MASTER'S THESIS

Politics and Economy in USA-EU Trade Relationship and the Issues of Research and Development

Politika a ekonomika v obchodních vztazích USA a EU a problematika výzjumu a vývoje

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I. OSOBNÍ A STUDIJNÍ ÚDAJE

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Pokyny pro vypracování:

Evropsko-americké vztahy po řadu desetiletí náležely a dosud náleží mezi nejvýznamnější bilaterální ekonomické vztahy ve světové ekonomice. Práce se zaměřuje na genezi evropsko-amerických vztahů, zejm. od 90. let do současnosti, nevyjímaje neúspěšná jednání o uzavření Transatlantického obchodního a investičního partnerství (TTIP). Práce si klade za cíl prokázat kooperativně-soutěživou dynamiku evropsko-amerických vztahů prostřednictvím analýzy vzájemných vztahů v oblasti výzkumu a vývoje (R&D), stimulů i překážek, jímž čelí.

Seznam doporučené literatury:

Anthony L. Gardner: Stars with Stripes: The Essential Partnership between the European Union and the United States (Cham: Palgrave Macmillan, 2020)
Gordon Friedrichs, Sebastian Harnisch, Cameron G. Thies: The Politics of Resilience and Transatlantic Order : Enduring Crisis? (Abingdon, Oxon ; New York : Routledge, Taylor & Francis Group, 2019)
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Marcus Glader: Innovation Markets and Competition Analysis: EU Competition Law and US Antitrust Law (Cheltenham, UK: Edwaed Elgar, 2006)

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Abstrakt

Diplomová práce pojednává o politicko-ekonomických vztazích USA a EU od konce druhé světové války po současnost. Zhodnocuje ekonomickou situaci mezi partnery, bilaterální obchod v sektoru high-technology a srovnává jej s obchodem s dalšími zeměmi. Cílem práce je definovat strukturu vědy a výzkumu v jednotlivých regionech, popsat hlavní rozdíly a prozkoumat konflikty vznikající v této oblasti. Nakonec se zabývá implementací 5G sítě a problémy s ní související.

Klíčová slova

USA, EU, Spojené Státy Americké, Evropská Unie, věda a výzkum, VaV, IKT, informační a komunikační technologie, bilaterální obchod, high-technology, VaV konflikty, 5G síť

Abstract

This master's thesis discusses the political-economic relations of the US and EU from the end of the Second World War to the present. It reviews economic situation between partners, bilateral trade in high-technology sector and compares it to trade with other countries. Goal of the thesis is to define structure of research and development in each region, describe main differences and investigate conflicts emerging in this area. Lastly, it looks into 5G network implementation and challenges related to it.

Key words

US, EU, United States, European Union, research and development, R&D, ICT, information and communication technologies, bilateral trade, high-technology, R&D conflicts, 5G network

Content

Introduction

United States are from the beginning of 20.century one of the biggest economic superpowers. It managed to solidify its place after Second World War and continues to build it precedent position in the world. It is dynamic nation with a rich history, diverse society, and a prominent role in global politics, economics, and culture.
On the other hand, the European continent was ravaged by destruction after Second World War and its economies were left at devastated state. In response to the horrors of war, European leaders sought to foster cooperation and prevent future conflicts. The idea of integrating key industries began with the establishment of the European Coal and Steel Community (ECSC) in 1951, which aimed to pool the coal and steel resources of member countries. This initial step laid the foundation for further European integration.
The relationship between the European Union (EU) and the United States (US) is a crucial aspect of global politics and economics. It is built upon historical ties, shared values, and extensive cooperation on various issues. The roots of EU-US relations can be traced back to the aftermath of World War II. The devastation caused by the war prompted the need for greater cooperation and actions which promoting shared fundamental democratic values, including respect for human rights, rule of law, individual freedoms, and market-based economies. These common principles have helped foster a strong bond between the two nations.

This thesis aims to map these bilateral relations, its development and the role of mutual trade and investment. In following pages, paper will try to answer key questions:

1. What is the current economic relationship between EU and US in high-technology sector? Is US being replaced by China?
2. What is the R&D structure in each country? What are the key differences between them and between project settings? What drives R&D gap between EU and US?
3. Are there any major conflicts between European Union and United States in area of R&D?
4. Was deployment of 5G network successful?

This master's thesis will map bilateral relationship between Europe (later European Union-27) and United States (US) from the end of Second World War until 2023. Firstly, it will describe history between both regions, its economic situation and bilateral trade. Sub-chapter is dedicated to bilateral trade in high technology sector and its importance in EU-US relation. Great emphasis is placed on problematics of Research and Development in both regions, its characteristics and development. Final chapter in dedicated to 5G network, its deployment in both regions and usability.

1 History

First chapter briefly summarizes relationship history of Europe (later European Union) and United States after the Second World War until 2023. It describes Europe's struggle after war and slow economic recovery which wouldn't be possible without help of United States. Second part of the chapter analysis evolution of trade relationship between Europe and United States. From first basic agreements up to most complex efforts to simplify and streamline trade. Including unsuccessful negotiation of Transatlantic Trade and Investment Partnership (TTIP) and recently established Trade and Technology Council (TTC).

1.1 Transatlantic relationship from 1945-2010

Weakened state of Europe after the Second World War and disintegration of Germany gave enough space for other emerging economies to come into light. The 1945 is known as the beginning of bipolar era between USA and Soviet Union. While Europe struggles many years after the conflict to regain its lost strength and centrality. Future conflict between US and Soviet Union, which was predicted by German dictator becomes inevitable and Germany will become its front line (Hanhimäki, 2012).

If we take into consideration the situation in Europe, the emerge of US and Soviet Union doesn't come as a surprise. The United States are the only country not impacted by destructive force of the war. And its power is growing even with last effects of Great Depression. On the other hand, Soviet Union remains the only country with military presence in more than half of the Europe. Military occupation after the war resulted in geographic deviation better known as West-East which will last over next four decades. While Western Europe turns to US for economic and military support, Eastern Europe wakes up under control of Soviet Union. And the beginning of Cold war is in the air (Hanhimäki, 2012).

1.1.1 Post-war period

Europe is facing a new phenomenon after the war: Soviet Union with key goal to expand its influence as far to the west as possible. Power of Union grows every day and scattered west doesn't have enough power to stop it alone. The effort to gain US military presence in the Europe is the key. And US president Truman has an uneasy task ahead of him. He needs to persuade congress and public that American participation is needed in Europe. And not only in economic sphere but also political. As a result, American president presents Truman doctrine which strongly supported democracy in Europe and was a way of stopping communist expansion (Cihelková, 2003).

This consequentially led to creation of ERP (Europe Recovery Plan), more often referred to as Marshall Plan. The large-scale economic aid program of the United States to promote European reconstruction. US Secretary of State George Marshall summarized political and economic situation of Europe, and its negative impacts on US economy. The most important aspect of the plan was that it is up to European countries to conceive and

coordinate the plan, which would US then finance. Second important part was that help is to be provided to any country which requests it: making sure Soviet Union is not taken out from the offer. The offer was very positively received and in July 1947 sixteen nations met in Paris to discuss specifics of the aid (Hanhimäki, 2012).
ERP was a long-term strategic program designed to help Europe recover from post-war effects and regain its full industrial potential. Willingness of US to provide such help was indication that not only is strong Europe strategically important for US to control threat of Soviet Union. But also, that US recognizes the potential of future regional cooperation. While many countries gladly accepted the program, Soviet Union declined and the tension between both countries continued to grow (Cihelková, 2003).
Around 1950 US became economically the strongest nation in the world. And among its biggest interests was no longer to protect home economic growth by dollar devaluation and tariffs. But to enforce free trades and by that discover new markets to operate in. Expectation was that base for trade liberalization will be International Trade Organization (ITO). But it was never signed, and instead temporary General Agreement on Tariffs and Trade (GATT) became permanent international organization. GATT was established in 1947 and signed by 23 countries: US, Canada and majority of west-European countries including Czechoslovakia (Cihelková, 2003).
GATT was a breakthrough in international trade. It set rules for what turned out to be one of the highest growth rates in international commerce. And it lasted for 47 years until 1994 when it was absorbed by World Trade Organization (WTO) (History of the multilateral trading system, 2023).
Throughout the Cold War (1947-1991), potential threat of Soviet Union pushed Western countries into collaboration with US. This period can be described as a moment of American primacy when US and EU go through the most significant convergence in history. It is time when we see defending and promoting of shared values, ideology and it gives us a taste of what true cooperation between nations could achieve. However even this period is not without challenges as new disagreements, like Banana war or International Criminal Court, come into light (Tocci, 2012).

1.1.2 Flourishing in 80s and 90s

Until late 20th century, the relationship between US and Europe was partially based on defence alliance. But with collapse of Soviet Union, new approach to international cooperation was in the air. Europe saw significant shift in distribution of forces in the world. With now “united” East, the cooperation started to grow. And becomes a base for what will turn out to be later biggest level of integration in the world, e.g., European Union. United States were not falling behind. Free trade agreement between Canada and US (CUSFTA – Canada-United States Free Trade Agreement) was successfully concluded in 1988. And we also see negotiations about free trade agreement between US, Canada and Mexico (NAFTA – North American Free Trade Agreement) and initiation of future Asia-Pacific Economic Cooperation (APEC) (Cihelková, 2003).
Significant changes in West-East relationship together with other moving powers led to declaration of US president G. Bush. He openly announced that US will support efforts to

unify Europe. In December 1989 US minister of foreign affairs proposed deepening of US-EU relations and new arrangement of these relationships based on political agreements (Cihelková, 2003).

1.1.3 New era

In 1992, majority of world was plunged into recession, including United States. Decision of US President George H. W. Bush to increase taxes despite his pre-election promise not to do so and his pro foreign policy cost him many votes in run for second term. Many believed that at the time negotiable NAFTA (North American Free Trade Agreement) will lead to rapid transfer of jobs from US to cheaper locations (Mexico) resulting in higher unemployment and deepening of crisis. These and multiple other reasons led to defeat of Bush by democratic candidate Bill Clinton. And in January 1993 President Clinton was appointed (Hanhimäki, 2012).

Clinton‘s office was primary focusing on domestic issues and less on foreign policy. However, he never ignored challenges US faced in international world. And during his presidency his focus shifted between crisis situations from Somalia and Haiti to Iraq and Rwanda. He was also forced to deal with conflicts in the Balkan region which started after the collapse of Soviet Union. After the end of Cold War many post-communist countries in Europe experienced waves of nationalism which ultimately led to desire of separation. In some cases, like Czechoslovakia, it was peaceful decision to split into two separate countries: Czech Republic and Slovak Republic. In case of Balkan, it led to largest military conflicts since the Second World War. Entity known as Yugoslavia was divided by ethnic lines and its trend towards autonomy didn’t appear for first time, nor was it surprise. After failed Serbian attempt to impose authorities over remaining countries, Croatia and Slovenia declared independency in June 1991. And by the end of the year, Macedonia and Bosnia-Herzegovina followed. Federal military, mostly consisted of Serbs, responded by interventions. Largest dispute was in Bosnia where parts of the land were seized by Serbs, Croats and Bosnians and country was divided into three-way warzone. During following years, United States played key part as they pressured NATO towards actions. This led to enforcing no-fly zone over Bosnia in 1993. But it was after Serbian shelling of Sarajevo that NATO started its aggression campaign. In August 1995, NATO attacked 338 Serbian targets which led to their agreement to participate in peace talks. In December 1995, peace accord was signed and as a result Yugoslavia split into six countries and two autonomous regions within Serbia (Hanhimäki, 2012).

In order to strengthen Europe, foster cooperation between individual states and to create possibility to collectively address challenges and make decisions, European Union is established in November 1993. It started with six founding members (Belgium, France, Germany, Italy, Luxembourg, and the Netherlands) with clear vision of the future single currency, foreign and security policy, and closer cooperation in justice and home affairs. Union has grown since then and today includes 27 member states across Europe. Since its creation EU presented many significant milestones. Among the major are: single market allowing free movement of goods, services and capital; peace and stability in Europe region; single currency (Euro); enhancement of global influence; free movement of people;

common policies and standards; collaboration in Research and Development; and many more (History of the EU, 2023).

Despite Clinton's focus on domestic issues, transatlantic cooperation during this period continued to grow. In coming years US and Europe Community (EC) agreed on common goals which were key for both regions and made them part of Transatlantic Declaration on EC-US Relations. Even though declaration was positively received by majority of the public. It was only guide for cooperation between US and EC with some determined rules. However, it was not concrete enough and therefore we see soon after efforts to create more specific document for enhancing the cooperation. This led to signature of New Transatlantic Agenda in Madrid in 1995. Essential goal of the agenda was not to only create tighter cooperation between the two regions. But also, to commence shared action which would strengthen transatlantic legal, technical, trade, diplomatic and security bonds (Cihelková, 2003).

Newly created partnership was built around four pillars: promoting peace, stability, and democracy around world; addressing global challenges; contribution to world trade expansion and economic relations; and building bridges across Atlantic (The New Transatlantic Agenda, 1995).

Year 1995 was revolutionary for trade relationships across globe as well. In January, World Trade Organization (WTO) was created, and it meant biggest international trade reform since the Second World War. While GATT was mainly focused on trade of goods, WTO was in addition dealing with trade of services and intellectual property (History of the multilateral trading system, 2023).

In years to come, US and EC signed numerous other agreements with main purpose to simplify trade between Europe and US. Among the most important ones were:

- EC-US Agreement on Custom Cooperation and Mutual Assistance in Customs Matter – 1997
- EC-US Agreement on Scientific and Technological Cooperation – 1997
- EC-US Agreement on Mutual Recognition – 1998
- EC-US Veterinary Equivalence Agreement – 1999
- EC-US Agreement on Drug Precursors
- EC-US Agreement on Environmental Research
- And others

In addition to above mentioned arrangements, both regions supported agreements concluded within the framework of the WTO to liberalize telecommunication, information technologies, and finance services (Cihelková, 2003).

Following years could be described as golden era of US and EU. In 1995, GDP of any other country except of Japan was nothing in comparison to them. The average per capita income in both regions was multiple times higher than in Russia and forty times higher than in China. Bilateral trade between EU and US accounted for 50 percent of total trade in the world and investment over 60 percent (Tocci, 2012).

There was also no question that between the two, US is the most effective and influential player in the world in early 90s. But with Soviet Union forgotten and integration of EU, Europe was emerging on horizon as new superpower (Hanhimäki, 2012).

1.1.4 2001-2010

Beginning of 21st century will be forever remembered for one of the biggest tragedies in US history. On 11th September 2001, in total fours commercial transport company's planes were hijacked. Two crashed into the World Trade Center in New York, one into the Pentagon and forth was landed safely thanks to passenger resistance in Pennsylvania. The terrorist group Al-Qaeda, led by Osama bin Laden, soon after the tragedy claimed responsibility for the attach. A wave of solidarity came over Europe and everyone felt for US. In months after the attack, European countries tried to provide support to US in all possible aspects. NATO adopted Appendix 5, which stated that any attack on the US is an attack on the entire alliance. As days passed, an attack on Afghanistan, where Al-Qaeda was believed to have a base, seemed inevitable. At least from the US point of view. With help of United Kingdom and strategically important allies in the east (Uzbekistan, Russia, Pakistan), international coalition led by the US invaded in October 2001 Afghanistan. By late 2001, most of Afghanistan was under the control of the United States and its allies. Question was, what will happen next with the post-Taliban country. Unlike the war itself, the post-war negotiations were more international. Germany was responsible for training the new political force, Great Britain focused on the fight against narcotics in the country, and Italy helped to reconstruct the legal system. Efforts to stabilize the country will continue for several more years with mixed results. But already under the baton of NATO as the overarching leader. By that time, however, the focus of Bush's foreign policy had shifted elsewhere, resulting in another, even more controversial military operation (Hanhimäki, 2012).

The events of September 9 changed a lot. A major concern of the United States was the possible misuse of weapons of mass destruction by terrorists. For this reason, in December 2001, they announced their withdrawal from the ABM (Anti-Ballistic Missile Treaty) from 1972. This treaty was created between the United States and the Soviet Union to limit anti-ballistic missile systems used against missile-based nuclear weapons. President Bush's office was concerned that at least 3 countries had developed nuclear weapons in secret - North Korea, Iraq and Iran, which posed a clear threat to the rest of the world. The goal of the United States was to create a defence system that would protect them in the event of an attack. However, protection was not the only thing the US was interested in. According to the proposal presented by President Bush to the United Nations, the United States should have the right to use military forces in case of preventing a security threat (Hanhimäki, 2012).

Such proposal was met with a wave of criticism. In translation, it was the right to wage a preventive war. However, the document itself, as one might expect, since this is probably impossible, did not include a clear definition of a sufficient threat. Not even detailed instructions on what such prevention looks like, from the number of soldiers to the size of the military operation. So it would only depend on the interpretation of the given party, what is a sufficient threat and therefore a reason to attack another country. Such thing was in many ways a gross violation of agreements and obligations still in force, for example the United Nation Charter (Hanhimäki, 2012).

In fall of 2002, US started to be specific in its focus on potential threat and therefore the target of this preventive war. It was Iraq, which under the leadership of Saddam Hussein, allegedly produced and hid weapons of mass destruction, despite several years of economic sanctions imposed on the country by the United Nations. The overthrow of Saddam Hussein saw the US as pivotal in the process of liberating the country and the subsequent shift to more democratic leadership and associated stability in the Middle East. Another argument was that as long as the situation in Iraq remains unpredictable and tense, the United States must maintain a large amount of military power in Saudi Arabia, which met with strong opposition from the local population. The United Nations has been repeatedly criticized for the ineffectiveness of the sanctions, which had an impact on the common people, but did not in any way damage the functionality of the country's leadership. By abolishing them, however, they would give the country room to renew its WMD (weapon of mass destruction) programs. All of these factors, together with strong public support for strengthening American security, ultimately led the US administration to decide to invade Iraq. In October 2002, President Bush received authorization from the House and Senate to use force against Iraq (Hanhimäki, 2012).

While support for this decision was strong within the US, it was a different story with the Allies. The initial transatlantic unity after the 9/9 attack can hardly be translated as a license to start an impunity war. In the following years, during which the conflict known as the Iraq War escalates, the US is heavily criticized and labelled as the American tyrant. And all this despite the internationally widespread disapproval of the entire military operation (Hanhimäki, 2012).

It is necessary to say that the actions of President Bush were approved not only by the government, but also by the majority of the American population. As of late September 2001, nearly 86% of adults approved of their president's foreign policy. However, in future years, this percentage continuously decreased, and along with it, faith not only in the presidential office, but also in state institutions and the government as such. In 2005, after another national tragedy, Hurricane Katrina, when the government did not provide enough support to affected victims, only 31% of the population expressed confidence in the government. And by the end of President Bush's first term, only 24% of Americans approved of his job performance (Two Decades Later, the Enduring Legacy of 9/11, 2021).

