Europe Facing Geoeconomics:

Assessing Finland's and the EU's Risks and Options in the Technological Rivalry

Mikael Wigell, Matthias Deschryvere, Christian Fjäder, Niklas Helwig, Ville Kaitila, Heli Koski, Josi Seilonen, Arho Suominen

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Abstract

The geoeconomic rivalry is accelerating with the world's major powers using economic instruments to advance strategic agendas. This poses a challenge to the EU and its member states. The EU's market-oriented approach to international economic engagement exposes it to risks arising from the geoeconomic power politics of other major powers. These risks are especially acute in the technological domain where Europe's competitiveness has been decreasing and its strategic dependencies on China and the United States growing. This report examines the risks and options for the EU and one of its member states – Finland – in adapting to the rise of geoeconomics. The report shows how the risk picture for European businesses are undergoing change, highlighting the need to incorporate geoeconomic dynamics into existing risk assessments. It also surveys emerging EU and Finnish policy instruments for managing strategic interdependencies and associated risks. The report gathers in-depth data on European and Finnish interdependencies with China and the United States, taking stock of critical strengths and vulnerabilities. Key policy recommendations following from this analysis focus on 1) introducing national geoeconomic risk assessments; 2) increasing strategic coordination of technological governance; 3) promoting trade cooperation; and 4) ensuring a level playing field for European companies.

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Keywords research, research activities, economic relations, international politics, technological development

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Eurooppa geoekonomian aikakaudella: Analyysi Suomen ja EU:n riskeistä ja vaihtoehdoista teknologisessa kamppailussa

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Tiivistelmä

Geoekonominen kilpailu on kiihtynyt maailman suurvaltojen ajaessa strategisia tavoitteitaan talouden keinoin. Tämä muodostaa haasteen EU:lle ja sen jäsenvaltioille. EU:n markkinalähtöinen lähestymistapa kansainväliseen talouteen altistaa sen riskeille, jotka kumpuavat muiden maailmanmahtien geoekonomisesta valtapolitiikasta. Nämä riskit korostuvat teknologian alalla, jossa Euroopan kilpailukyky on laskenut ja sen strategiset riippuvuudet Kiinasta ja Yhdysvalloista ovat kasvussa. Tämä raportti tarkastelee EU:n ja Suomen eri vaihtoehtoja geoekonomian nousuun sopeutumiseksi, sekä tähän liittyviä riskejä. Raportti osoittaa eurooppalaisten yritysten riskinäkymien olevan muutoksessa ja korostaa tarvetta ottaa geoekonomiset näkökohdat huomioon riskejä arvioitaessa. Siinä kartoitetaan myös, millaisilla politiikan välineillä EU ja Suomi pyrkivät nyt hallitsemaan strategisia keskinäisriippuvuuksia ja niihin liittyviä riskejä. Raporttiin on kerätty dataa Euroopan ja Suomen keskinäisriippuvuuksista Kiinan ja Yhdysvaltain kanssa ja arvioitu kriittisiä vahvuuksia ja haavoittuvuuksia. Tämän analyysin pohjalta raportti tekee politiikkasuosituksia, joiden keskeisiä kohtia ovat: 1) geoekonomisten riskiarviointien luominen, 2) teknologian hallinnan koordinaation lisääminen, 3) kauppayhteistyön lisääminen ja 4) tasapuolisten toimintaedellytysten turvaaminen eurooppalaisille yrityksille.

Asiasanat tutkimus, tutkimustoiminta, taloussuhteet, kansainvälinen politiikka, teknologinen kehitys

