementing a set of technological policies and programs aligned with environmental goals. These policies include the Lisbon Strategy, Europe 2020, Horizon Europe, as well as environmental initiatives such as the European Green Deal, the Circular Economy, and the Clean Energy Transition. Taken together, these measures have not only reduced emissions and improved environmental resilience but also provided a successful model for integrating technology with environmental policy.

In contrast, the United States has taken a different but complementary approach. The country, particularly through its private sector and innovation-driven market, has played an effective role in the development of clean technologies, energy efficiency, and advances in areas such as artificial intelligence,

biotechnology, and alternative energies. However, environmental policies in the United States have always been volatile and influenced by political and partisan variables. Unlike the European Union, which sees environmental policies as part of a holistic agenda, in the United States, these policies have been more reactive, issue-oriented, and security-oriented. However, measures such as the passage of the CHIPS and Science Act and the allocation of hundreds of billions of dollars for the development of clean technologies, renewable energy, and research in emerging areas indicate a change in the US approach in the 2020s; an approach that seeks to respond to environmental goals while simultaneously competing technologically with China.

On the other hand, recent geopolitical developments, especially the Russia-Ukraine war, have shown that technological and environmental policies cannot be implemented in a vacuum and without taking into account the international environment. These crises have led to a review of the EU's policy priorities, leading it to reduce its dependence on fossil fuels and accelerate the transition to renewable energies. However, challenges such as temporary reductions in environmental budgets, pressure for emergency energy supplies, and a return to some polluting sources also emerged in the wake of these crises. This fact indicates that the resilience of technological policymaking in the face of crises requires the design of structures that maintain a balance between environmental security, energy security, and economic and geopolitical interests.

Finally, a comparative study of the European Union and the United States shows that neither approach – the European program-oriented or the American innovation-oriented – is complete on its own, but combining the strengths of these two models can lead to the formation of an efficient global model of technological policy-making with an environmental approach. A model in which technology plays a role not only as a tool for economic growth, but also as a driver for protecting the planet, reducing ecological vulnerability, and enhancing the resilience of societies. This model can pave the way for countries to move towards a green, smart, and sustainable future and pave the way for effective international cooperation in the areas of technology, environment, and global security.

Recommendations

- R Develop and implement an international enforcement mechanism for countries' environmental commitments
- Condition international support and investments on compliance with environmental principles
- Strengthen global environmental justice through the transfer of clean technologies to developing countries
- Develop ethical and intergenerational frameworks in technology policymaking.

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