President Bush's administration ignored advice to approach the issue of war with caution, which had direct effects on transatlantic relations and widespread anti-American sentiment in the public. In the summer of 2003, a survey was conducted in six European countries (Great Britain, France, Germany, the Netherlands, Poland and Portugal) and the main question was whether people approve the foreign policy led by President Bush. Only 30% of respondents said 'yes' and less than 6% agreed 'strongly'. In France, the number of those who disagreed even reached 80%. And even in Great Britain, which was the biggest supporter of the US in Europe, the opponents prevailed by 2 to 1. In 2004, anti-Bush/anti-American feelings continued to grow. And by the end of the year 76% of Europeans did not agree with the international policy of President Bush and the United States (Hanhimäki, 2012).

During the following years, when the war in Iraq lasted, transatlantic relations entered a fundamental crisis. Critics from Europe as well as the US condemned the violation of international regulations and disregard for basic human rights and freedoms. And the fact that no weapons of mass destruction were discovered in Iraq after the intervention of American troops led to growing suspicions that President Bush and his main European supporter, Prime Minister of the British government Tony Blair, deliberately distorted the situation in Iraq in order to achieve the desired result and the invasion of Iraq (Hanhimäki, 2012).
Major shift happened in 2011, after the death of Al-Qaida leader Osama bin Ladin. Late in the year, US units slowly started to retreat from the country. The departure of key people associated with the war in Iraq, and their subsequent filling by new people, was very important for the future EU-US relations. For example, the new US Deputy Secretary of Defence and National Security Adviser, who toured Europe with the aim of improving international relations. Changes in the leadership of other countries also contribute to improving the mood. Long-time critics of the Bush administration, such as German Chancellor Gerard Schröder and French President Jacques Chirac, were being replaced by Angela Merkel and Nicolas Sarkozy. And although Bush remains a very unpopular figure in the minds of Europeans, transatlantic relations started to become more friendly (Hanhimäki, 2012).

1.2 2010-2023

Joint effort to rebuild Europe's fragmented economy, industry and agricultural after the war led to continuous political and economic cooperation between western European countries. This later resulted in creation of formal economic integration that ended up being the highest level of working integration in the world. And in November 1993 European Union (EU) was established. European Union was an answer to Europe's biggest problem which was big fragmentation and vulnerably to larger countries (Cihelková, 2009). Since then, EU gradually grown and currently composes of 27 countries with more than 447,5 million inhabitants.

1.2.1 Transatlantic Trade and Investment Partnership (TTIP)

The Transatlantic Trade and Investment Partnership was largest and most complex proposed bilateral trade agreement between the US and the EU. Negotiations around TTIP started in July 2013 and were planned to take multiple rounds until consent reached. Its main purpose was to liberate trade between EU and US by which would create a free trade zone encompassing half of the world economy (De Ville, 2016).
Before TTIP, EU and US discussed trade issues though GATT which later transformed into WTO. TTIP was a way to simplify the trade and boost bilateral trade and investment. Part of the negotiations were classified and kept from public but from European Commission's later press release we can estimate that among the proposed tools were:

- Eliminate both tariff and non-tariff barriers on goods;
- Lower trade barriers on services;

- Eliminate customs duties on digital commerce and IT;
- Introduce comparable rights for investors in participating countries;
- Reduce or eliminate artificial or trade-distorting barriers;
- Enhance customs cooperation among the EU and the US;
- Ensure equal labour rights in the EU and the US to avoid unfair labour competition
- Obtain mutual agreement on environmental standards, intellectual property rights, and product standards.

(Hayes, 2022)

From the beginning TTIP divided citizens into two groups: advocates and opponents. They agreed on very little as both presented completely opposite view of agreements impact on economy. However, they agreed that if signed, it will be gamechanger for both partners. According to supporters, TTIP will create many opportunities for companies which will drive profit and therefore make everyone wealthier. Plus allow economic growth in both regions. Critics, on the other hand, feared that TTIP will benefit only big corporate business and leave us all with worse jobs and less opportunities (De Ville, 2016).

Negotiations were paused by US president Donald Trump who shifted his priorities from free trade agreements after his inauguration in January 2017. But major setback was already departure of United Kingdom, which was crucial pro-trade voice within commission, from EU in 2016. Suddenly instead of EU-US discussions, focus moved to UK-US and UK-EU with goal to minimize damage to existing trade ties between countries. Ultimately on 15 April 2019, the negotiations were declared "obsolete and no longer relevant" by the European Commission (Korteweg, 2023).

1.2.2 Trade and Technology Council

Trade and Technology Council (TTC) was established in June 2021 at the US-EU Summit in Brussel by US president Biden, European Commission president von der Leyen, and European Council president Michel. It is a transatlantic political platform that should serve as a forum for technology cooperation and advance democratic approaches to trade, technology, and security, and ultimately benefiting both parties. Unlike TTIP which tried to formalize cooperation though deals, council focuses on the process of cooperation. And after years of cold transatlantic relations, it represents new era of partnership between EU and US. (U.S.-EU Summit Statement, 2021).

According to information from European Commission website its main goals are:

- To ensure that trade and technology serve EU's and US societies and economies, while upholding common values
- To strengthen technological and industrial leadership
- Expand bilateral trade and investment

(EU-US Trade and Technology Council, 2023).

In September 2021, first inaugural TTP meeting was held in Pittsburgh, United States. Meeting ended in 17 pages long statement with draft of a roadmap to collaboration. It included 10 working groups each focusing on specific technological problem. The groups are:

- Tech standards,

- Climate and green tech,
- Secure supply chains,
- Information and communication technology and services (ICTS) security and competitiveness,
- Data governance and tech platform regulation,
- Misuse of technology threatening security and human rights,
- Export controls,
- Investment screening,
- Promoting SME access to and use of digital technologies, and
- Global trade challenges.

(U.S.-EU Summit Statement, 2021)

On the latest, fourth, ministerial-level meeting of the TTC, EU and United States agreed on areas of collaboration:

1. Cooperation in area of emerging technologies
   Among the most important understanding between both regions is that Artificial Intelligence (AI) presents big opportunities but also threats to the world. Shared goal is to set standards and tools for trustworthy AI. Another big topic is e-mobility and wireless communication systems. International standard on megawatt recharging system for heavy-duty vehicles was established and vision to 6G roadmap was laid out.
2. Defence of human rights and values, and fight against foreign information manipulation and interference
   EU and US created set of principles which should protect and empower minors. Big concern remains disinformation that currently often comes from Russia. Both regions issued statement with actions to fight these disinformation and information manipulation.
3. Increase in bilateral trade for easier, greener, and safer trade
   Steps to simplify trade in specific sectors were taken. Among the key areas are veterinary medicine, marine equipment or machinery. To promote greener and sustainable trade between partners, program Transatlantic Initiative on Sustainable Trade was created. Additionally new program called Clean Energy Incentive Dialogue was put in place to support clean economy. United States and European Union also continue to perform tasks to increase their security. Examples are export restrictions of sensitive items to Russia and Belarus.

(EU-US Trade and Technology Council enhances cooperation in emerging technologies, sustainable trade and economic security, 2023)

2 Current economic situation

Following chapter reviews bilateral trade between European Union and United States in ten years period from 2012 until latest available data of 2022. Through analysis on trade of goods is performed with details per product. Followed by data with bilateral trade of services and investment. Second part of chapter is dedicated to high-technology sector and

its trade not only between EU and US but also rest of the world. We asses key players in this sector and its development in last decade. Additional attention is given to EU-US relationship and its future in high-tech sector.

2.1 Bilateral trade in goods

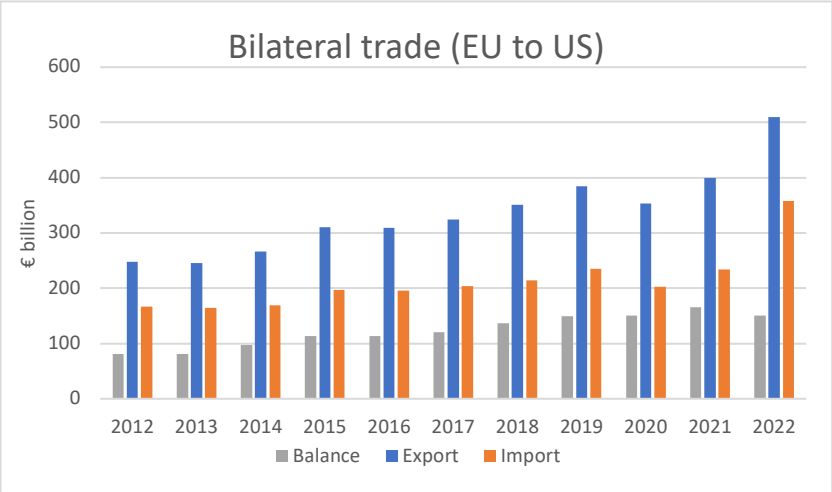

Figure 1 Bilateral trade (EU-US), 2012-2022

Source: Eurostat (ext_st_eu27_2020sitc and DS-018995)

Despite multiple disagreements in last few decades, the bilateral trade in goods between EU and US continues to grow. From €415 billion in 2012, total trade in goods increased to €868 billion in 2022. That is more than double the size with average annual growth rate of 19%.

In 2022, EU's export to US exceeded €500 billion which is a 27.5% increase from 2021. EU's import from US also achieved its highest value of €358.4 billion, up by 53.5% from 2021. There is however visible small drop in 2020. Distinctive rising trend can be observed in last decade even with challenges brought by year 2020 – pandemic of Covid-19 and trade restrictions across globe. All while maintaining steady trade deficit which was decreased from 2021 to 2022 to €150.9 billion.

Both partners are key for its unruffled trade functioning. US is largest exporting partner for EU in goods, and it is accounted for 19.8% of total EU export. It is followed by the United Kingdom (12.8%) and China (9.0%). Import from US is 11.9% of total EU import which makes US second most important partner in terms of import right after China with 20.8%.

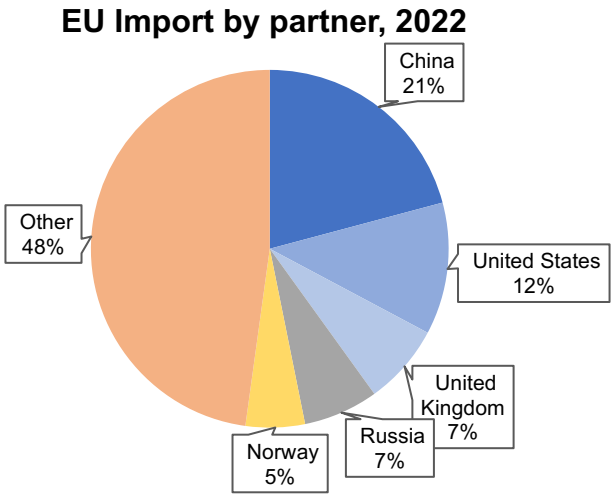

Figure 3 EU Import by Partner, 2022

Source: Eurostat (ext_st_eu27_2020sitc and DS-018995)

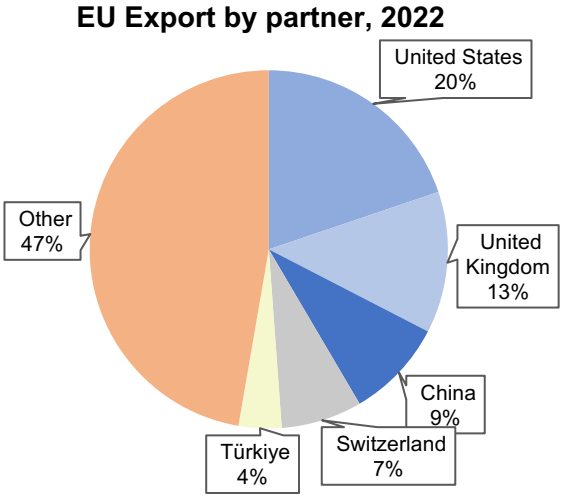

Figure 2 EU Export by Partner, 2022

Source: Eurostat (ext_st_eu27_2020sitc and DS-018995)

2.1.1 Bilateral trade by product

In Figure 4, we can see breakdown of trade between United States and European Union by SITC (Standard international trade classification) groups. The red shades represent the primary goods: food & drink, raw materials, and energy. Green shades show the manufactured goods: chemicals, machinery & vehicles, and other manufactured goods. Lastly blue represents other goods.

We can see that while some of the values haven't changed much between 2012 and 2022, some are significantly different. Major change is visible in Energy import, where we can observe 19% increase from 2012 (10%). According to Eurostat data, it is mostly due to change of import between US, Norway and Russia. We can assume this is driven by Russian invasion to Ukraine. By changing its main energy supplier from Russia to US and other European countries, EU showed support to Ukraine and its disagreement with President Putin's actions. On the other hand, machinery & vehicles import dropped from 40% to 28% in 2022. Effect on export was smaller with only larger variance on chemicals which increased from 23% to 29%. And decrease in machine & vehicles from 43% to 37%.

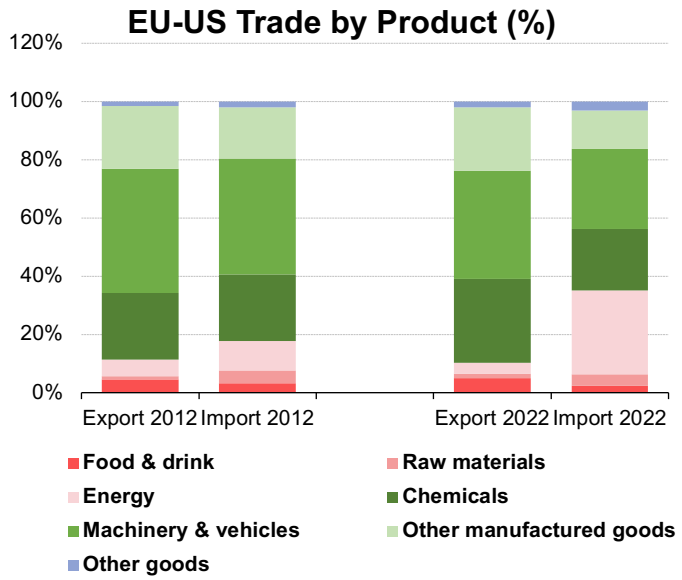

Figure 4 EU-US Trade by Product, 2012 and 2022

Source: Eurostat (ext_st_eu27_2020sitc and DS-018995)

2.2 Bilateral trade in services

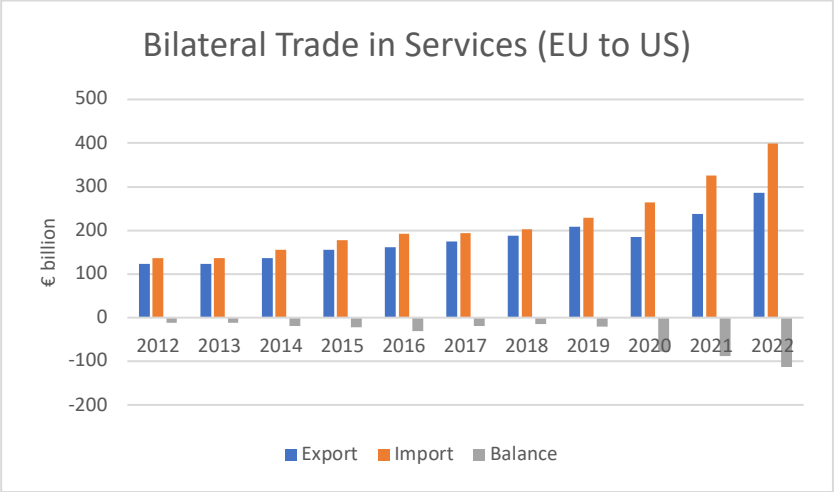

Figure 5 Bilateral Trade in Services

Source: Eurostat (BOP_ITS6_DET__custom_6420430) and OECD database

Bilateral trade in services reached a significant milestone in 2021 when it exceeded €500 billion. Since then, it continues to rapidly grow with average annual rate of 24% in past decade. In absolute values it increased from €259 billion in 2012 to €864 billion in 2022. Export of services grew by 131% during measured period from €123 billion to €285 billion and with annual average growth rate of 21%. And import shows even higher numbers with average increase of 27% per year, resulting in all time highest service import in 2022 of €399 billion. This also drives increase in trade deficit which was more or less in line until 2019 when it started to magnify. By the end of 2022, it is -€113 billion across all types of services. Major portion comes from Other business services where we see 10% variance.

2.3 Investments

One of the best indicators of economic integration is foreign direct investment (FDI). FDI is investment between an investor who is a resident of certain country to a company in another country. Main purpose is to gain a long-term decision-making power in the foreign company which equals to at least 10% of the common stock. It shows permanent interest of the investor in the company and his share in the management. And it has positive impact on economy growth and employment between all participants.

2.3.1 US FDI to Europe

There is no question whether the FDI from US to EU grows. Between 2000 and 2010, the amount more than tripled from $687 billion to $2,035 billion. And investment continued to increase in the second decade of 21st century as well. It went up by 78% from $2,035 billion in 2010 to $3,629 billion in 2020. Last year from 2020 to 2021, increased by another 9.7% to $3,981 billion.

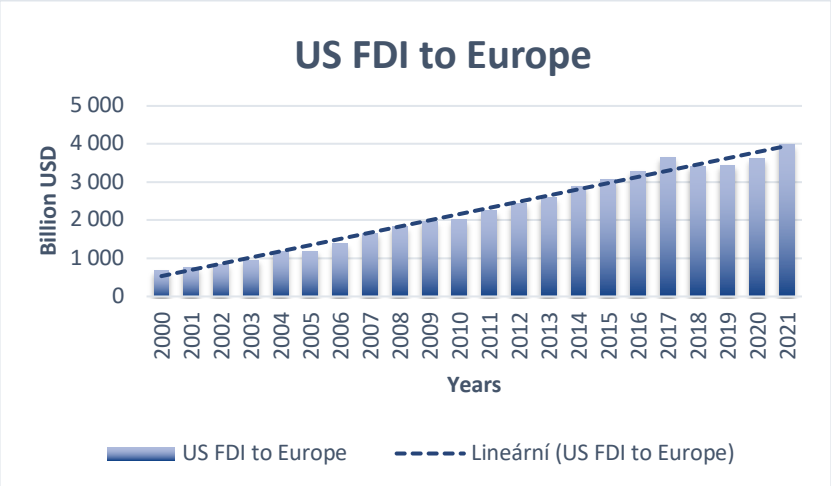

Figure 6 US FDI to Europe

Source: U.S. Bureau of Economic Analysis
(Available on: https://www.bea.gov/international/di1fdibal)

2.3.2 Europe FDI to US

Similar picture is visible on the other side. Europe FDI to US increased from $887 billion in 2000 to $1,660 billion in 2010, up 87%. And by another 69% between 2010 and 2020 to $2,808 billion. Last year 2021 shows growth of 13.5% to final FDI of $3,186 billion.
Based on numbers, we can conclude that not only governments see benefits in cooperation between EU and US, but also private sector acknowledges the potential future partnership can have. And it is willing to invest into it.