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Referat

Den geoekonomiska kampen har accelererat emedan världens stormakter börjat använda ekonomiska styrmedel för att främja strategiska mål. Det utgör en svår utmaning för EU och dess medlemsländer. EU:s marknadsinriktade förhållningssätt till ekonomisk verksamhet utsätter EU för risker som härstammar från andra stormakters geoekonomiska maktpolitik. Dessa risker accentueras inom teknologiområdet där Europas konkurrenskraft har försvagats och dess strategiska beroende av Kina och USA vuxit. Denna rapport undersöker riskerna och möjligheterna med geoekonomins frammarsch för EU och ett av dess medlemsländer – Finland. Rapporten visar hur riskbilden för europeiska företag har förändrats och lyfter fram behovet av att införliva geoekonomisk dynamik i befintliga riskbedömningar. Den kartlägger också potentiella styrinstrument som EU och Finland kan använda sig av för att hantera strategiska beroendeförhållanden och med dessa sammankopplade geoekonomiska risker. Rapporten samlar in data om europeiska och finska beroendeförhållanden med Kina och USA, och analyserar kritiska styrkor och sårbarheter. Analysen medför följande policy-rekommendationer: 1) införande av nationella geoekonomiska riskbedömningar; 2) ökad strategisk samordning av teknologisk utveckling; 3) främjande av internationellt handelssamarbete; och 4) säkerställande av lika villkor för europeiska företag.

Nyckelord forskning, forskningsverksamhet, economiska relationer, internationell politik, teknologisk utveckling

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LIST OF ABBREVIATIONS

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
BATX	Baidu, Alibaba, Tencent, and Xiaomi
BEA	Bureau of Economic Analysis, U.S. Department of Commerce
BRI	Belt and Road Initiative
CAC	Cyberspace Administration of China
CAI	EU-China Comprehensive Agreement on Investment
CBAM	Carbon Border Adjustment Mechanism
CCP	Chinese Communist Party
CER	Critical Entities Resilience
CIPS	China International Payment System
CNIPA	China National Intellectual Property Administration
Covid-19	Coronavirus Disease 2019
CPC	Cooperative Patent Classification
DESI	Digital Economy and Society Index
DMA	Digital Markets Act
EC	European Council
EDT	Emerging and Disruptive Technologies
ENP	European Neighbourhood Policy
EPO	European Patent Office
ERA	European Research Area
ETLA	ETLA Economic Research
EU	European Union
EU27	Member States of the EU
FDI	Foreign Direct Investment
FIIA	Finnish Institute of International Affairs
FTA	Free Trade Agreements
GAFAMI	Google, Amazon, Facebook, Apple, Microsoft, and IBM
GDP	Gross Domestic Product
GVC	Global Value Chain
HS	Harmonized Commodity Description and Coding System
ICT	Information and Communication Technology

IMF	International Monetary Fund
INSTEX	Instrument in Support of Trade Exchanges
IoT	Internet of Things
IPC	International Patent Classification
IPCEI	Important Project of Common European Interest
IPI	International Procurement Instrument
IPO	Initial public offering
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
ITU	International Telecommunications Union
M&A	Mergers and Acquisition
MNE	Multinational Enterprises
MOST	Ministry of Science and Technology
NATO	North Atlantic Treaty Organization
NCI	NATO Communications and Information Agency
NESO	National Emergency Supply Organization
OECD	Organisation for Economic Co-operation and Development
OFDI	Outbound Direct Investment
PCI	Productive capacities index
PLA	The People's Liberation Army
R&D	Research and Development
RTA	Revealed Technological Advantage
SC42	The standardization association for Artificial Intelligence (AI)
SCRI	Supply Chain Resilience Initiative
SFS	Finnish Standards Association
SITC	Standard International Trade Classification
SOE	State-Owned Enterprise
STI	Science, Technology and Innovation
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TFEU	Treaty on the Functioning of the European Union
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
US/USA	United States of America
USPTO	United States Patent and Trademark Office
USTC	University of Science and Technology of China
VTT	VTT Technical Research Centre of Finland
WTO	World Trade Organization

1 Introduction

1.1 Background

Economic cooperation and strengthening interdependence became a prominent feature of international economic relations in the latter half of the 20th century, especially after the end of the Cold War. While there have been notable setbacks in recent years, most notably the failure of the Transatlantic Trade and Investment Partnership and the rejection of the Trans-Pacific Partnership by the United States, there are signs of enduring economic cooperation and interdependence. For example, the European Union continues to negotiate new free trade agreements with various partners. The Comprehensive and Progressive Agreement for Trans-Pacific Partnership as well as the Regional Comprehensive Economic Partnership agreement have recently entered into force.