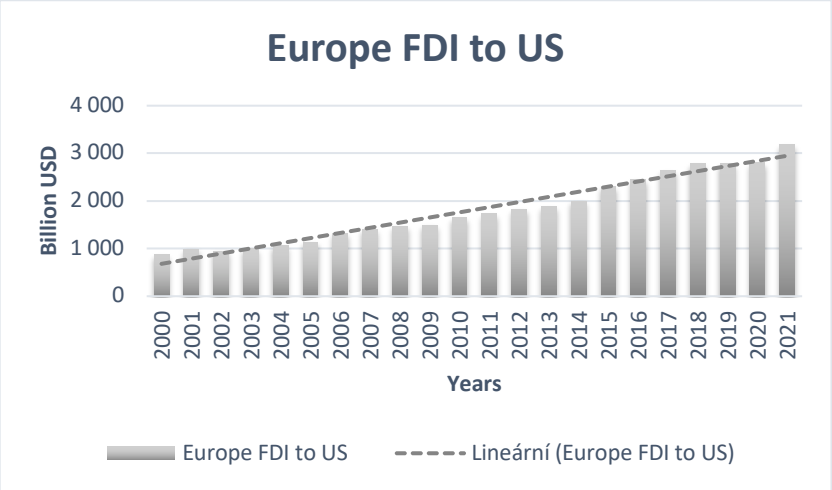

Figure 7 Europe FDI to US

Source: U.S. Bureau of Economic Analysis
(Available on: https://www.bea.gov/international/di1fdibal)

2.4 High-tech sector

Following sub-chapter will focus on international trade between EU and its key partners in high-tech sector. It will provide details per product and give extra attention to EU-US trade.

2.4.1 Definition of high-technology sector

High-technology, or commonly known as high-tech, are products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Given continuous development of the sector, there is no clear definition of high technology in international trade which would cover all aspects of it though out the time. Therefore, different countries, economic units use different definition which suits their goods classification (HS – Harmonized System, SITC – Standard International Trade Classification, NAICS – North American Industry). According to SITC, which is system used in all following analysis, we divide high technology into nine groups:

1. Aerospace,
2. Computers and office machines,
3. Electronics-telecommunications,
4. Pharmacy,
5. Scientific instruments,

6. Electrical machinery,
7. Chemistry,
8. Non-electrical machinery,
9. and Armament.

(Eurostat indicators on High-tech industry and Knowledge – intensive services, 2022)

2.4.2 European Union

Bilateral trade of high-technology products between EU and US grew in measured period by 110%, from €99 billion in 2012 to €208 billion in 2022. From chart below we can see that US was replaced by China as number one trading partner in high-tech industry in 2020 when China's numbers (€168 billion) surpassed US with €156 billion. Since then, the gap continues to grow. It also confirms generally knows facts that China replaced US as number one goods trading partner of EU.

It is important to mention that EU import of high-tech products is larger than its export. We see a trade deficit over €35 billion in 2022. And while trade balance with China is negative with deficit of almost €130 billion, US have positive balance of almost €30 billion implying that export to US is higher than import.

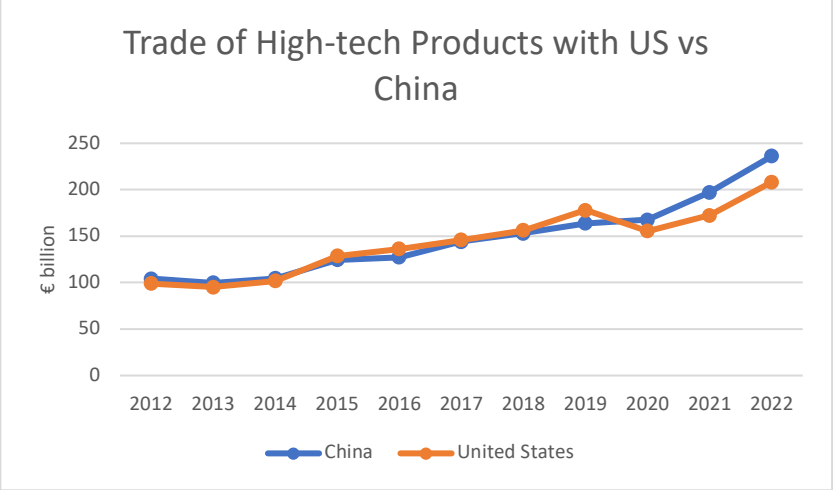

Figure 8 EU High-tech Trade with US and China

Source: Eurostat (Comext database DS-018995)

2.4.2.1 EU high-tech import

EU import of high-tech products from non-EU countries increased from €252 billion in 2012 to €482 billion in 2022. We can notice small drop in the numbers in 2020 which was caused by pandemic of Covid-19 and restriction which were imposed on international trade. However, we can see that economy was able to quickly recover and reach almost €400 billion in 2021.

When looking at numbers from partners perspective, Taiwan and Vietnam show the highest average annual growth rate. Taiwan has 11% and Vietnam 10.8%. In absolute value, largest increase represents China which grew from €81 billion in 2012 to €183 billion in 2022.

Thought out the years it became norm that over half of total non-EU import comes from China and US. And while this statement continues to be true, split of percentages between both countries as key import partners shift significantly in last three years. US share dropped from 23% in 2019 to 19% in 2022. On the other hand, China increased its share from 33% in 2019 to 38% in 2022. Figure 10 also shows that in total €, China shows significant increase in last three years. While US reached pre-covid numbers in 2022.

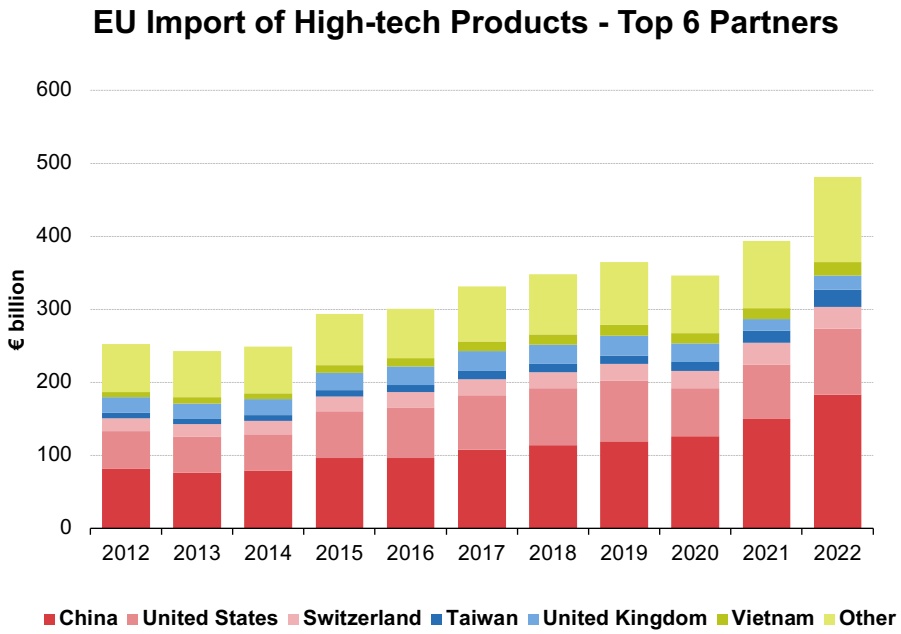

Figure 10 EU Import of High-tech products – Top 6 Partners

Source: Eurostat (Comext database DS-018995)

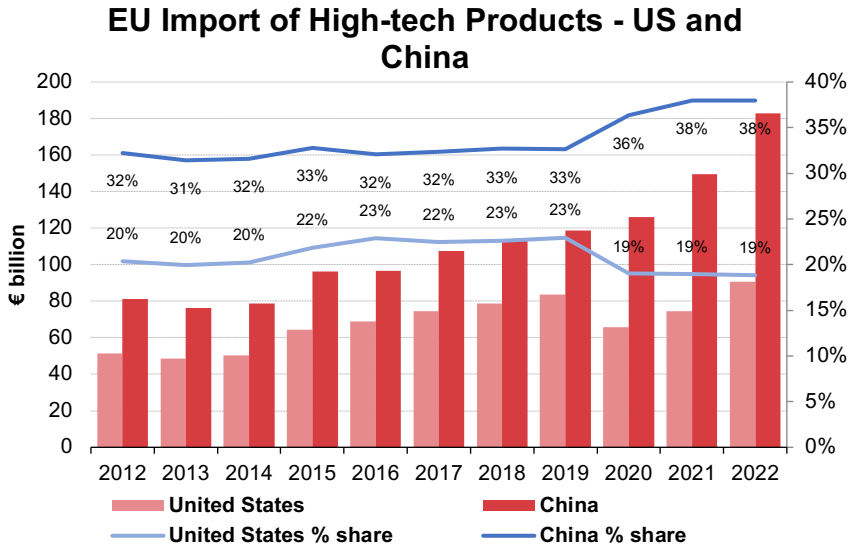

Figure 9 EU Import of high-tech products - US and China, 2012-2022

Source: Eurostat (Comext database DS-018995)

When we analyze numbers per product, we see that import of high-tech products from US mostly consists of Aerospace and Pharmacy. This is significantly different to other partners from Asia where major trading products are circling around Electronics-

telecommunications and Computers and office machinery. United States are responsible for 65% of total Aerospace import and 40% of all Pharmacy one. These are highest numbers from all trading partners and assumption is that given specialization US poses in these areas and past relationship, it is not likely to change anytime soon.

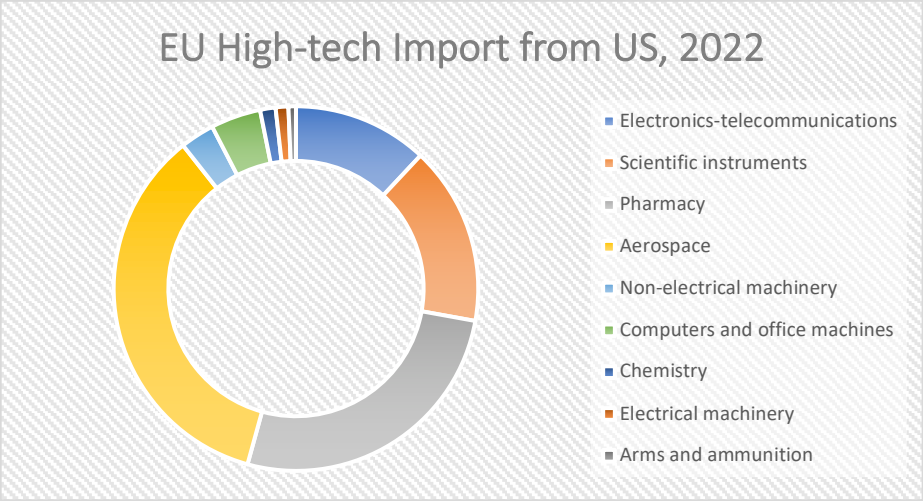

Figure 11 EU High-tech Import from US, 2022

Source: Eurostat (Comext database DS-018995)

2.4.2.2 EU High-tech export

Between 2012 and 2022, EU export of high-tech products increased from €259 billion to €446 billion. That equals to 5.6% average annual growth. Similar to import, EU export of high-tech products lived through a dip in 2020 caused by the pandemics. But while US position in import seems unsure, export is solid as ever. During past 10 years, export to US increased from €48 billion (18%) in 2012 to €118 billion (26%) in 2022. And is now representing more than quarter of total high-tech export. EU's export to China maybe didn't grow this much in absolute figure, but it grew most in average annual rate with 9.5% over the years.

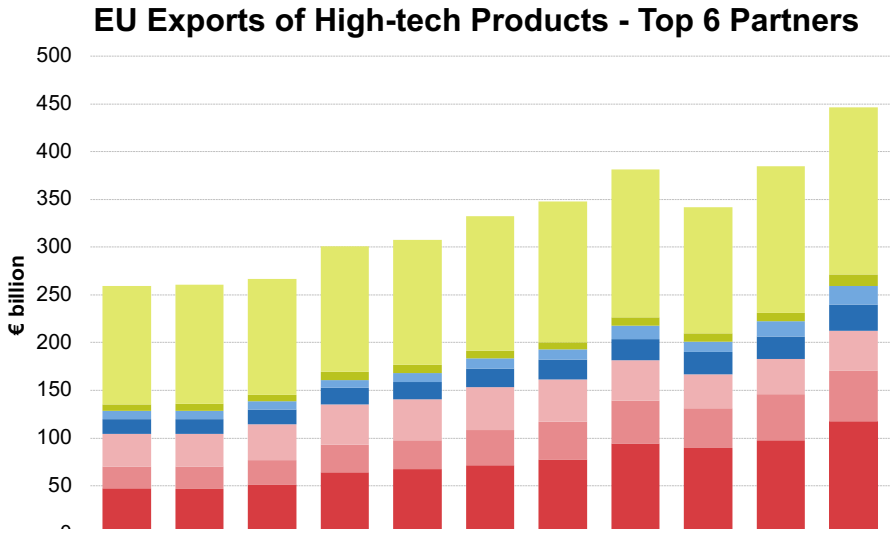

Figure 12 EU Export of High-tech products - Top 6 Partners, 2012-2022

Source: Eurostat (Comext database DS-018995)

In table 1, we can also observe significant drop in export to United Kingdom. This can be largely explained by UK's departure from European Union which was voted out in 2016. The Brexit transition period ended in 2020, and UK experienced high drop by 25% of import from EU (Spisak, 2023).

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Extra-EU	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	18.4	18.0	19.3	21.4	21.9	21.5	22.4	24.7	26.3	25.4	26.3
China	8.8	8.9	9.7	9.4	9.9	11.1	11.4	11.8	12.1	12.5	11.9
United Kingdom	13.1	13.2	14.0	14.1	13.9	13.6	12.7	11.1	10.3	9.5	9.4
Switzerland	6.0	6.0	5.9	5.7	5.9	5.9	5.9	5.8	6.8	6.3	6.2
Japan	3.3	3.2	3.1	2.7	3.0	3.1	3.2	3.7	3.3	4.0	4.2
Türkiye	2.7	2.8	2.7	3.0	2.8	2.4	2.1	2.3	2.5	2.4	2.8
Other	47.7	47.8	45.4	43.6	42.6	42.4	42.4	40.6	38.6	39.8	39.2
Share top 7	52%	52%	55%	56%	57%	58%	58%	59%	61%	60%	61%

Table 1 % Share of EU Export to non-EU Countries, 2012-2022

Source: Eurostat (Comext database DS-018995)

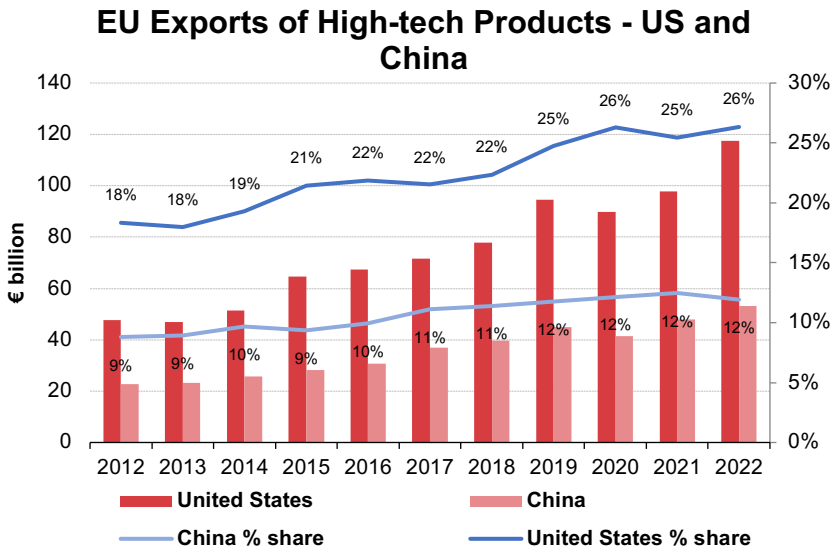

Figure 13 EU Export of High-tech Products - US and China, 2012-2022

Source: Eurostat (Comext database DS-018995)

EU high-technology export to US per product paints similar picture to import and is extremely dependent on Pharmacy industry. Export of Pharmaceutical products is almost 50% of all export to US and it is 40% of total EU export in this industry. Second place in export belongs to Scientific instruments with only 15%. The export structure to US is like with no other partner. Export to China is for example almost 40% driven by Electronics-telecommunications.

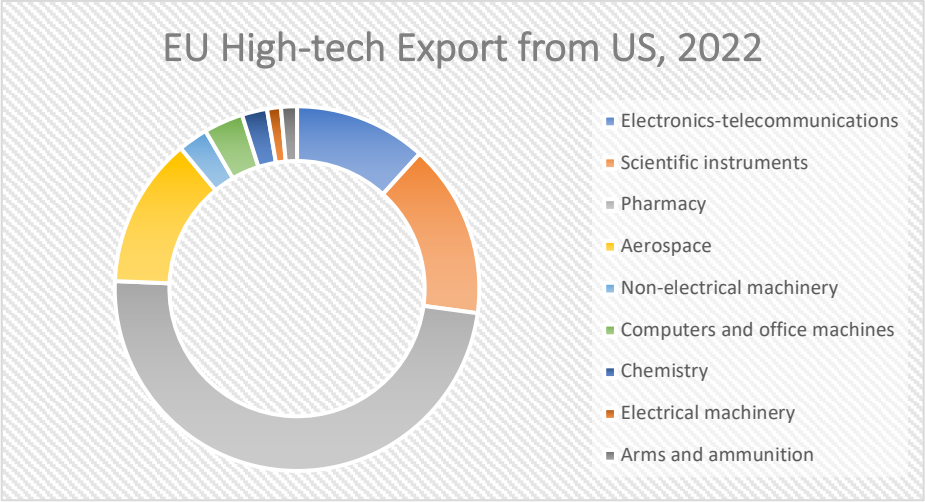

Figure 14 EU High-tech Export from US, 2022

Source: Eurostat (Comext database DS-018995)

2.4.3 Bilateral trade in high-tech sector

Bilateral trade in high-tech sector grew by unbelievable 110% in last decade, from €99 billion in 2012 to €208 billion in 2022. The recurring fluctuation in 2019 caused by the Covid-19 epidemic is also visible in bilateral trade numbers. And we can also notice visible shift in trade balance which went from negative in first 7 years to positive in 2019 and continued to grow in positive numbers until the end of 2022. The balance in 2012 was -€4 billion, while in 2022 it was positive €27 billion. That is mostly caused by increase in EU high-tech export which grew by average 22% each year. While import had annual growth rate of 16% during measured period.