Despite these developments, recent years have also seen the acceleration of geoeconomic rivalry, characterized by the broad use of economic tools to achieve strategic and security goals. This involves a range of major and middle powers, but most notably for this report, China and the United States. As China and the United States ramp up this competition, economic interdependence is cast in a new light. What was once heralded as a barrier to conflict has now turned into a currency of power, as economic interdependencies are leveraged for power political ends, feeding a geoeconomic chain reaction with states applying broader trade controls, investment screening and data localization measures out of concern for their economic autonomy (see Choer Moraes and Wigell, 2020). This report examines the risks and opportunities for Europe arising from these ongoing geoeconomic dynamics, particularly competitive ones, and assesses relevant policies whereby the EU and one of its member states – Finland – tries to manage its strategic economic interdependencies.

This new era of geoeconomic competition is putting pressure on the rules and institutions that govern the international economy. Economic and security thinking are converging due to the increasing significance of economic functions and relations for the strategic interests and national security of various states. Consequently, states are increasingly concerned about "excessive" dependence on others, and the global interdependency is more often viewed as a vulnerability which needs to be addressed by increasing state control over the economy and enhancing self-sufficiency and resilience (Choer Moraes and Wigell 2020). This is particularly true for the technological domain.

Technological innovation has always played a key role in great-power rivalries. Technological leadership has helped fuel the US's economic advantage and military predominance. To underpin its own rise, China now faces an "innovation imperative", meaning that it needs to obtain and develop technologies in order to continue climbing the global value chain, overcome the "middle-income trap"[1] and equip itself with critical military resources (Blanchette 2021). China has sought to close this technological gap by adopting a wide panoply of geoeconomic means, ranging from new industrial policies to technological cooperation and acquisition, as well as by allegedly engaging in industrial espionage and intellectual theft. The United States has responded by increasingly seeking to decouple from the Chinese economy, especially in the technological domain as this report shows, and by putting pressure on others to follow suit.

For the EU, the rise of geoeconomics poses a difficult challenge. The EU was designed on the premise that economic and security policy should remain separate, and now finds itself ill-equipped for their increasing convergence. In this new context, the EU has started to develop policies to enhance its own economic and technological competitiveness and promote its ability to participate in defining the rules of the game for the global economy (Helwig 2021). What this amounts to is a redefinition of Europe's economic and technological sovereignty in order to better manage its economic interdependencies, reducing dependence on others without resorting to unfounded protectionism that could accelerate the geoeconomic chain reaction and harm the interests of European businesses (see e.g. European Commission 2020a).

The EU discussions on how to better manage the risks of global economic interdependencies are held under the banner of "open strategic autonomy". The term emerged as a reaction to the ongoing debate on European strategic autonomy, and represents a typical compromise between the competing objectives of EU member states (Helwig 2020). Some member states (such as France), with an economic structure that benefits from a more protective industrial and trade policy, broadly emphasize the autonomy aspect. The more market-liberal and trade-reliant member states (including the Nordics) highlight the openness of the European economy. Hence, open strategic autonomy, as the European Commission (2021a) defines it, is not primarily about protectionism. Instead, it also includes goals such as the promotion of the EU's competitiveness and the rules-based global trade system. The European Commission and EU member states are in the process of finding the right policy mix between protectionist

1 The "middle-income trap" is a somewhat contested notion of how rapid growth from low-income to middle-income levels – fuelled by cheap labour, basic technology catch-up, and the reallocation of labour and capital from low-productivity sectors like traditional agriculture to export-driven, high-productivity manufacturing – is often followed by lower growth (Gill and Kharas 2007).

measures, innovation and competitiveness, as well as international engagement to advance their economic interests in a more competitive environment (Helwig 2021).

In order to influence this EU ambition in line with its own interests, Finland must be able to assess its own vulnerabilities to geoeconomics and gather up-to-date data concerning Finland's economic and technological interdependencies. At present, there is little systematic analysis of Finnish vulnerabilities or meta-level analysis concerning Finnish economic and technological interdependencies with the United States and China in particular. Such analysis is indispensable for creating situational awareness for Finnish strategy work, policy preparation and decision-making, and security of supply, both at the domestic as well as the EU level, and for supporting Finnish companies that increasingly find themselves at risk of becoming collateral damage in the global geoeconomic struggle.

1.2 Research objectives, tasks and consortium

The report's **research objectives** can be stated against this backdrop, in that it seeks to improve the existing understanding of ongoing geoeconomic dynamics involving great powers such as the United States and China; advance understanding of related geoeconomic risks and opportunities for the European Union and for Finland in particular; gather up-to-date research data on the economic and technological interdependencies of Finland and the EU vis-à-vis China and the United States; as well as critically assess relevant policy options for strengthening European economic and technological sovereignty.

With these overall objectives in mind, the research centred on **five specific tasks**:

First, to identify and assess the evolving geoeconomic risks stemming from the intensifying US-China rivalry. Developing a clear understanding of these emerging risks is needed in order for both European policymakers and European companies, including Finnish ones, to be able to address any potential vulnerabilities and devise policies to enhance competitiveness and economic resilience.

Second, to assess current EU policies for managing the ongoing Sino-US geoeconomic rivalry and any policy implications for Finland. Such an assessment is needed to assist both Finnish policymakers and companies to make informed decisions about how to best manage current developments.

Third, to map out Finnish economic dependencies on China, the European Union and the United States in order to improve our understanding of both the risks and opportunities for Finland stemming from the accelerating global geoeconomic competition.

Fourth, to map out Finland's science, technology and innovation (STI) cooperation with the United States and China in order to gain a general understanding of Finland's technological competences, dependencies and resources. Looking at the overall cooperation dynamics and zooming in on who cooperates in which technology areas is valuable as it reflects technological interdependencies and relative strengths, but also potential vulnerabilities. These insights can contribute towards a national investment agenda that strengthens Finland's own technological capabilities and preparedness.

Fifth, to assess Chinese and US technology-oriented acquisitions of European, including Finnish, companies and their level of specialized technological advantages in relation to European, and especially Finnish, business sectors. Understanding the entry patterns of Chinese and US technology giants into European markets is important because these entry patterns will affect competition dynamics in European markets, consumer welfare and, by extension, European technological sovereignty and competitiveness.

The **project consortium** behind this report was specifically built with such a multidisciplinary research mission in mind, gathering political, economic and technological expertise from its three main consortium partners – the Finnish Institute of International Affairs (FIIA), ETLA Economic Research (ETLA), and VTT Technical Research Centre of Finland (VTT). The actual project team consisted of the following persons:

Mikael Wigell, Research Director, FIIA (Project Leader)
Christian Fjäder, Senior Research Fellow, FIIA
Niklas Helwig, Leading Researcher, FIIA
Anu Ruokamo, Specialist, FIIA
Josi Seilonen, Associate Specialist, FIIA
Heli Koski, Research Director, ETLA
Ville Kaitila, Researcher, ETLA
Arho Suominen, Principal Scientist, VTT
Matthias Deschryvere, Senior Research Scientist, VTT

1.3 Research data and methods

The project has adopted a **multidisciplinary approach** with regard to research material and methodology, combining qualitative research (standard documentary analysis, expert interviews) and quantitative research (descriptive statistics, bibliometric analysis, survey research, data-driven analytics). Close collaboration between consortium partners allowed the project to systematically harness its multidisciplinary expertise and ongoing quality control.

By utilizing relevant literature and policy documents from Finland, the European Union and the United States, Chapter 2 conducts a conceptual analysis of geoeconomics and geoeconomic risks for the European Union and Finland, with a specific focus on the impact of technological "decoupling" between China and the United States. Based on the analysis, the chapter identifies three underlying trends driving the evolution of geoeconomic risk – the securitization, balkanization, and weaponization of the global economy – and examines their combined impact on the global economy, global supply chains, and Finnish and European businesses. Based on the conceptual analysis and the risk examples gathered, the research for the chapter further focused on testing and validating a tentative typology of geoeconomic risks by conducting a survey on Finnish companies, complemented by six in-depth expert interviews with Finnish policymakers and experts. These interviews were carried out in the summer of 2021.