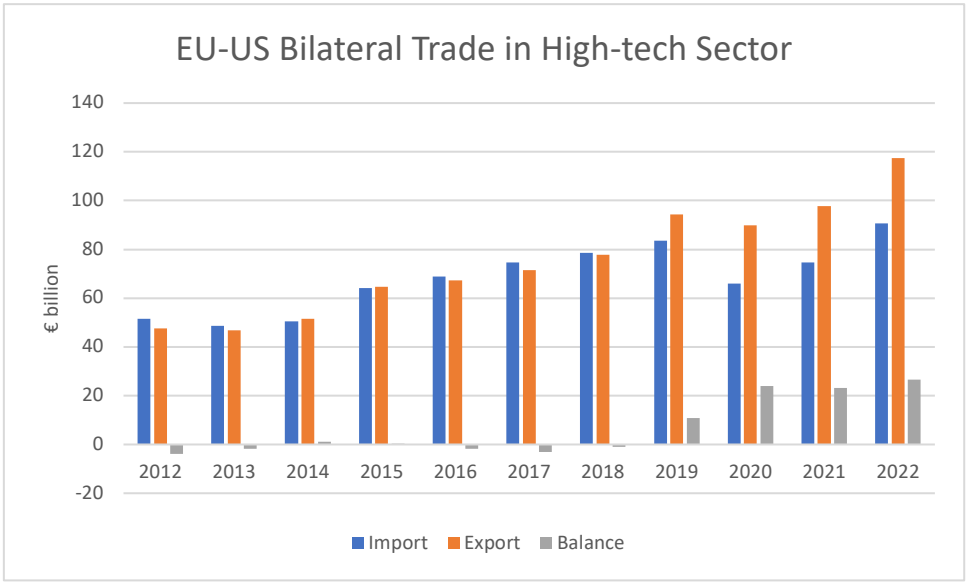

Figure 15 EU-US Bilateral Trade in High-tech Sector, 2012-2022

Source: Eurostat (Comext database DS-018995)

2.4.4 What is the US-EU future in high-tech sector?

Even though we see that China is extremely important partner for EU in high-technology sector and maybe disrupted bilateral trade between EU and US a bit, US remains indispensable trading partner especially in Aerospace and Pharmacy industry. In last ten years, Pharmacy imports to US increased by $16 billion and it export by $45 billion. It is fair to assume this will not change anytime soon as relationships with other trading partners are based on different industries with little or no trade history in it. In the end we can say that while China overtook US as number 1 trading partner in goods, position of US is solid in FDI and it still plays crucial part in EU trade.

3 Research and Development (R&D)

This chapter will briefly present the basic division of R&D activities, its key parts and characteristics. It will review and analyze current R&D spend and investigate its key indicators and performance in last two decades. It will look into specific programs, collaborative efforts and project settings in both US and EU. Compare its R&D structure and answer to question what drives variance between them. It will also explore EU-US R&D spend per sector and what, if any, difference exists in this area.

3.1 Definition of R&D

General definition of *Research and Development* says it is a set of innovative activities undertaken by corporations or governments in developing new service or products and improving existing ones. It contains creative and systematic work undertaken in order to increase knowledge and to generate new applications of available knowledge. R&D is always directed to new findings based on hypotheses or original concept and commonly the outcome is uncertain. The process is always planned and receive specific budget for the activity. Its main goal is to produce outcome which can be traded in a marketplace (Definitions of R&D, 2018).

Research is simply said process of discovering new knowledge. It is an organized search or aimed exploration for new knowledge with belief that it will be useful in creating new product, service, process or technique or improving existing one. *Development* is interfacing of research discoveries or other knowledge into a plan for creation of new product or process that will bring benefit. Or improvement of existing product or process. It consists of conceptual phase, design, testing of alternatives, prototype creation, and operation of pilot unit (Definitions of R&D, 2018).

In order to be any project classified as R&D, it must fulfil five criteria. The activity or product must be:

- novel
- creative
- uncertain
- systematic

- transferable or reproductible

(UNESCO, 2023).

One of the most important things when talking about R&D is source of its funding. Source refers to the unit which provides the budget for needed performance. It may be internal or external to the reporting unit. External can be then divided into five major groups: Business enterprise, Government, Higher education, Privat non-profit organization, and Rest of the world (UNESCO, 2023).

Another important aspect is sector which it belongs to and what type of R&D it is. There are three types of R&D:

- Basic research
- Applied research
- Experimental development

And fours sectors:

- Business enterprise
- Higher education
- Government
- Private non-profit

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. It analyses properties, structures, and relationships with a view to formulating and testing hypotheses, theories or laws. Results have generally no direct or immediate benefit but are published to make it accessible for other entities. ***Applied research*** is an original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Rest is meant to be valid for a single or limited number of products, processed or methods. It gives operational form to ideas. The outcome is often patented or kept secret. ***Experimental development*** is systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed. In other words, it transfers gained knowledge though research into operational outcomes, inducing project's tests or evaluation (OECD, 2002).

In context of R&D data we recognize fours sectors: ***Business enterprise*** is usually the biggest sector. It includes both private and public enterprises. And it represents all resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders. ***Higher education*** sector consists of all universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status. It also includes all research institutes, centres, experimental stations, and clinics that have their R&D activities under the direct control, or are administered by, tertiary education institutions. ***Government sector*** comprises of all units of central (federal), regional (state) or local (municipal) government, including social security funds, except those units that provide higher education services or fit the description of higher education institutions. The sector doesn't

include public enterprises even if they are owned by government. ***Private non-profit*** sector is all non-profit institutions serving households, except those classified as part of the Higher education sector. It also includes households and private individuals engaged or not engaged in market activities (UNESCO, 2023) (OECD, 2002).

3.2 R&D investment

Main indicator of R&D investment is called R&D intensity which is defined as R&D expenditure as a percentage of gross domestic product (GDP). When talking about enterprises, intensity refers to ration of a company's R&D investment to its revenue. R&D is the main driver of innovation, and R&D expenditures and intensity is its main indicators used to monitor the progress/development in comparison to plan or other entities.

3.2.1 EU and US

Following analysis is performed with latest available data for both regions which is 2020. US investment into R&D in 2020 reached 3.4% of GDP which is equivalent to €631 million. From Figure 16 we can see that it is the highest % in the history after steady growth from 2012. Since then, it increased almost by 1%. Although EU R&D investment continues to expand as well, it is still far behind the US numbers. In 2020, EU recorded 2.3% R&D expenditures as % of GDP which equals to €310 million. Based on these findings, we can conclude that US invests over 1% of GDP more into R&D areas and in real numbers, their investment is twice as big as the EU's.

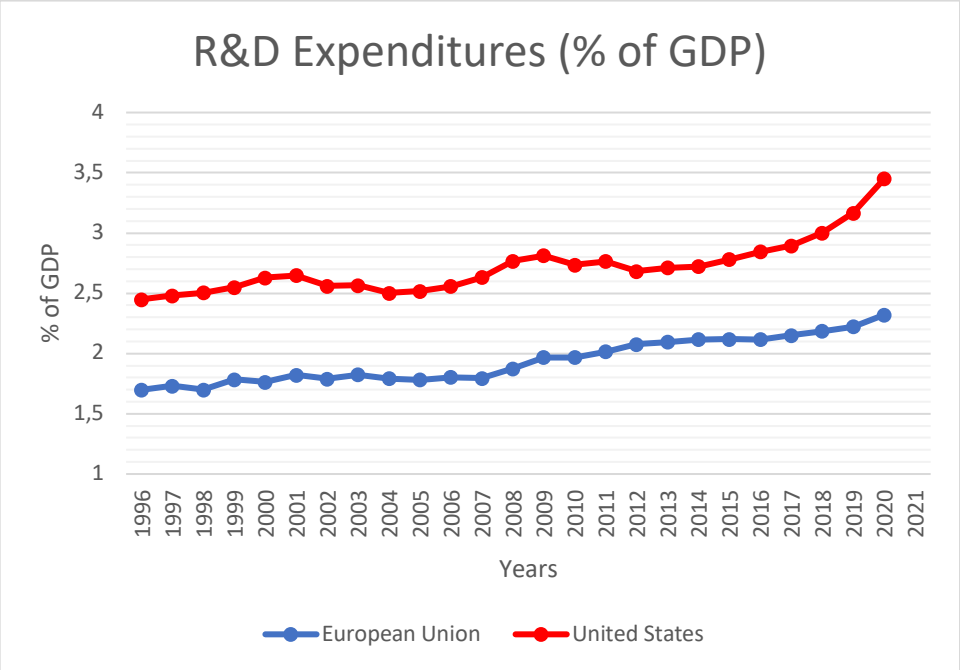

Figure 16 R&D Expenditures (% of GDP) - US and EU, 1996-2020

Source: The World Bank - Data
Available on: https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

An investigation of R&D expenditures by source of data shows that over half of the investments in 2020 were funded by business enterprises in both regions. This share remains mostly unchanged during last decade. However, there is 8% difference between both areas. While EU business enterprises represent 58% share of all R&D investments, US is 66%. On the other hand, EU benefits from higher government funding which is over 30% while US must settle with 20%. Third highest funding comes in both cases from "rest of the world" sector.

Table 2: R&D Source of Funding

	EU-27	USA
Business enterprise	57.9	66.3
Government	30.2	20.1
Higher education	1.2	3.1
Private non-profit	0	3.3
Rest of the World	9.6	7.2

Table 2 R&D Source of Funding, %, 2020

Source: Eurostat (RD_E_GERDTOT) and OECD database

While reviewing R&D intensity by **sectors of performance**, we can notice that in 2020, majority of R&D was in both regions, performed in business enterprise sector. Second largest sector was higher education. Followed by government sector and lastly private non-profit sector. We can observe that business enterprise sector is driving the highest variance between EU and US. By this we can conclude that the missing R&D in EU in comparison to US is from business sector while investments in other sectors are more or less the same.

Table 3: R&D Performance sectors

	EU-27	USA
Business enterprise	1.51	2.58
Government	0.27	0.32
Higher education	0.51	0.39
Private non-profit	0.02	0.14
TOTAL	**2.31**	**3.43**

Table 3 R&D % of GDP per Performance Sector, 2020

Source: Eurostat (RD_E_GERDTOT) and OECD database

3.2.2 R&D per country

Among the EU member states, highest R&D intensity was recorded in 2020 in Sweden (3.49%) and Belgium (3.35%). On the other hand, lowest ratios were recorded in Romania (0.47%), Malta (0.65%) and Latvia (0.69%). From Figure 17, we can observe that leader in R&D intensity is Israel (5.44%) which is quickly being followed up by South Korea (4.8%). The difference in the relative significance of R&D expenditure between countries can be often explained by levels of investments within the business enterprise sector. While R&D expenditure in the EU's business enterprise sector was equivalent to 1.5% of GDP in 2020, this ratio reached 3.79 % in South Korea, 2.58% in the United States, 2.57% in Japan and 2.52% in Sweden. The relative significance of R&D expenditure in the government and higher education sectors was broadly similar across regions.

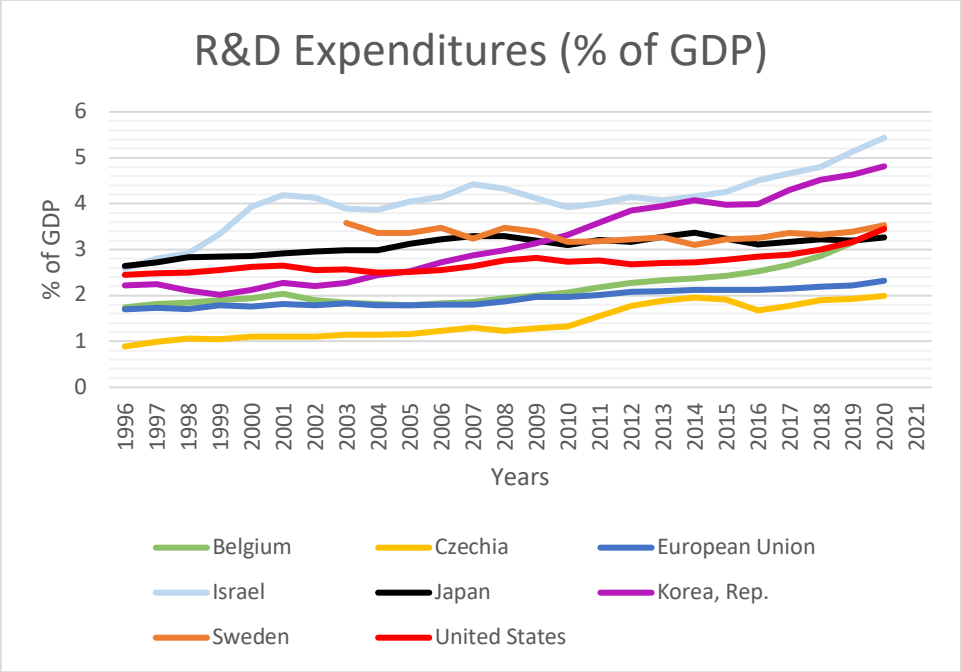

Figure 17 R&D Expenditures (% of GDP) – Per Country, 1996-2020

Source: The World Bank - Data
Available on: https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

3.2.3 R&D intensity gap between US and EU

Despite all the EU's effort and strong performance in R&D investment, the gap between both regions continues to grow in last decade. The difference is driven by structural effect which means that majority of US firms operate in industries with higher R&D intensity than in EU. Such industries include: technology hardware and equipment, software and computer services, pharma and biotech, and health care equipment and services. In comparison to US, there are significantly less leading innovative companies operating within these industries in EU. And while US highest share of R&D comes from Software and Computer Services (32%), EU's is from Automobiles & Parts sector (32%). Companies are particularly missing ICT sector where EU invests 4.7 times less in 'technology hardware and equipment' and 10.6 times less in 'software and computer services'.

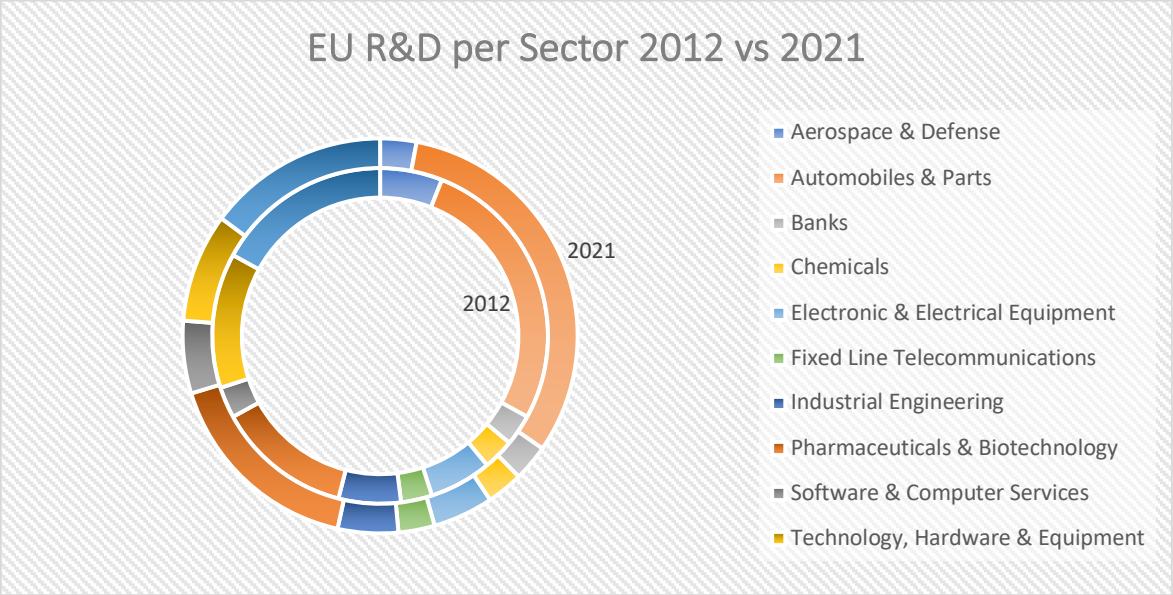

Figure 19 EU R&D per Sector 2012 vs 2021

Source: EU Industrial R&D Investment Scoreboard
Available on: https://iap.unido.org/articles/corporate-rd-intensity-gap-and-structural-change

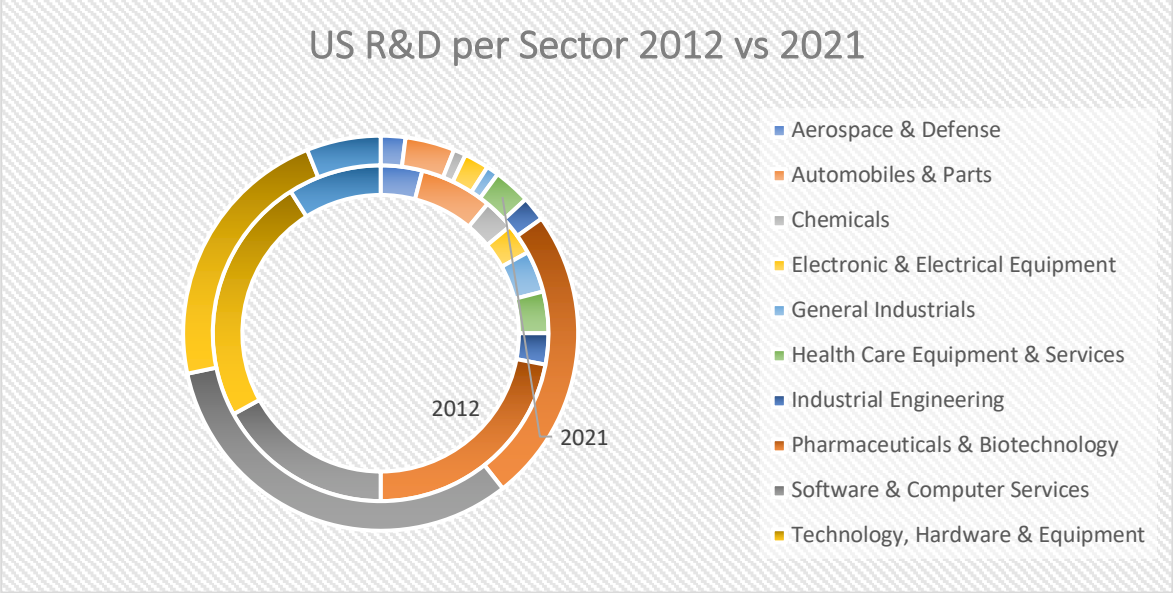

Figure 18 US R&D per Sector 2012 vs 2021

Source: EU Industrial R&D Investment Scoreboard
Available on: https://iap.unido.org/articles/corporate-rd-intensity-gap-and-structural-change

Another reason for the gap is drop in amount of top R&D investor firms in EU. From top 2,500 R&D investors in the world, only 401 reside in EU in 2021. Which is significant drop from 519 in 2012. On the other hand, US numbers went down only from 796 in 2012 to 779 in 2021 (Moncada-Paternò-Castello, 2023).