Chapter 3 identifies and assesses the current and emerging EU policy initiatives and frameworks related to geoeconomic risks and their potential impact on Finland. Based on the analysis of EU policy documents and the review of secondary literature, the researchers created a map of current EU policy initiatives, focusing in particular on their defensive versus strategic characteristics. This exercise was complemented by expert interviews with EU and Finnish officials working on trade and economic policies. The interviews were conducted online in the first half of 2021. In order to evaluate the potential impact on Finland, the relevant Finnish policy documents were cross-analyzed with the corresponding EU policies, and recommendations were peer-reviewed in internal workshop sessions.

Various descriptive statistics were used to map Finnish economic dependencies in Chapter 4. The economic relations between Finland (and the EU) on the one hand, and China and the US on the other, were first evaluated by using publicly available UNCTAD data on goods and services trade, as well as Statistics Finland and OECD data on the trade of domestic value added. The research method was thus quantitative and descriptive. Since often-used international foreign direct investment (FDI) statistics are problematic in several respects,[2] we used Statistics Finland's data on Finnish multinational firms' foreign subsidiaries abroad and foreign multinational firms' subsidiaries in Finland, as well as the respective Bureau of Economic Analysis (BEA) data from the US. The data in goods trade are available at the very disaggregated HS 6-digit level, and they can also be used to analyze the development of trade linkages between the United States and China. In this way, it is also possible to analyze how these two countries' interdependencies have developed generally and in selected products or product groups. The analysis was

2 The flows are influenced by tax regimes, which delinks them from actual physical investment activities. Furthermore, FDI flows do not capture all investments made by multinational firms.

complemented with services trade data, although it is not as comprehensive as the data in goods trade. Services trade is more important for the US, while goods trade accounts for a higher share for China.

In order to map Finland's technological capabilities as well as research and development (R&D) networks with the US, China and the EU, Chapter 5 combines big data sources on R&D activities with analytical methods applied on proprietary databases containing (1) scientific publication data (Scopus) and (2) patent data (Patbase and Patentsight). Within the scope of the chapter, a descriptive analysis is conducted on co-publication and co-patenting dynamics between Finland and the USA, and between Finland and China. While important technological areas and key players are highlighted and a concise case study is demonstrated on a full set of critical quantum technologies, the approach remains quantitative and does not include a qualitative assessment of separate critical technologies.

In Chapter 6, data were obtained from multiple sources to map how Sino-US companies' actions may shape the competitive field in Europe and Finland. Data concerning large Chinese- and US-based companies' acquisitions during 2000–2018 were extracted from the Crunchbase database. Descriptive data analysis was used to explore the annual total number of acquisitions of the US and Chinese technology giants and, further, the relative importance of acquired companies' product market areas. The data concerning patent applications to the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO) during 2005–2019 were acquired from the PatentInspiration database and the OECD "Patents by technology" statistics covering 2005–2017. We calculated the revealed technological advantage (RTA) index to measure the US- and Chinese-based technology companies' (innovation) specialization in different technology domains compared to European countries, Finland, and the world.

During the course of this project, a number of **internal workshops** and **webinars**[3] were organized. In particular, the project organized a FIIA webinar *Recognizing 'geoeconomic risk': Rethinking risk management for the era of great power Competition* (17.6.2021) in conjunction with the publication of FIIA Briefing Paper 314 (see below). The project came to its conclusion with the organization of the FIIA webinar *Europe facing geoeconomics: Risks and options in managing economic and technological interdependencies for the EU and Finland* (3.2.2022), where the final report of the project was published.

3 Due to the Covid-19 pandemic, in-person seminars were replaced by webinars organized via Microsoft Teams. Internal workshops and project meetings were organized as hybrid events when possible.

The project has also **published** two policy briefs: FIIA Briefing Paper 314 (06/2021) *Recognizing 'geoeconomic risk': Rethinking corporate risk management for the era of great-power competition*, and the ETLA column (24.9.2021) *Miksi vientimme Kiinaan muuttui raaka-ainevetoiseksi?* [Why did our exports to China become raw material-driven?].

1.4 Structure of the report

The report has been structured with a view to its main objectives, namely to analyze the risks and opportunities for the European Union, and Finland, from the current Sino-US geoeconomic competition, and to assess relevant policy options for managing it.

Part 1 concentrates on examining the risks for European and Finnish companies from the accelerating geoeconomic competition, and major policy instruments for dealing with those risks.