In the end, if EU wants to decrease the R&D intensity gap, it has to start by change its structure and focus more on important innovation sectors such as ICT and less on its automotive stronghold. Latest EU's FP Horizon Europe and its strategic plan and vision should serve as a mean to achieve that (Moncada-Paternò-Castello, 2023).

3.3 European Union

Primary goal of research and innovation in European Union is to create strategy for smart, sustainable, and inclusive growth which will lead to global competitiveness of Europe. This strategy is largely funded by “Framework programs for Research and Innovation”. Current FP is labelled Horizon Europe and it is the biggest EU’s R&D program in history with timeframe for 2021-2027 and a budget of €95.5 billion. It is a successor to previous FP Horizon 2020 and FP7 and it aims at strengthening competitiveness and growth of European countries through development, support, and implementation of EU policies while maintaining global challenges (European Commision, 2023).
The programs provide funding for R&D in all sectors. And although it is functioning as main fund stream for European researchers and innovators for their activities, program is open for everyone outside of EU as well as long as it reflects EU’s vision and applicants meet required conditions for eligibility.

3.3.1 Horizon Europe

Horizon Europe is a key current framework program to fund research and innovation in European Union in 21. century. Its main goals are to:

- Address climate change challenges
- Help to achieve sustainability development targets set by United Nations
- Support the EU’s competitiveness and growth
- Encourage international cooperation, and reinforce the effect of research and development
- Support creation and better distribution of new knowledge and technology
- Create job opportunities which will take full advantage of talents in EU, support economic growth, optimize competitiveness and investments to strengthen European Research Area

Similarly, to its predecessor H2020, it consists of three pillars which represents three long term objectives of European Union. Excellent science, global challenges & European industrial competitiveness, and Innovation Europe (European Commision, 2023).

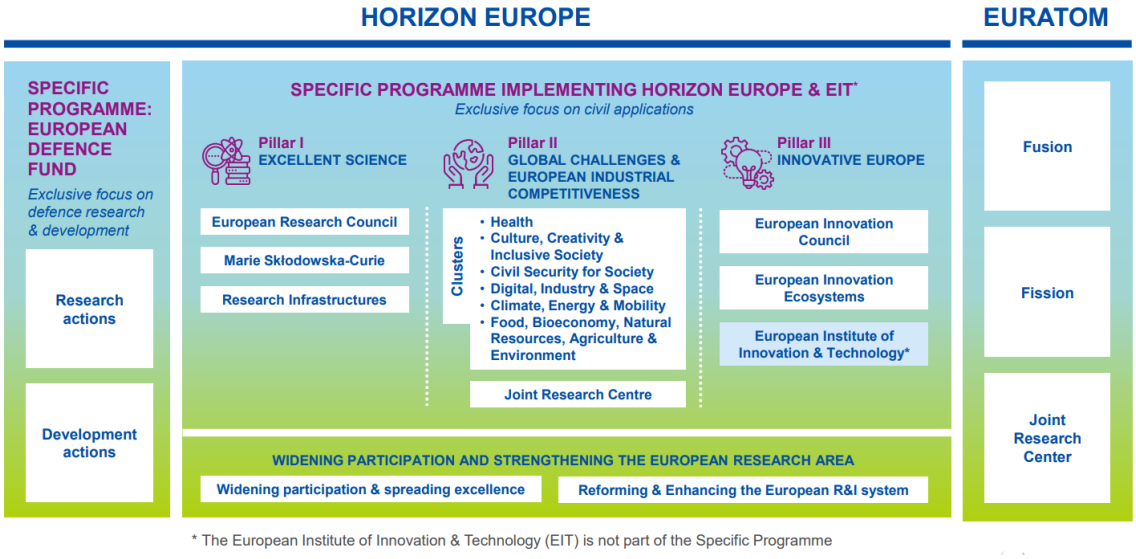

Figure 20 Horizon Europe

Source: European Commission Factsheet on Horizon Europe
Available on: https://research-and-innovation.ec.europa.eu/document/9224c3b4-f529-4b48-b21b-879c442002a2_en

Programme's goal is not only to support ICT opportunities, but also to shows a certain mission EU wants to communicate to the public. Mission is defined as list of actions across disciplines to achieve inspirational and measurable goal within a specific timeframe, with significant impact on wide range European Union population. In Horizon Europe, there are five missions set with target date 2030.

1. Adaptation to climate change, including societal transformation – Speed up process to healthy and prosperous future of the planet
2. Cancer – Goal is to save more than 3 million people by deeper understanding of illness, preventing where possible, optimalization of diagnoses and treatment, and equitability across Europe
3. Healthy oceans, seas, coastal & inland waters – This mission focuses on cleaning marine and fresh waters and by that restoring damaged ecosystems and habitants
4. Climate-neutral & smart cities – turn 100 European smart cities into innovation hub to spread awareness to other cities, promote its the positive impact on quality of life and sustainability in Europe
5. Soil health & food – Target is to secure at least 75% of all European soil to be healthy for food, people, nature, and climate

It was launched on 1st of January 2021 and as of June 2023, it already funded €19,38 billion to projects.

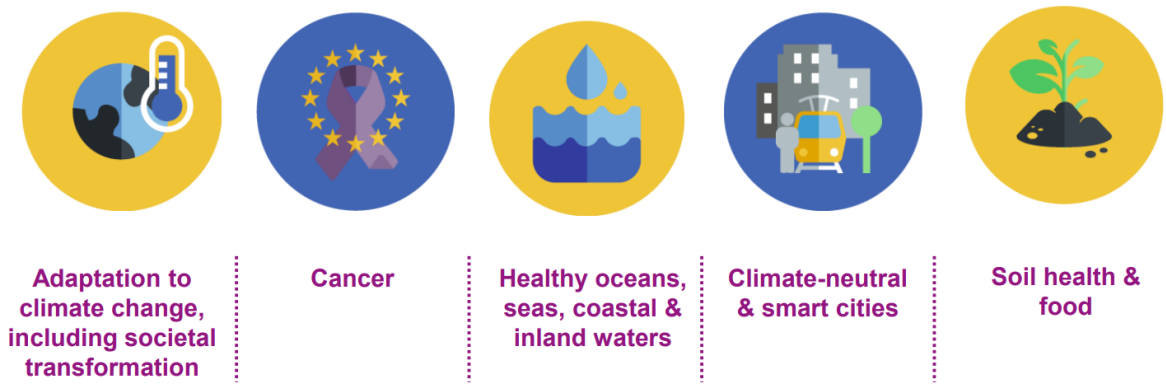

Figure 21 Horizon Europe: Missions

Source: European Commission Factsheet on Horizon Europe
Available on: https://research-and-innovation.ec.europa.eu/document/9224c3b4-f529-4b48-b21b-879c442002a2_en

3.3.2 Horizon 2020

Horizon 2020 between European Union and third countries was ninth in European's series of R&D programmes. It lasted from 2014 to 2020 and it had over €80 billions of budget spread across all sectors of innovation (European Commision, 2023). It is main goal was to connect key researchers and innovators to encourage better collaboration. Other strong characteristics included increase in participation of small and medium-sized businesses; focus on new forms of innovations; and bigger attention on international cooperation partnership. H2020 represents the EU's vision: "Open innovation, open science, open to the world." Which means that even though it is the main source for European researchers and innovators to get funding for their projects, it is open to everyone else outside of the EU as well (Klessova, 2020).
It can be evaluated as the most successful framework program in areas of R&D so far. It resulted in:

- More than 1.5 million collaborations in over 150 countries
- 84% of all investments were focusing on Sustainable development and 30% addressed climate change
- Number of proposals was twice as high as in previous engagements
- €48.2 million was set aside for coronavirus R&I just seven days after EU reported first case
- 19% productivity increase in companies funded by the programme

(European Commision, 2023)
H2020 can be divided into three pillars: Excellent science, industrial leadership, and tackling societal challenges. Pillars are then split into thematic areas reflecting EU policy priorities. Every area has a specific two-year Work Programmes which address specific documents for calls and topics. Example under **excellence science** pillar would be the aim to attract the best talents in the industry. The **industrial leadership** pillar lays out research and development support across five technology areas: information and communication

technologies (ICT); nanotechnologies, advanced materials, and production; biotechnology; advanced manufacturing and processing; and space. **Social challenges** pillar centers around several grand challenges for Europe and the world: health, demographic change, and well-being; food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio-economy; secure, clean, and efficient energy; smart, green, and integrated transport; climate action, environment, resource efficiency, and raw materials; inclusive, innovative, and reflective societies; and secure societies (Klessova, 2020).

Interorganizational projects under H2020 can be divided into three types: Research and Innovation Actions (RIAs), Innovation Actions (IAs), and Coordination and Support Actions (CSAs). **RIAs** are projects with at least three partners from three different EU member states or countries associated with FP. They are focusing on development of new knowledge or technology, product, process, or service improvement. They typically focus on pilot activities and test of technical feasibility in near-to operate environment, meaning lab or simulated environment. And regardless of each partners involvement, funding equals to 100 percent from total costs. On the other hand, **IAs** are creating close-to-market prototypes, or improved product or service. In other words, they are helping to bring the subject of the project closed to the market application. Similarly, to RIA, minimum number of participants is also three. But in this case funding it decreased to 70 percent from total costs for profit-making legal entities. Non-profit organizations are eligible for 100 percent funding. **CSA** are not research and innovation related activities. Typically, these projects map certain scientific research areas, projects focusing on organization of large events. They can be submitted individually per entity and are financed 100 percent from total eligible costs (Výzkumné a inovační akce, inovační akce a koordinační a podpůrné akce, 2020).

During its activity, H2020 signed grants for 9825 collaborative projects providing €68,3 billion funding from EU. It total H2020 is responsible for 4726 RIAs, 2265 IAs, and 2834 CSAs with over 46 unique participants (European Commision, 2023).

Spawned from the previous FP versions, the collaboration on the project must be joined effort of all partners. And not individual tasks under overarching frame. This must be exhibit already in the proposal phase and it is evaluated according to criteria based on which grant is either given or not (details in table 4). The specific way of collaboration is also stated and agreed upon in proposal preparation phase (Klessova, 2020).

	Eligibility conditions for participation
Research & innovation actions (RIA)	At least three legal entities. Each of the three must be established in a different EU Member State or Horizon 2020 associated country. All three legal entities must be independent of each other.
Innovation actions (IA)	At least three legal entities. Each of the three must be established in a different EU Member State or Horizon 2020 associated country. All three legal entities must be independent of each other.
Coordination & support actions (CSA)	At least one legal entity established in an EU Member State or Horizon 2020 associated country.
SME instrument	At least one SME. Only applications from for-profit SMEs established in EU Member States or Horizon 2020 associated countries.

Table 4 H2020 Eligibility for Participation

Source: Horizone 2020 General Annexes
Available on:
https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016_2017/annexes/h2020-wp1617-annex-c-elig_en.pdf

3.4 United States

In contrast with European Union, US doesn't have one program which would manage overall R&D activities in the country. Instead, there are multiple Federal government agencies that sponsor R&D projects. Each has its own program, priorities, mechanism, and regulations for eligibility. Some funding is also available on State level. However, these are normally available only to local applicants for regional needs. This means that no foreign entity or even entity from different US state is eligible for the funding (Klessova, 2020).
Federal R&D priorities are drafted on yearly basis from three sources of information:

- Memorandum from Office of Science and Technology Policy (OSTP)
- The Congress
- The State Department and connected funding agencies.

Priorities with their budgets are then yearly recorded by OSTP in the Multi-Agency Science and Technology Priorities for the Fiscal Year Budget. Agencies use several ways of financing organizations. Among the most common ones are grants, cooperative agreements, or procurement contracts. Each agency has not only different mission and funding mechanism. But also size and type of grants, their length, or number of participants. Project can be awarded by few tens of thousands of dollars or millions. As well as last from few months to several years (Klessova, 2020).
In general participation of foreign countries in US R&D projects is allowed, welcomed, and seen as beneficiary. Although funding is in majority of cases unpredictable, and it is

therefore normal that foreign participants cover their expenditures. Among the most important organization providing R&D funding in US are:

- National Science Foundation (NSF),
- National Institutes of Health (NIH),
- Department of Defense (DoD),
- Department of Energy

(Klessova, 2020).

3.4.1 National Science Foundation

NSF is independent US agency which supports all areas of fundamentals science and engineering, except of medical science. It was established in 1950 by Congress and its main goals are to promote the scientific progress, advance the national health, prosperity and welfare, and secure national defence. It is active in all 50 states and US territories and its investments account for 25% of total federal support to R&D activities (NSF, 2023).

Given its primary goal is to support national priorities, NSF generally doesn't provide financial support for non-US researchers. Exception is when foreign organization's involvement is essential to the project. US organization needs to state why the specific part of delivery cannot be performed locally and is therefore crucial to obtain help from foreign entity. But even then, the NSF provides support only for the US portion of the collaborative work. The agency however strongly supports any collaboration with foreign partners where financial means are provided from other sources. Example would be project PICASSO which was a collaboration co-funded by NSF and EC though H2020. Another noteworthy difference to EU FP is that NSF doesn't provide funding to smaller businesses. Reasoning behind is that government agencies have isolated programs and budgets for Smaller Business Innovative Research (SBIR) and Small Business Technology Transfer (SBTT) (Klessova, 2020).

To simplify international collaboration between US and foreign partners NSF has an Office of International Science and Engineering (OISE) whose primary goal is to promote innovation among US research community by making international knowledge and infrastructure more accessible. OISE has offices across world, including in Europe. In EU, its main role is to: promote collaboration between US and EU science and engineering, represent NSF across multinational organizations in EU, and to monitor and report developments in EU academic circles. OISE not only promotes international cooperation but also enlists specific opportunities which NSF marked as designed for multinational collaboration (Klessova, 2020).

In FY 2022 which lasted from October 1st, 2021, until 30th of September 2022, NFS enacted budget of $8.8 billion on R&D appropriations which is a 4.1% increase from FY 2021. Over 1,800 partners received NSF funding, 352,000 researchers, trainees, teachers and students were supported directly by NSF, and over 11,000 competitive awards were funded with estimated funding rate of 28% (NSF, 2023).

Current NSF budget for fiscal year 2023 is set to $10.492 billion and similarly to EU's Horizon circulates around three pillars: Strengthening Established NSF; Bringing the "missing Millions" into the STEM Workforce; and Accelerating Partnerships. Pillars cross six themes which represent NSF's areas of focus: Climate and Clean Energy Research, Equity for Underserved Communities, Discovery Engine, Emerging Industries, Research Infrastructure, and Organizational Excellence/Agency Operations and Award Management.

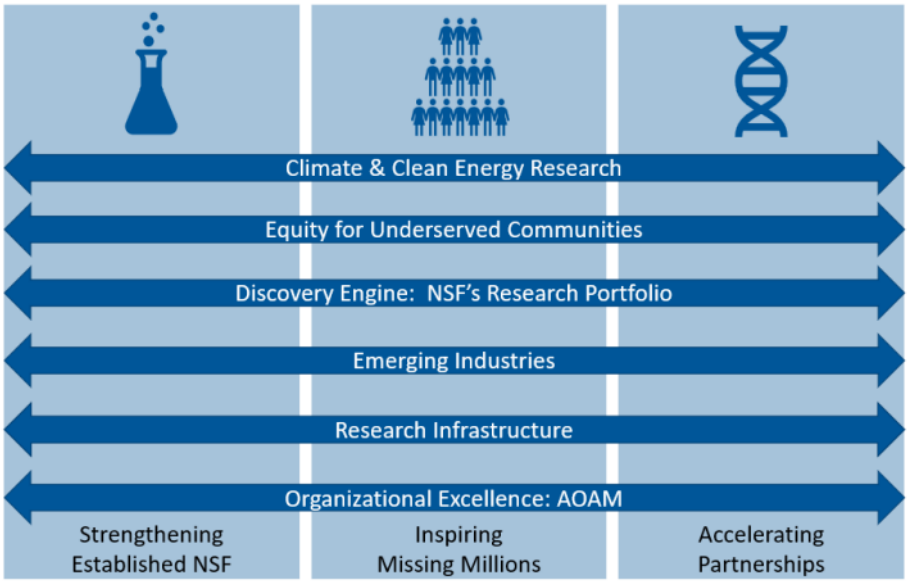

Figure 22 NSF FY23 Budget Details

Source: NSF Website
Available on: (https://new.nsf.gov/)

Since 2017, NSF has been building background for what it considers to be "Big Ideas" though R&D activities (figure 23). It invested and supported emerging opportunities that could benefit US nation. Latest report talks about 10 Big Ideas which can be divided based on its type into research or process category (NSF, 2023).

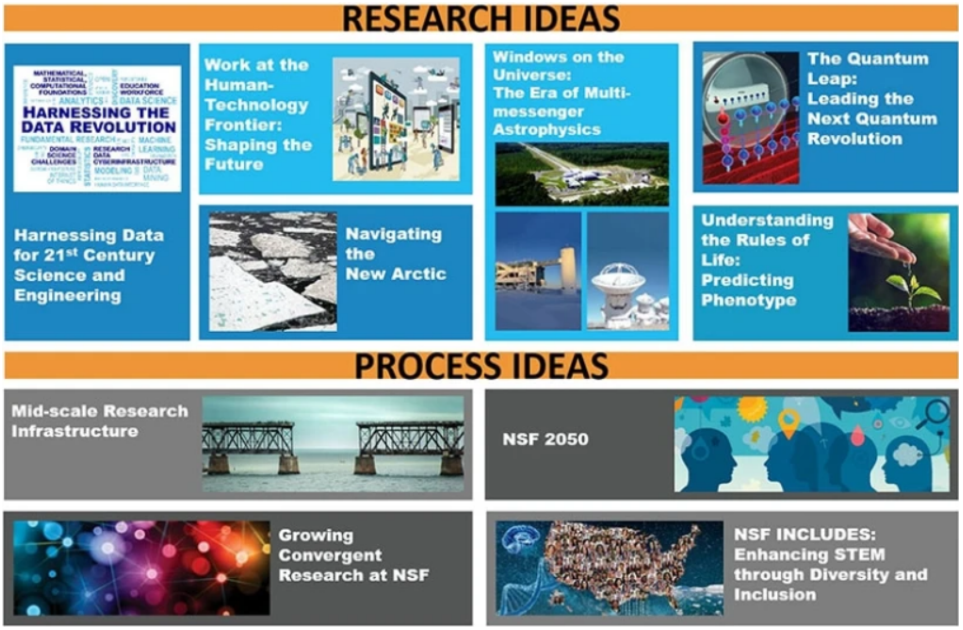

Figure 23 NSF: Research ideas

Source: NSF Website
Available on: (https://new.nsf.gov/)

Budget request for next FY 2024 from President Biden to Congress includes budget of $11.314 billion for NSF which is an increase by 18.6% from current plan. It supports president administration's priorities and lays out heart of NSF's mission (figure 24).