Chapter 2 looks at how economic policy has become a key strategic means in great-power rivalry and how states, as a result, are attempting to control the economic networks that connect the world. By instrumentalizing businesses, they change the risk picture for both public and private companies. The securitization of the economy entails a first source of new risk as states attempt to strengthen their control of companies in sectors considered strategic and security-sensitive. Another source of risk stems from the balkanization of the global economy, whereby it would disintegrate into separate spheres of economies decoupled from each other. The competition for control of the global standard-setting regimes constitutes an emerging area of such risk. A final source of risk is the weaponization that accelerates the use of sanctions and export controls. It entails more barriers for companies and puts pressure on the rules-based international system.

The critical risk from these dynamics for both public and private firms is that they increasingly become used as pawns in the accelerating geoeconomic rivalry between major powers. Moreover, as geoeconomics is hollowing out the predominant market rules which have prevailed until recently, the risk picture for many businesses is undergoing major change. Importantly, this not only concerns private and public corporations in sectors of immediate and obvious strategic importance. The inclusion of data as well as research and development (R&D) information and know-how in the sphere of critical security technology further complicates this picture. The chapter consequently suggests that there is an increasing need to develop typologies for geoeconomic risk. Both public and private sector parties can utilize such typologies in identifying, assessing and mitigating their unique risk picture.

Chapter 3 assesses the EU's current and emerging policies for managing its interdependencies and associated geoeconomic risks, as well as major policy implications for Finland stemming from them. In recent years, the EU has been remarkably active in reassessing its economic relations with the wider world and in making them more strategic. While the EU's defensive policies aim at making the bloc more competitive and shielding European companies from distortive and coercive measures of external origin, the EU has also adopted a more strategic approach and uses its economic power to promote its interests and values globally. In contrast to some of the protectionist and market-interventionist solutions discussed and pursued at the EU level, the Finnish approach focuses more on managing the risks of an internationally connected economy. Beyond Europeanizing its security of supply focus, there is a need for Finland to actively shape the current EU agenda and toolbox on countering geoeconomic risks. The chapter suggests that it is in Finland's strategic interests to promote multilateral rules-based frameworks in order to maintain an open global economy and seek means to hedge against the potential balkanization of the global economy. Finland should consider following the EU's emerging approach to integrate various policy areas concerning the strategic environment.

Part 2 of the report gathers more detailed data on European and Finnish economic and technological dependencies, taking stock of some critical strengths and vulnerabilities.

Chapter 4 focuses on collecting and analyzing data concerning Finnish economic relations and dependencies with regard to China, the European Union and the United States. The current state and recent development of Finland's economic relations with China, the EU and the US are reviewed mainly by using different trade statistics and statistics on foreign subsidiaries. The chapter also compares the results with the EU27 average and selected member countries such as Sweden and Germany, which are important for Finland. It analyzes general economic interdependencies as well as selected product groups. This largely descriptive analysis highlights the current relative economic importance of China and the United States for Europe and Finland, and discusses US-Chinese economic relations. In terms of goods and services trade and multi-national enterprises' foreign operations, the United States remains more important for Finland than China. China's importance has increased since the turn of the century, but in many respects its share is no longer growing. Instead it is the United States that has become relatively more important for Finland during the past decade.

Chapter 5 focuses on mapping Finland's technological competences and its R&D cooperation dynamics with the United States and China. The analysis contributes to a better understanding of the interdependencies that can preserve, produce or undermine technological competences. By using multiple data sources that focus on research and industry equally, the analysis quantifies the extent to which there is academic and

business cooperation in research and development. These proxies of technological advancement include a plethora of different vantage points from which to analyze the change in dynamics. For example, based on publication data, Finland is arguably a true science powerhouse when normalized to its size. Despite the rising number of publications and cooperation, the challenge that generally applies not only to Finland but to Europe more broadly is that the investments in science do not lead to valorization within Europe. Based on patent data, Finland's R&D activities with the US have followed a downward trend, while those with China have increased and stand out in their relative importance. The uncovered evidence from patents can point towards a decoupling of R&D between the USA and multiple EU countries. Key in understanding R&D cooperation dynamics with the great powers are the activities undertaken by Nokia and Huawei respectively. Both companies deserve continuous attention in forging opportunities and limiting risks. While a focused case study on quantum computing sheds light on a key set of critical technologies, a set of policies oriented towards developing technological competences will be needed to tip national investment dynamics – both in capabilities and infrastructure – in the right direction. There is an open window of opportunity to contribute to the "4% R&D by 2030" agenda.