Figure 24 NSF: Missions

Source: NSF Website
Available on: (https://new.nsf.gov/)

3.4.2 National Institutes of Health (NIH)

NIH is the US medical research agency with main goal to discover ways to improve health and save lives. It is "the largest biomedical research agency in the world" and its mission is "to seek fundamental knowledge about the nature and behaviour of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability" (NIH, 2022).

Among the most important NIH's missions are:

- Promotion of creative findings, discoveries, innovative research strategies with a goal to improve health and protect human subjects

- Development and maintenance and renewal of scientific resources which will help diseases prevention
- Expanding medical knowledge and related sciences in order to enhance well-being of US citizens
- Being a prime example of scientific integrity, social responsibility and public accountability

(NIH, 2022)

And in order to support these goals, NIH provides programs to support research in areas: causes, diagnostics, prevention, and cure of human diseases; process of human growth and development; biological effects of environmental contamination; understanding mental psychological disorders; programs to encourage knowledge share between health organization (NIH, 2022).

Unlike NSF, NIH regularly funds researchers outside of the US. In FY 2022, it spent $33.3 billion of its $45.2 billion budget which is an increase by 3,1% from previous year. It supported 1,576 grants and 2,707 institutions and organization across US and internationally (NIH, 2022).

In 2018, the NIH and the EC agreed on collaborative funding for joint projects which deal with health-related research. This makes NIH the largest US program with visibility and predictability of funds not only to US researchers but also to EU. To simplify the collaboration even more, bilateral working groups were established on both ends (Klessova, 2020).

NIH is one of the few agencies in US which has specific policy in place for foreign applicants. In general, foreign entities are eligible to apply for grants except of Kirschstein-NRSA institution research training grants, program project grants, centre grants, resource grants, SBIT/STTR grants, or construction grants. There is however a possibility to receive grant for domestic institution with foreign component (Klessova, 2020). Official NIH website states, that eligibility of foreign organization for a grant is determined based on below:

“Foreign applicants are strongly encouraged to review the Eligibility of the Funding Opportunity Announcement (FOA) to determine whether their non-domestic (non-US) entity (foreign organization) is eligible to respond to the particular FOA. Additional information on grants to foreign institutions, international organizations and domestic grants with foreign components can be found in the NIH Grants Policy Statement.” (NIH, 2022)

Further information is available in each FOA. EU-based organization’s grants are controlled by previously mentioned agreement from 2018 which in principle guarantees their eligibility.

3.4.3 Department of Defense (DoD)

DoD is a major funding organization for R&D in United States. Its budget includes funding for the OSD (Office of the Secretary of Defense) and the DoD Service research organization. There are seven Service research organization under DoD. Communications-Electronics Research, Development, and Engineering Center (CERDEC); Defense Research and Engineering Network (DREN); High Performance Computing Modernization Program

(HPCM) and three Research Laboratories based on the type of armed force: Air Force (AFRL); Army (ARL), and Navy (NRL) (Klessova, 2020).
DoD strongly supports foreign organizations in submitting proposals. Announcements from Defense Advances Research Projects Agency (DARPA) frequently mention that all sources capable of fulfilling Governments request may submit the motion that will be considered. Non-US organizations can apply as long as they fulfil all necessities around security regulations, control laws, and other specific virtues which may occur project by project (Klessova, 2020).
Latest FY 2024 budget request for research, development, test, and evaluation (RDT&E) is $145 billion which is the largest request in history (Department of Defense Releases the President's Fiscal Year 2024 Defense Budget, 2023). DARPA's budget request for 2024 was $4.4 billion from which over half is dedicated to Advanced Technology Development. Majority of the remaining budget should go to Applied Research (DARPA, 2023).
Interestingly big part of DoD-funded research can be classified as basic research. Despite the fact that DoD's primary source of innovations are DARPA deals with projects that should in specific period create revolutionary change. Its scientific areas spread from physics, engineering, biology, medicine, computer science, chemistry, mathematics, material and social sciences, neurology, and many more (Klessova, 2020).
Funding opportunities are generally shared via Broad Agency Announcements from DARPA. They also include all necessary information applicant organization may need.

3.4.4 Department of Energy (DoE)

Main purpose of DoE is to create prosperity and security by tackling environmental, energy, and nuclear challenges though transformative science and technology solutions. Its budget request is sent to Congress and its main priorities are:

- Climate action
- Energy jobs
- Energy justice
- Investments

(U.S. Department of Energy, 2023)

Figure 25 DoE Priorities

Source: U.S. Department of Energy
Available on: https://www.energy.gov/

DoE's budget request for FY 2024 is $52 billion. It should serve as targeted investment in US citizen's prosperity. Among the main goals are: reducing energy costs for American

household while making their homes healthier and energy consumption efficient; sustainable, clean energy supporting climate challenge; investment into clean energy solutions; increase of America's Energy Security by creating domestic energy supply chain depend less on foreign countries like Russia (U.S. Department of Energy, 2023).

R&D research opportunities within DoE are managed by DoE's Office of Science (SC), and the Advances Research Projects Agency – Energy (ARPA-E). Important are also National Laps which are making High-Performance Compounding equipment available to researcher from industry and academic soil. By that they are able to maximize possible intellectual outcome (Klessova, 2020).

ARPA-E was established in 2007, with the goal to represent what DARPA does for defence. Similarly to DARPA, it announces its opportunities for grants via Funding Opportunity Announcements (FOAs). They centered around specific energy area and how to overcome technical barriers surrounding it. ARPA-E also provides periodic OPEN FOAs that focus on high potential projects in energy related technologies. More details can be found on hhtps://arpa-e-foa-energy.gov/ (Klessova, 2020).

Foreign entities are eligible to apply for funding from ARPA-E. However, there are strict criteria that need to be met in order to be accepted. Foreign entities can submit proposal as a Standalone Applicant, lead organization for a Project Team, or as a member of the team. All work done by foreign entities must be performed by subsidiaries in the US (including US territory). Request for exception from this rule can be submitted in the Business Assurance & Disclosure Form which is handed in with the application (Klessova, 2020).

Another important organization under DoE is Office of Energy Efficiency and Renewable Energy. Opportunities are available on https://eere-exchange.energy.gov/. Foreign applicants are eligible for the funding but in this case, it may be required for Prime Recipient of the grant to be incorporated under the laws of US. Alternatively foreign entity needs to have subsidiary or affiliate incorporated under the laws of US. (Klessova, 2020).

3.4.5 NITRD: A programmatic Umbrella Covering ICT

Networking and Information Technology Research and Development Program is the US primary funding program related to research and development in ICT area. It is one of the oldest programs which helps to coordinate activities between multiple agencies. On average NITRD invests $9.6 billion annually into R&D programs that focus on advanced information technologies in compounding, networking, and software. Program's main goal is to identify, develop and support advanced technologies needed by Federal Government and Nation (NITRD, 2023).

NITRD program can be split into smaller Program Component Areas (PCAs) mirroring the US priorities. Agencies working on the same priority meet through Interagency Working Groups (IWG) which helps them maximize the R&D resources and budgets and to prevent duplicate actions. 5G, Big Data, Internet of Things, or Smart Cities those are nowadays few of the key topics for ICT. Areas of highest investments are Artificial Intelligence, High End Compounding Interagency Working Group, and Large-Scale Data Management and Analysis (Klessova, 2020).

3.5 EU-US R&D cooperation

History between US and EU is full of cooperation in area of Research and Development. Specific agreements have been in place for years and both regions are not afraid to share relevant information when wanted or needed. The general relationship can be described as open, transparent, fair, and inclusive which makes both participants natural science and technology partners (Klessova, 2020).
Control over cooperation between EU and US in area of R&D is done by Agreement for Scientific and Technological Cooperation which was first signed in 1998 and since then re-signed four times always with five years validity. Latest agreement is valid until October 2023. Part of this agreement was a roadmap to cooperation from 2014 which laid out areas of focus for both countries. These prime concerns include: marine and Artic research, health research, transportation and materials research, nano safety, regulatory research, safety research, energy research, brain research, digital science, and many others (Klessova, 2020).

3.5.1 US participation in the EU R&D Financial Programmes

Given the new EU Financial Program Horizon Europe only started in 2021 we will investigate US contribution in previous FP which is Horizon 2020. Latest priorities in 2018-2020 period of H2020 were focused on digital transformation of health and care, automated driving, and road automation. And great attention was also given to the area of Future Internet and Advanced Wireless Platforms which will become matter of great importance (Klessova, 2020).
With final numbers available on European Commission side, we can document that US entities have participated 2,077 times in 1,586 signed grants of H2020. In total receiving €125M from direct EU contribution. Such numbers put US on top of the list of Non-Associated Third country participants. Ahead of US is only Israel with 2,103 participations and €1billion EU contribution. US is also leading non-European country in terms of funding as it is responsible for 28% of all non-EU funding, followed by China (9%) and Canada (6%) (European Commision Qlik dashboard, 2023).
Some US companies participate in EU programmes more often than others. For example, on top of the US participants list are Honeywell International and University of California. Among most common reasons for joining the programme are networking with EU partners and expansion/introduction into European markets. US participants perceive cooperation with EU partners as non-problematic, supportive, and rewarding. In interview related to H2020 programme, not a single US company regrated joining the project regardless of its sector. They valued the share responsibility, peer-to-peer approach, and high level of knowledge, quality of work, and expertise which they received from their counterparts in other locations. The impacts on some companies was so significant that in order to make future grants more accessible, they decided to open small branch in EU. By the end of the participation, majority of the US firms believes, that knowledge about the EU funding should be spread more widely as many companies are not aware of their possible eligibility (Klessova, 2020).

When asked EU coordinators, why they joined forces with US companies, most common reply was that they offered unique expertise or technology which benefited project greatly. Because of this some EU coordinators were actively searching US involvement. EU participants also described that their working relationship to US partner was no different to EU's. Even if there was sometimes more administrative work involved (Klessova, 2020).
From all the points above we can state few final notes about US participation in EU's programmes:

- United States is a major cooperation partner in H2020 Framework Programme
- Health sector is the most attractive to US participants followed by ICT
- Among most valued benefits of the cooperation are deeper knowledge, complementary scientific expertise, technology development, reputation gain from programme participation, identifying and networking with key partners, awareness of latest R&D activities in EU and other countries, and lastly opportunities for wider sources of funding
- All partners reported that US industries lack information about programmes and possibilities for European Commission fundings

4 Conflicts in R&D area

Any relationship between two different subjects is complicated and there are disputes from time to time. Transatlantic history is no different. Even though the benefits of cooperation for both parties are significant, it is not without challenges.
Following chapter will cover some of the R&D trade conflicts between the two regions. Some of them originating way back and some more recent ones without resolution not fully concluded.

4.1 Beef hormone dispute

In 1989, EU banned import of beef meat which contained specific growth promoting hormones and were according to them threat to health and safety of the public. Such bans are allowed within the WTO but only if sufficient scientific evidence is presented to support the claim. EU failed to provide adequate proof. And therefore, not only the WTO ruled in favour of the US. Selected arbitrator by WTO also authorized US to impose tariffs on EU of $116.8 million per year (Thornton, 2019).
Ten years later, EU discovered that 12% of "safe" beef meat imported from US included previously banned hormones. In 2002, EU Scientific Committee on Veterinary Measures claimed that specific growth promoting hormones present health risks for consumers and as a precaution EU wanted to extend the ban to entire American beef export (Thornton, 2019).
Coming months brought series of discussions. US threated to impose 100% punitive duties on other goods of total value $900 milliards. EU tried to negotiate with return of lost profits of beef. But US would agree to the proposition only if the ban was lifted as well. Given EU

strongly stood behind its opinion that the specific growth hormones, which they banned, are risks for heath, they declined and rather accepted the US sanctions (Cihelková, 2003).
The precaution principles we saw in European Union with regards to beef growth hormones are not new to the world. In case of uncertainty whether some product or its part is threat to food safety, EU is not afraid to take needed measures to prevent potential risks (Thornton, 2019).

4.2 Environment

One of the biggest problems of modern world is without doubt environment and how can we preserve our planet for future generations. To ensure that, Kyoto Protocol to the United Nations Framework Convention on Climate Change was adapted in 1997. Participating countries pledged to reduce greenhouse gas emissions by at least 5.2% in comparison to 1990 levels until 2012. Second part of protocol was approved in December 2012 with timeframe for next 8 years. EU and its member countries increase the originally agreed number and committed to decrease emissions by 20% by 2020 (Kjótský protokol k Rámcové úmluvě OSN o změně klimatu, 2008–2023).
Union's attitude towards climate crises is clear: industrialized countries need to make the best effort to decrease emission as they have the largest potential and enough resources to take the measures. In addition, they pollute the air the most. US is responsible for producing 30% of total greenhouse gas in the world. EU's commitment was to decrease its production by full 8% and US by 7%. However shortly after the signature, US requested reduction of the limit. US president questioned the emission's impact on climate and in 2001 announced that US will not ratify the Kyoto Protocol. His main argument was that only developed countries were obligated to commit (not developing). And that costs exceed the benefits (Cihelková, 2003).
Multiple countries expressed their disappointment with US attitude. By withdrawal from the protocol, US separated itself from one of the most important parts of transatlantic cooperation and New Transatlantic Agenda, risking any future bilateral relationship with Europe. And even though there were more countries which didn't join the EU in the second committed period to decrease emissions by 2020. Or were forced to exit from the Protocol due to numerous reasons. US remains the one nation that backed out without even trying.

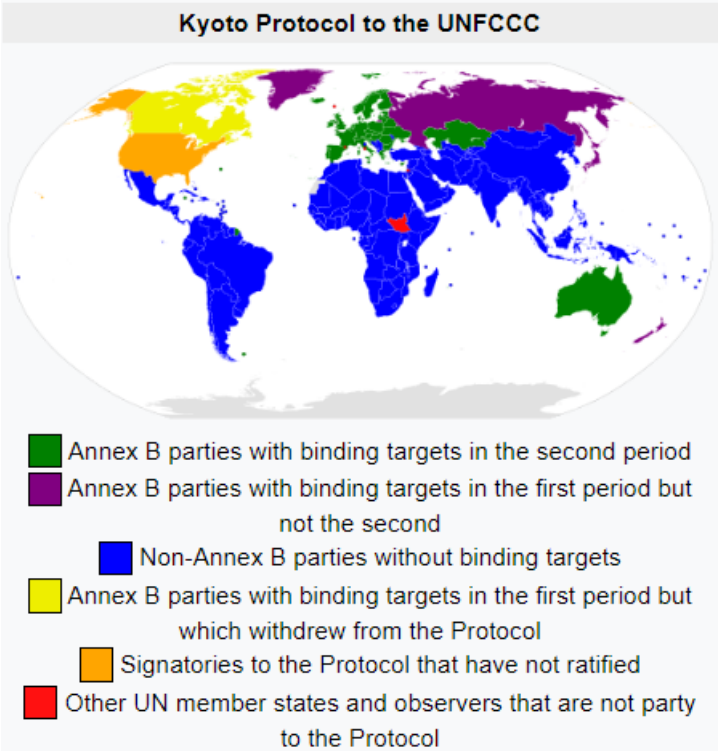

Figure 26 Kyoto Protocol Involved Parties

Source: Wikipedia
Available on: https://en.wikipedia.org/wiki/Kyoto_Protocol

4.3 Genetic modified organisms

Genetic modified organism (GMO) is an organism whose DNA has been altered using genetic engineering techniques. And while genetic modified animals are used in research, GM plants are common daily goods. Humas has used breeding methods to alter organisms for thousands of years. Starting from corn to dogs, humans selectively bred organisms for generations to gain certain traits and to limit others. In last few decades, biotechnology created possibilities within this field that no one could foresee (Genetically Modified Organisms, 2020).

Critical remains identification of desired traits we want to transfer to new organism. Once we estimate the trait, such as pest or disease resistance, or higher nutritional content, scientist develop recombinant DNA (rDNA). RDNA is then used in creation of new empowered organism that will carry the desired trait.

Together with big success of GMO comes high knowledge uncertainty and ethical concern. Many people are challenging that we are unsure how big risk GMO presents to the ecosystems and natural environment. The impact could be almost zero or could be devastating. Ethical concern can be divided into two. One is worry about integrity and sustainability of the natural environment. Second is social consequences related to possible supply monopoly which would be driven by specific genetic patent right (Peterson, 2010).

In May 2003, US together with Canada and Argentina, filled complain to WTO regarding delays in authorization of GMO food. According to US, some EC members imposed bans on biotech products which were already approved by the EC for general marketing and import

across EU. Such actions can be perceived as discriminatory and against General Agreement on Tariffs and Trade (GATT). Major argument from EU was that they have to respect other agreements which are giving more background and address specific complexities related to the GMO topic. In this case EU was referring to Cartagena protocol on Biosafety, in which US, nor Canada and Argentina were parties. Cartagena protocol permits cautions when dealing with products created by application of new technology. Following round of negotiations failed to achieve any agreement between all parties (Peterson, 2010). Therefore, in August 2003, the dispute went to a WTO Dispute Settlement Panel (WTO, 2023).

In 2006, WTO ruled in favour of US saying EU needs to provide scientific evidence of potential harm. EU was forced to lift its moratorium by November 2007 or face sanctions from WTO. While WTO's final decision could be seen as victory for US, it didn't prevent EU from creating stricter GMO regulations than in US and other countries. So while this one moratorium was marked as violation of GATT, any other future product-specific measures EU may adopt was not legally addressed. So WTO made ruling against EU only on technicalities but didn't force it to revise its regulatory system (Peterson, 2010).

4.4 Inflation Reduction Act

One of the key president Biden's pre-election promises, during his presidential campaign in 2020, was to strongly support fight against climate change. And therefore, early after his appointment, discussions started to circle around new US climate policy. During 2021 Democratic party presented first draft of this policy which is later to be called Inflation Reduction Act (IRA). It contains eight titles, each addressing directly or indirectly issues related to climate change. IRA aims to put better control over inflation, lower prices of prescription drugs, and invest into domestic energy production while promoting clean energy. Although the pro-climate aspects of IRA were positively perceived outside of US, its local-content requirements (LCRs), such as 'Made in America' car components, faced several criticisms (Scheinert, 2023).

President Biden's administration presented in 2021 what is to be largest climate change and health care bill in US history. The legislation of IRA includes investment of about $375 billion spread over next decade and its goal is to cut of greenhouse gas emission up to 40% by 2030 in comparison to 2005. Big part of the desired climate-enhancing is achieved through targeted tax breaks with main instrument in a form of tax credits and deductions. Some of the measures have limited duration and expire during 2024, others are permanent (Scheinert, 2023).

Example is a tax credit of up to $7,500 for purchasing electric vehicle (EV). Specifically, it is a tax rebate of $4,000 for used vehicles and up to $7,500 for new ones for household with income of $300,000 or less, or single people with income of $150,000 or less (Mascaro, 2022).

Catch is that in order to be eligible for the tax refund, an electric vehicle must contain a battery built in North America with minerals mined or recycled on the continent. The tax credit consists of two parts each for $3,750 (critical minerals and battery components). Both are evaluated based on "applicable percentage" of the value of extraction and

processing of minerals in US or in a country with which the US has a free trade agreement. Another LCR requirement is that the final assembly of vehicles must happen in US and price cannot exceed $55,000 for cars and $80,000 for vans, SUVs and pickups (Busch, 2023).

Early after first draft or IRA was presented many European countries expressed their disagreement with these specifics in the US climate law. French president Emanuel Marcon and German Chancellor Olaf Scholz marked these actions as a violation of free trade. And it can be by all means considered as an attack on the World Trade Organization's international trade (Coming this Holiday Season: A Trans-Atlantic Subsidy War, 2022).

General answer to the US IRA would be creation of competitive plan in the EU. But EU was already running similar program though the Recovery and Resilience Facility (RRF) way before US even started to talk about IRA. EU is therefore now not "forced" to react. Unfortunately, the RRF works in a different way than IRA and it is expected its funds will be all used by 2026. It was created based on Article 122 TFEU, which is classified as action for crisis situations. And its main goal was to counter the economic consequences of the COVID-19 crises. It is a temporary financing instrument which is part of NextGenerationEU (NGEU) and is classified as exceptional, capped, time-limited, and a one-off. EC provides funding up to €250 billion by issuing NGEU Green Bonds. The RRF comprises grants and loans. Together with other NGEU contributions, their total amount is capped at €750 billion, but inflation adjusted it would be in excess of €800 billion. The repayment of the Commission borrowing will be spread from 2028 to 2058 (Scheinert, 2023).

On February 1st, 2023, EC presented Green Deal Industry Plan, which is designed to enhance the competitiveness of EU's net-zero industry and support the fast transition to climate neutrality. This can be perceived as an EU's attempt to response to IRA (The Green Deal Industrial Plan, 2023).

Following discussions after IRA's first proposal, not only between EU and US but also other impacted countries, led to smaller adjustments in IRA resulting in adding the phase "or in a country with which the US has a free trade agreement". This sentence wasn't part of the original proposition and gave exception to Australia, Canada, South Korea and Mexico. However, given failed TTIP (Transatlantic Trade and Investment Partnership), EU doesn't have any trade agreement with US and therefore its vehicles don't classify for newly introduced tax refund. IRA was officially signed by President Joe Biden on Tuesday August 16th, 2022. Negotiations between EU and US continue and are far from being concluded. Question is if and how will WTO interfere and what will it mean for both parties (Moens, 2023).

Until resolution concluded, we can only assume impact IRA will have on EU. Two biggest ones which are expected are reduction of international trade and decrease of FDI due to possible relocation of EU firms to the US. How big will be the relocation remains mystery for now. We have to note that some companies already started the relocation due to cheaper energy (Scheinert, 2023).

As of today, negotiations are circling around critical minerals which are key components of EV batteries. The talks between US president Joe Biden and EU president Ursula von der Leyen started on March 10, 2023 (Moens, 2023).

Latest update from EC on June 14th, 2023, contains information that EU has adopted its guidelines for negotiating a Critical Minerals Agreement (CMA) with the US. Concluded EU-US CMA would grant EU status similar to free trade agreement (European Commision, 2023).

4.5 Information Technology Agreement

Original Information Technology Agreement (ITA) was signed on December 13rd 1996 at WTO conference in Singapore through Ministerial Declaration on Trade in Information Technology Products. It is the largest tariff liberalization agreement in history of WTO and its goal was to eliminate import duties on high technology products including computers, telecommunication equipment, semiconductors, testing equipment, scientific equipment, and other accessories to these products. From initial 29 members it grew quickly and today ITA covers 81 WTO members. Since its signature the sector which was duty freed became the fastest growing in the world trade. Products falling under ITA were accounted for $1.6 trillion in 2013 which is almost three times more than when the deal was signed in 1996 (Information Technology Agreement — an explanation, 2023).

In May 2008, US filed a dispute to WTO in regard to tariff treatment of certain information technology products in EU. According to US which was later backed up by Japan, Taiwan and China, EU violated IRA by putting duty on some ICT imported goods. Specifically, on flat-panel computer displays, multi-function printers and televisions set-top boxes. In 2010 WTO ruled in favour of US and its partnering countries. EU didn't appeal to the decision and was forced to comply with the panel. However, the issue was how EU proposes to comply. According to many US IT companies and customs officials, EU offered unclear and ambiguous solution. Main issue was that EC gave guidance to its members without any legal certainty that the products will be duty-free. Some additional discussing between both regions continued and in July 2011 official understanding between EU and US was recorded in WTO under articles 21 and 22 of the DSU WT/DS375/17 (Palmer, 2011).

Given the continues evolvement and changes in ICT sector, in 2012 members of ITA started to consider that current list of products under ITA should be renewed and expanded. This resulted in informal meeting in Geneva where 54 WTO members expressed their support for ITA expansion. After several rounds of negotiations, on July 24th, 2015 ITA members agreed on elimination of tariffs on additional 201 products. The trade of these products was evaluated at $1.3 trillion per year. Products include new generation of semi-conductors, GPS navigation equipment, optical lenses, and new medical equipment such as magnetic resonance imaging and ultra-sonic scanning (Information Technology Agreement — an explanation, 2023) (WTO, 2023).

Regular update of ITA list of products should also help prevent similar disputes in the future.

4.6 Disputes over R&D collaboration

In recent years both parties made great effort to simplify the applicant processes or create a "workaround" to a series of technical and legal obstacles which were preventing other

side from participation in R&D programs. Especially EC performed certain administrative changes with implementation of new FP Horizon Europe that should lead to increase of EU projects involving US partners. Among the most problematic topics were liability, publishing rights, intellectual property rights, legal jurisdiction for contractual disputes, and others (Hudson, 2021a).
Major issue revolving around liability was that even though US researchers participated in European projects. They often didn't get any funds from EU FP, but they were still liable for anything that goes wrong in the grant or submit to dispute resolution in a European court. Horizon Europe draft included exception under which US partners didn't have to sign Commission grant agreement which would protect them from these situations (Hudson, 2021b).
A workaround the non-receiving funding from EU except if criteria is met could present subcontracting. Horizon Europe doesn't prevent non-European partners from becoming subcontractors to the project. That way they can receive money for specific service they will deliver. However, this option is still bound by set of rules that need to be followed. Second option is cooperation between various funding agencies. Researchers would be paid from research grants from their country of origin. This already happened in Horizon 2020 in specific research areas such as Atlantic Ocean or health projects (Hudson, 2021b).
Key message remains that both parties are interested in deepening the Transatlantic relationship in area of R&D, from basic research to cooperation on critical and emerging technologies.

5 5G

This chapter will shortly introduce 5G network, its evolution, and most critical features. Second part will be dedicated to summary of technological 5G R&D priorities in European Union and United States, collaboration between the regions and looking forward picture of what can we expect in near future in 5G telecommunication industry. This chapter is deep dive into R&D which is directly linked to high technology (chapter 2.4).
First two sub-chapters will be conceptual-historical and following three will be application-analytical.

5.1 What is 5G?

The fifth-generation mobile network is a successor of the previous standards of global wireless networks. It builds on the 1G, 2G, 3G, 4G and LTE (Long-Term Evolution) and improves their imperfections, shortcomings, increases capacity and speed. It represents major revolution in ICT sector that will provide high-reliability, efficiency, and security in critical services (Klessova, 2020).
Evolution of 5G network:

- 1G – calls
- 2G – calls and SMS
- 3G – calls, SMS, and Internet

- 4G – calls, SMS, Internet, and Photo & Video
- 5G – 4G + high-speed internet, videocalls (ultra-HD, 3D), broadband connection, battery enhancement
- 6G – successor of 5G with expectation to achieve over 95 Gb/s speed

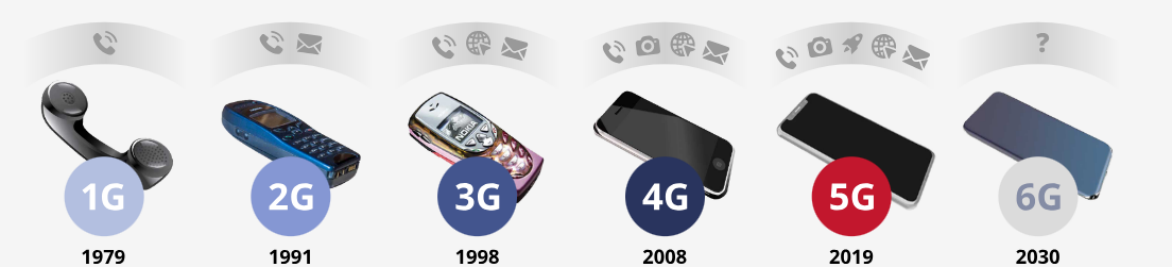

Figure 27 Development of networks

Source: 5G Platforma pro chytrý svět
Available on: https://www.5gvcesku.cz/cs/co-je-to-5g.html

5G offers everything 4G did and in addition increases data transfer speed up to 10 Gb per second which means it can be 100-times faster than 4G. Even with this amazing feature, 5G has lower latency, meaning all tasks can be performed in real time without delay. Another big advantage is higher availability and network capacity. It is assumed that even more advanced network 6G will shortly follow (Co je to 5G?, 2022).
Expectation from 5G network is that it will not only bring new products and services but also have impact on all industries in society. Among its potential benefits are:

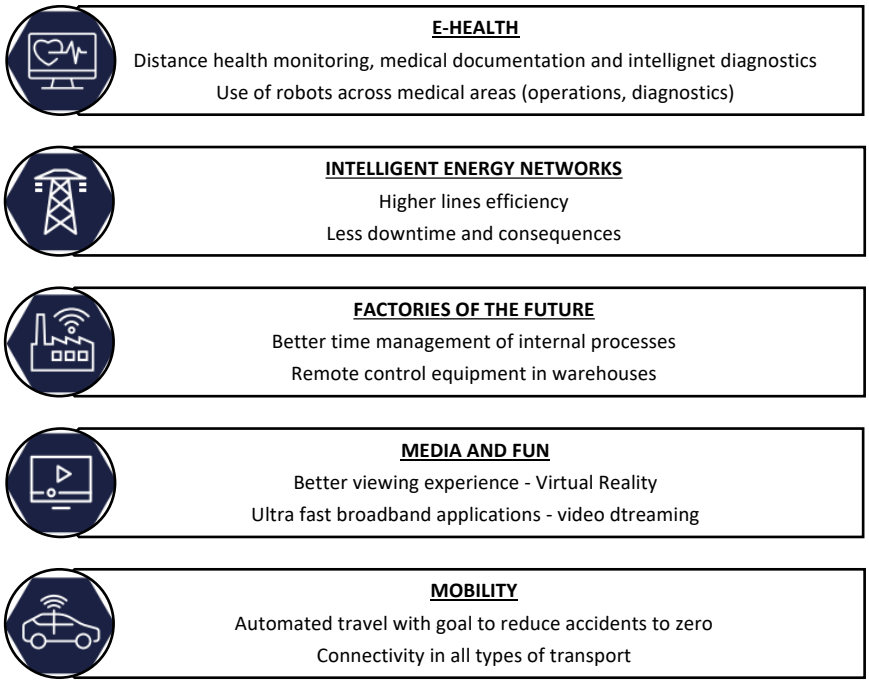

Figure 28 5G benefits

Source: Soubor opatření EU pro bezpečnost sítí 5G
Available on: https://ec.europa.eu/newsroom/dae/redirection/document/77762
(Soubor opatření EU pro bezpečnost sítí 5G, 2021)

With no doubt, we can say that internet is one of the most successful products in the world. Today, more than five billion people can access the internet through mobile connection and much more by wired connections. The goal of 5G is to provide mobile connectivity to the last billion, from which majority lives in separated and scarcely populated areas (Klessova, 2020).
Both EU and US share key social drivers and future challenges which can be improved with 5G implementation.

- **Health, demographic change, and well-being** where major problem remains growing population and related insufficient agricultural production. 5G communications can provide tools for more efficient farming and waste reduction.
- The need for **secure, clean, and efficient energy** drives shift to renewable sources and decentralized energy productions. Latest network will be able to transmit information about electric power very fast which creates foundations for smart electricity grids.
- 5G will enhance development in area of **smart, green, and integrated transport** by laying down fundamentals for creation of smart infrastructures and connected vehicles in both European Union and United States. Resulting in less overcrowding and fewer accident.
- Last crucial driver is desire for **privacy, security, trust, and safety** which is equally gaining relevance in EU and US

(Klessova, 2020)

5.2 5G R&D priorities in the European Union

In 2016, European Commission released strategic initiative called “5G Action Plan” with an aim to make 5G reality for all people across the EU. The plan laid out clear path for public and private investment on 5G infrastructure. Among the key points were:

- set clear roadmap and priorities regarding 5G cooperation across all EU member states with network introduction targeting to 2018 and commercial large-scale introduction by the end of 2020;
- provide spectrum bands for 5G ahead of the 2019 World Radio Communication Conference (WRC-19);
- urge early development in major urban regions and along the major transport nodes and roads;
- foster pan-European multi-stakeholder trials which would trigger transformation of technological innovation into full-fledged business solutions;
- simplify implementation of industry-led fund in order to support 5G related innovations;
- connect key players in 5G area towards unified promotion of global standards

(5G Action plan, 2022).

EU’s second important 5G initiative is 5G public-private partnership (5G-PPP) from 2018. It represents joined effort of European Commission and European ICT industry to deliver solutions, architectures, technologies, and standards for ubiquitous communication infrastructure (About the 5G PPP, 2022). Since 2018, it targets important investment

opportunities for 5G end-to-end infrastructure. It ensures cooperative trial actions with EU and non-EU partners. In 2017, 5G PPP reported 5G pan-EU trials roadmap which points out areas of focus: smart city, consumer and professional services, industry, digital health and public safety and digital divide (Klessova, 2020).
Several key actions were identified from later releases of Next-generation mobile networks (NGMN) White Paper on 5G, the H2020 Work Programme 2016-2017/2018-2019 on ICT, and the 5G PPP White Papers on 5G architecture and on vertical industries. From these sources we can note below actions:

- **New air interface technologies**: activities related to development of new transmission scheme:
    - Support set of requirements from low rate sensors to very high rate high-definition (HD and 3D);
    - Promote local and wide areas systems, multilayer deployments, secure steady performance coverage and capacity;
    - Possibility to use frequency bands between 6 and 115 GHz (mmWave) for ultra-high-speed access.
- **Coordination and optimalization of user access**
- **Dual/multi-connectivity**: connection of user equipment to multiple base stations
- **Ultra-reliable low-latency communication (URLLC)**
- **High-capacity elastic optical networks**: creation of new optical networks to support high data rates
- **Software network architecture**: efficient, cheap, reliable networks; relocation of services
- **Management and security for virtualized networks**: configuration of network nodes; network analytics tools; security at multiple domains
- **Technology validation and testbeds for verticals**: experimental testing of 5G technologies that show the highest prospect of necessity and usability

(Klessova, 2020)

5.3 5G R&D priorities in the United States

Majority of funding in United States dedicated to 5G research comes from NSF, DARPA, NIST, and White House. These agencies were used to identify and analyze key focus points of US in area of 5G:

- **New air interface technologies**:
    - **mmWave**: dedication to provide multi-Gbps data rate to the users at very high frequencies. Among its advantages is wide range of academic institutions. On the other hand, disadvantages are availability of spectrum and high signal attenuation and limited penetration though obstacles (walls). Several solutions to overcome these difficulties are being sought.
    - **New waveforms**: focus on 5G transmission below 6 GHz.
- **Spectrum management**: efficient usage of available spectrum
    - **Shared spectrum access**: Support of various radio access technologies to a specific frequency band. There are two users presented, primary and

secondary. Secondary user can use the spectrum only when primary doesn't. Consequently, this leads to need for base stations that are capable of spectrum sensing and agile frequency hopping.
    - **Interference**: Research in inter-node area to remove limiting factor of interference between radio access nodes.
    - **Full duplex technique**: Goal to transmit and receive signals at the same frequency at the same time by means of analogue hardware, and digital cancelation techniques. It is noted that decrease of interference of 85dB signals is enough for Wi-Fi. But not for cellular context with much higher transmission power.
- **Ultra-low response times**: Development of ultra-reliable low latency communication (URLLC) technologies aiming towards Industrial Internet of Things (IIoT). Major player in this area is NSF which joined forces with private sector to achieve the goal.
- **D2D and vehicle-to-everything (V2X) communications**: Side-link communication with main purposes to:
    - Cover expansion beyond the official infrastructure;
    - Unicast communication with no infrastructure;
    - Produce attractive informational broadcast.

  Support of usage automated cars, platooning, and interactions between vehicles related to V2X activities.
- **OpenFlow and SDN (software-defined networking)**: Aim to separate control and data layer with control software instead of hardware.
- **Testbeds and trials**: Trials to test practicality and usability of research results and subsequential realization.

(Klessova, 2020)

Public 5G research sector implemented together with NSF pivotal actions. Its goal is to stimulate and build US research leadership in 5G area and circulates around three components:

1. **Platforms for Advanced Wireless Research (PAWR)**: Ultimate goal is to create four city-scale testbeds for carrying out advanced wireless research. Testbeds are funded as a PPP from NSF and industry with budgets of US$ 50+50 million. The first testbed is specialized in mmWave and is located in Silicon Harlem (New York City, New York). It is run by Rutgers University, New York University, and Columbia University. Second, POWDER/RENEW platform testbed focuses on complete software-defined infrastructure and multiple-input, multiple-output (MIMO) technology. It is located in Salt Lake City (Utah) and managed by University of Utah and Rice University.
2. **Fundamental research enabling advances wireless networks**: Significant investment of US$ 350 million was obtained from NSF and spread into 7 years period to fund testbeds research.
3. **Community leadership and engagement**.

(Klessova, 2020)

5.4 EU-US R&D collaboration in 5G network

European Union and United States are one of the most involved regions in 5G network R&D. Other important actors are South Korea, China, and Japan. Big portion of the research is conducted around key enabling technologies for 5G network which are described in Figure 29. There is significant overlap between 5G priorities between EU and US but each focuses a bit more on specific technology. For example, US's hub circulates around mmWave and massive MIMO. On the other hand, EU represents more overarching perspective on 5G system architecture and focuses on vertical industries requirements. Both regions are responsible for good quality research even though each excels in various sectors resulting in higher competitiveness in 5G (Klessova, 2020).

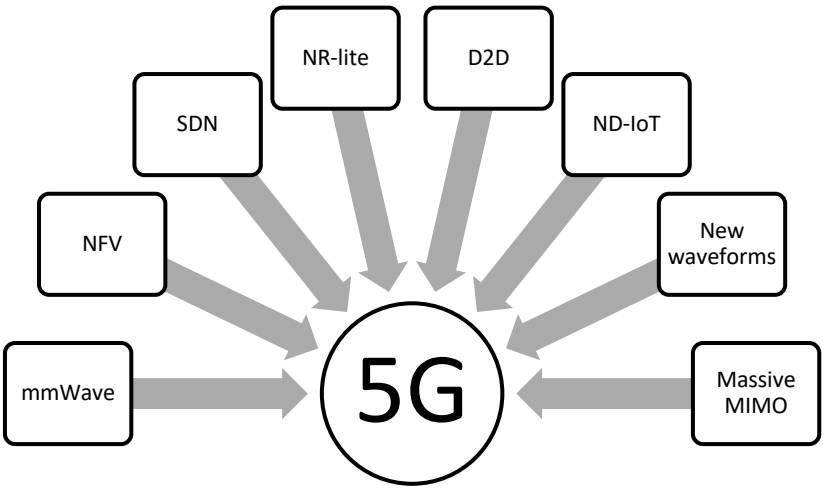

Figure 29 5G key enabling technologies

Source: ICT Policy, Research, and Innovation - Klessova

If we take United States, they are top of the field in mmWave technologies. During most recent trials US conducted testbeds on ultra-high data rates in mmWave spectrum for purpose of video streaming and virtual reality applications. Extended cooperation between US and European vendors, like Nokia and Ericsson, was and still is crucial in this area of research (Klessova, 2020).

European Union on the other hand, seems to be a little bit more progressive in area of Device-to-device (D2D) communication which is key technology component for automotive applications. Given Europe's certain economic dependency on automotive industry, EU early on invested together with key car manufactures in this 5G network research area. Example is BMW which together with other vendors teamed up in H2020 project METIS from 2012 to 2015 (Klessova, 2020).

Both regions strongly rely on PPP to achieve their priorities and to spread 5G to the market. Important part of cooperation is unification of industry standards. Already existing 3rd Generation Partnership Project (3GPP) is expanding its standardization processes to include 5G era and beyond. Its mission is to create Mobile Broadband Standard with growing emphasis on IoT connectivity. It was formed in 1998 and it unites seven

telecommunications standard development organizations. And its main contributors are key player from the field including Nokia, Ericsson, Intel, and Qualcomm (Introducing 3GPP, 2022).
We must note that important players in 5G network R&D are also outside of these regions. Asia with Huawei, Samsung, and NEC play active part in research as well as operators in Latin America who are continuously looking into opportunities 5G network presents. To link different stakeholders from all continents, Global 5G Event was established (Klessova, 2020). 5G Global Event is a series of summits organized by leading 5G organizations who share commitment to bring 5G technology to the market. Its main goal is efficient roll-out of 5G technology between 5G AI (EU), 5G Americas, 5G Forum (Korea), 5G MF (Japan), 5G Brasil and IMT-2020 (China) (8th Global 5G Event, 2022).
History of bilateral 5G research between EU and US is full of achievements. Example is Communications Lead User program or National Instruments' radio frequency (RF) program. Primary goal of the cooperation is to efficiently exchange information between both regions which will ensure its competitiveness and continuous leading position of EU and US in 5G research worldwide. In spite of that, there are some challenges that need to be overcome. One of the major dissensions is definition of 5G. While in US 5G means any improved version from current 4G up to the 3GPP standards. EU describes 5G by evolving 3GPP standards and its future releases which are expected to be focused on verticals, smart society, health, Industry 4.0 and automotive. This can cause misunderstandings between partners when discussion possible collaboration and different expectations from involved parties. It is interesting to note that EU and US companies are competitors also on global level. For example, US subsidiaries (Intel, National Instruments) in EU participate in Horizon projects while US branches of European companies (Nokia-Bell Labs, Ericsson) participate in NSF PAWR program (Klessova, 2020).

5.4.1 Where are we today with 5G?

First country to deploy 5G network was South Korea in April 2019 and according to Statista reports it is expected to stay the lead in technology penetration for years to come. It is expected that by 2025, 60% of mobile subscription in South Korea will be 5G.
During 2019, EU vendors started to offer limited 5G services in cities. During 2020, 5G launches spread across Europe and by the end of the year, all EU countries had commercial 5G communication with only four exceptions. By 2021, most of the objectives specified in 5G Action Plan were met and Europe's focus shifted to improvement of coverage which continues until today. In January 2022, all 27 EU Member States had commercial 5G available. And as of April 2023, 5G coverage in Europe reaches 81%. (European 5G Observatory, 2023).
Deployment of 5G started in United States in 2018. Major mistake happened in 2019, when in contrast with other countries which deployed mid-band spectrum because of its flexibility and ideal capacity and distance reach, US pursued mmWave for its 5G deployment. Even though mmWave boosts the capacity, it doesn't support long distances and it has troubles penetrating barriers. DoD quickly came with alternative solution and started to auction out widespread bases to commercial interests to raise more financials

for mid-band spectrum. This quickly boost 5G launches across country with few final carries launching their 5G services in 2022 (Alvarez, 2022).
Table below shows how many live 5G commercial networks (according to 3GPP standards) are as of 17.7.2023 deployed around the world. Data are provided by TeleGeography & 5G Americas.

Table 5: Number of Commercial 5G Networks:

	LTE	5G
Africa	161	22
Asia	140	63
Europe	165	113
Latin America	129	28
Middle East	51	24
Oceania	39	9
US and Canada	17	14
Global Totals	**702**	**273**

Table 5 Number of Commercial 5G Networks

Source: TeleGeography & 5G Americas
Available on: https://www.5gamericas.org/resources/deployments/

Even though 5G is implemented, we are using and harvesting only fraction of its benefits and potential. Especially possibilities of vertical industries are yet to be fully discovered. Because of 5G characteristics like low latency and high speed, it is ideal for creation of "vertical" markets in automated industries such as industrial and agricultural automation, automotive industry, transport, and healthcare. Related trials are performed in Germany, but commercial deployment is far behind the consumer services (European 5G Observatory, 2023).
Interestingly, although roll out in both EU and America is almost complete, it brings little difference to common citizen. Even though 5G population coverage in EU is 81%, majority of it is done via shared spectrum with 4G and/or lower bands. For example, bands with 700 MHz, which have problems with consistent high-quality 5G services and are not able to provide high throughput to the users. It is expected that 5G uptake will increase gradually from 2023 onwards. Prediction shows that by the end of 2023, 150 million are going to reach 5G connectivity with a subscription penetration rate 88% by 2028. Progress in Central and Eastern Europe, where 4G subscriptions are still 75% of the market and are expected to grow until 2025, is predicted to be slower due to spectrum allocation processes. (5G Observatory: Biannual Report April 2023, 2023).
Another study by ABI Research shows that by the end of 2023, more than 270 million American subscribers will use 4G connectivity. However, given 5G concentrates in large cities, only 170 million will access 5G. Another issue it that consumers lack desire to pay premium price for 5G connectivity when 4G is enough (Kelly, 2023). Data from 5G Americas show that 5G penetration in North America is 32% and wireless connections increased by 76% from 2021 to 2022, reaching 1.05 billion subscribers. It is predicted that by the end of

2023 number of connections will be 215 million and 5.9 billion subscribers by the end of 2027 (Global 5G Connections Increase 76% Annually and Now Reaches 1.05 Billion, 2023).

5.5 Beyond 5G

It is fair to say that year 2020 belonged to 5G with its first appearance and deployment in 2019. As of January 2022, commercial 5G is available in all 27 EU member countries and 50 US states. And even though the world is using only about half of the 5G potential, discussions about its even more complex successor 6G are all around the industry.
Already in 2018 Finnish government launched the first 6G research program in the world and only year later in March Federal Communications Commission (FCC) opened the terahertz (THz) spectrum for 6G research in United States. Asia is not falling behind as China announced its start of 6G research in November 2019 by Ministry of Science and Technology and official launch of Technology International Mobile Telecommunications 2030 initiative. Japan released its 6G strategic plan in April 2020 and South Korea in January 2020 (Wang, 2023).

5.5.1 European Union

In Europe, key player in 6G research is Finish Oulu University. Its 6G Flagship research program published first paper in 2019. The White Paper gave brief introduction to drivers, challenges, requirements, and questions regarding 6G. Second was Hexa-X initiative established by European Commission which represents EU's 6G flagship. It is a 2.5-year project led by Nokia with funding from European Horizon programs. It connects 25 key players in the field with aim to create long-term investment into wireless technology (Bajpai, 2021).
Since then, many other EU partners showed interest in 6G research. In April 2021, Germany announced plan to invest into 6G research, 6G Research Hub and 6G Platform. 6G Smart Networks and Services Industry Association (6G-IA) was established in EU to support shared research and knowledge exchange. And International Telecommunications Union (ITU) released first draft of 6G research roadmap in February 2020 (Wang, 2023).

5.5.2 United States

On the annual Big 5G Event, which was held in May 2023, in Austin, Texas conversations circled around evolution of the telecommunications cloud and networking, 6G and Open RAN. Largest initiative related to 6G in United States is Next G Alliance (NGA) funded by Alliance for Telecommunications Industry Solutions (ATIS). Its goal is to advance wireless technology in North America over next decade though private sector. NGA is actively releasing in-depth reports with aim to address critical aspects of 6G wide area and challenges related to it. Roadmap to 6G was established and among the key priorities are:

- Applications
    - Multi-sensory extender reality
    - Distributed sensing and communications

    - Network enabled robotics and autonomous systems
    - Personalizes user experiences
- Societal and economic needs
    - Quality of life
    - Digital equity
    - Data privacy
    - Economic growth
    - Sustainable society
- Sustainability
    - Reuse and recycle of water, waste, and materials
    - Sustainable network optimalization
    - Sustainable supply chain
    - Sustainable operations
    - Decarbonization
- Technology
    - Realizing the next generation of 6G radio systems and devices
    - Natively integrating AI/ML into networks, systems, and devices
    - Transforming systems to fully leverage/enable distributed cloud and communications
    - Achieve trustworthy, secure and resilient solutions for North America

(Next G Alliance Research Priorities, 2023)

Some of the biggest technology players joined NGA in order to share knowledge and drive better R&D results. Apple, Google, Cisco, AT&T, Bell Canada, Ericsson, Facebook, Microsoft, Nokia, Qualcomm Technologies Inc., Samsung, T-Mobile, Verizon, Hewlett Packard Enterprise, Intel, LG Electronics and many others are part of this initiative. ATIS believes that, "By leveraging the knowledge gained from the development and early deployments of 5G, the US can establish itself as a global leader in ideas, development, adoption, and rapid commercialization of 6G." (Bajpai, 2021).

5.5.3 US and EU cooperation in 6G

Growing cooperation between US and EU is expected to continue beyond the 5G. US-EU Joint Statement of the Trade and Technology Council from 31st May 2023 announces commitment of both partners to deepen the cooperation on technology issues, including AI, 6G, online platforms and quantum. Shared goal is to maximize value new technologies can offer while protecting democratic values and kick in new wave of economic growth (U.S.-EU Joint Statement of the Trade and Technology Council, 2023).

In June 2023, governments of United States of America and the Republic of Finland, released a joint statement announcing strong future cooperation on advanced wireless communication. This is a deepening of already existing cooperation between both countries with aim to promote open and interoperable networks. Two major parts of the agenda are:

1. To explore synergies and possibilities to create a joint ecosystem for R&D in 6G and sensing applications by:

2. And to support pathways to cultivate wireless communications for economic, environmental, and societal impact by:

(Joint Statement of the United States and Finland on Cooperation in Advanced Wireless Communications, 2023).

Bilateral cooperation in 6G R&D between US and EU is cost-effective and profitable for both partners. Each country is going to benefit from developed solutions, as well as rest of the world where it will lead to enhancing equality of society and quality of life. Among the most important topics which should be explored during 6G research, and which should lead to major scientific advancements in the sector are:

- Connecting the last billions in unserved areas;
- Wireless premises networks;
- mmWave technology beyond 5G;
- spectrum farming and harmonization.

(Klessova, 2020)

Conclusion

Political-economic relations between European Union and United States dynamically developed since the end of the Second World War. Scattered and ununited Europe became once again major superpower, not only in economy but also politically and socially. Which was possible thanks to generous support of United States. And together they created strong, solid baseline for future development of their relations.
Despite multiple smaller disputes between both partners, and unsuccessful TTIP negotiations, the European Union and the United States enjoy the strongest economic and investment relationship in the world. In the beginning of this paper, I described political-economic affairs (trade, investment) as portion of the conceptual part of the thesis. Then I moved to application part which investigated trade in high-technology sector, problematics of Research and Development, and 5G network case study.

Second chapter investigated economic relations between EU and US in last decade and answered to question: *"What is the current economic relationship between EU and US in high-technology sector? Is US being replaced by China?".*
EU-US bilateral trade remains the largest on planet despite the fact, that China overtook US as EU lead trading partner in goods. Combined bilateral trade of goods and services remains the largest and it peaked €1,5 trillion in 2022 which indicates 47% growth from pre-pandemic year 2019. And not only trade can support the claim, that EU-US relationship is the most important and profitable bilateral relationship there is, but also investment. US FDI in Europe companies grew by 78% in last decade and almost 10% between years 2020 and 2021. Similarly, Europe FDI in US increased by 69% in last ten years which shows mutual interest in cooperation.
In some areas it is more visible that China is great competitor for both economies. High-tech import to EU from China significantly grew in last years while import from US stagnated. But US remains the most important trading partner in high-tech industry. EU export to US was more than double the size of China in 2022 and continues to remarkably grow in last decade making US indispensable component of EU economy. And while China and other Asian countries become superpowers in specific industries such as Electronics-telecommunications and Computers and office machinery, US stays the most important trading partner in Aerospace and Pharmacy industry. Where US is responsible for 65% of all Aerospace import to EU. And in pharmacy, US drives 50% of export which equals to 40% of total EU medical export and 40% of its import.
Both partners are also continuously working on relationship improvements. Example is 2021-EU-US summit, after which both allies released statement with major goal to renew transatlantic partnership in post-pandemic era. Or launch of EU-US Trade and Technology Council (TTC) which is designed to coordinate global trade, economic and technology issues, and strengthen trade and economic relationship of both sides.

In chapter 3, I answered question: *"What is the R&D structure in each country? What are the key differences between them and between project settings? What drives R&D gap between EU and US?".*

R&D mechanisms in US and EU are completely different which makes it hard to compare. The funding of Research and Development in European Union is controlled centrally which makes it easier to coordinate and harmonize projects and initiatives in various technology and innovation sectors. These programmes are deployed under European Commission and its primary goal is to create strategy for smart, sustainable, and inclusive growth which will lead to global competitiveness of Europe. Its latest programme is called Horizon Europe with total budget of €95.5 billion spread between years 2021-2027. And it is the largest R&D Financial Programme in history of EU. In addition, many countries in EU have their own individual R&D programs which are run by country leadership separately.

On the other hand, US doesn't have any overarching mechanism which would finance its research. Instead, federals agencies fund their own programs which are sometimes overlapping each other. Among the major agencies leading Research and Development in US are National Science Foundation (NSF), National Institutes of Health (NIH), and Department of Defense (DoD). Current NSF budget for 2023 is $10.492 billion and similarly to Horizon Europe focuses on: Climate and Clean Energy Research, Equity for Underserved Communities, Discovery Engine, Emerging Industries, Research Infrastructure, and Organizational Excellence/Agency Operations and Award Management.

Despite EU's attempts to match the US R&D investment levels, per latest data as of 2020, they remain far behind. In that year, US expenditures reached 3.45% of GDP, while EU showed only 2.32%. Major variance comes from business enterprise sector where US companies invest over 1% of GDP more than EU. This is largely caused by type of the firm as US companies operate in industries with higher R&D intensity than EU's. These industries include: technology hardware and equipment, software and computer services, pharma and biotech, and health care equipment and services. On the other hand, EU concentrates on Automotive industry. In reality, EU invest significantly less in ICT sector than US. Specifically, 4.7 times less in 'technology hardware and equipment' and 10.6 times less in 'software and computer services'. In addition, number of the most innovative firms in EU, which invest the most in R&D, dropped from 519 in 2012 to 401 in 2021. That being said, if EU wants to catch up with the US in R&D area, they need to start with restructuralization of its economy and shift to more innovative sectors.

In recent years there are many initiatives to enhance collaboration between both regions in R&D area. Cooperation as a part of Financial Programs is possible but it brings certain challenges depending on type of the program and source of its funding. However, both partners are continuously working on elimination of these barriers.

Chapter 4 focused on question: *"Are there any major conflicts between European Union and United States in area of R&D?"*.

Throughout the years there were multiple disagreements between both partners in area of Research and Development. The most recent Inflation Reduction Act dispute draw a lot of attention due to illegal favouritism of American electronic vehicles (EV). Issue revolved

around tax credits which were US citizens promised in exchange of EV purchase with American battery, disqualifying EU automotive products. After long negotiations, EU and US came to an agreement in June 2023 which will level up opportunities for car manufactures in both regions.
Another recorded dispute in WTO is related to incorrect tariff treatment of technology products in EU. US complained that EU illegally poses tariffs on technology products which are under exception of Information Technology Agreement (ITA) and therefore duty free. Problem was quickly resolved as WTO ruled in favour of US and EU took actions to comply.

Final chapter 5 dealt with question: *"Was deployment of 5G network successful?".*
Even though deployment of 5G network is almost done in both EU and US, majority of subscribers are using only fraction of its potential. There are many opportunities in 'vertical industries' which haven't been explored yet, but which are being investigated. Multiple studies in US and data from EU show that even though the 5G coverage rate in both countries is high, only part of citizens use 5G network and many are satisfied with 4G which is cheaper and more reliable. There is still a lot of work to do to spread 5G connectivity and awareness. But it is expected that number of users is going to grow from 2023 onwards in both regions and people are slowly going to switch from 4G to 5G network.
Relationship between EU and US presents great number of chances for both regions. Shared interest in technology issues and goal to maximize value new technologies can offer, while protecting democratic values, and desire to kick in new wave of economic growth, will ensure cooperation between the two superpowers will continue. Next challenges on the list are 6G, Artificial Intelligence and Vertical Industries.

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Prohlášení:
Dávám svolení k půjčování této diplomové práce. Uživatel potvrzuje svým podpisem, že bude tuto práci řádně citovat v seznamu použité literatury.

Jméno a příjmení: Lenka Andera
V Praze dne: 09. 08. 2023 Podpis:

Jméno	**Oddělení/ Pracoviště**	**Datum**	**Podpis**