Chapter 6 concentrates on the economic and technological competition between the United States and China in Europe via the actions of large global players. The global markets are shaped by US and Chinese technology giants. So far, regulation has not succeeded in reducing the market power of US-based companies in Europe. Their dominance in different technology areas and product markets, and the domains in which these companies expand their activities, affect European and Finnish companies' possibilities to succeed. The exceptional number of users of the platforms of data giants, generating massive data pools for the platform owners, gives these companies a competitive advantage not only in the platform markets, but also in the traditional markets they access. Technology giants' acquisitions have generated competitive concerns as their buyouts of small, innovative companies may be targeted to eliminate their potential future competitors and their innovation. The chapter first assesses the Chinese and US technology giants' acquisitions of European companies in different product markets. The ownership of intellectual property rights of key emerging technologies will further determine companies' success in global competition. Second, the chapter explores global technology giants' technological advantages or specialization in different technology domains compared to the European and Finnish business sectors. Data gathered and laid out in the report shows that the US-based technology giants have rather aggressively targeted and bought European companies. Chinese big tech companies, on the other hand, acquired only a few European firms during the 2010s, but their buyout activities in Europe have recently increased. The global technology giants had a technological advantage over Europe and Finland in information and communication technology (ICT), but not in other sample technology domains.

Chapter 7 in **Part 3** of the report summarizes key arguments and implications for Finland.

1.5 Policy recommendations

For the EU and its Member States, such as Finland, the key challenge in the current environment of intensifying geoeconomic rivalry is the balancing of economic openness and preparedness. Maintaining Europe's open economic platform is central for the efficient allocation of resources, ensuring competitivess and for continuing to reap benefits from Europe's comparative advantages. Yet, the rise of geoeconomics requires enhancing Europe's preparedness to economic disruptions and risks caused by critical external dependencies.

The EU and its Member States, including Finland, have demonstrated awareness of the need to prepare for geoeconomic risks, as Chapter 3 of this study demonstrates. Current EU policies focus especially on promoting the EU's open strategic autonomy as a framework to balance openness and preparedness. Finland's security of supply model similarly aims to sustain national preparedness within a framework of an open economy. However, as Chapter 2 of this study shows, current geoeconomic dynamics requires us to step up these efforts. To this end and based on the analysis conducted in this study, we propose four bundles of recommendations.

1.5.1 Introducing national geoeconomic risk assessments

At present, national risk assessments in EU member states consider a wide range of natural, anthropogenic and socio-natural risks, including national security risks such as terrorism, cybersecurity and hybrid threats. However, recent developments requires national security risk assessments to put much stronger emphasis on geoeconomic risks, both of a "systemic" and "strategic" character. Systemic geoeconomic risks are those that stem from disruptions in global sypply chains because of pandemics, natural disasters or regional instabilities. Strategic geoeconomics risks are those that stem from policy actions meant to lever economic instruments for power political goals. Herein, it is essential to include private sector actors that are in the forefront of these risks and responsible for the majority of critical economic infrastructure and services. Advancing joint situational awareness between both public and private actors is a key pillar of preparedness to geoeconomic risks.

Specific measures include the following:

a. Establishing a strategic-level public-private dialogue on geoeconomic risk with the aim of creating a living situation picture on critical dependencies in trade, finance, supply chain, critical technology and data.
b. Incorporating geoeconomic risk assessments into existing national risk maps with the help of corporate risk assessments.

1.5.2 Increasing strategic coordination of technological governance

The Sino-US competition is focused on technological supremacy and containment. For the EU and its member states, it warrants a focus on technological sovereignty while maintaining a measure of open cooperation in order to improve competitiveness, innovation and productivity. Herein, Europe faces coordination challenges. Access to up-to-date and formatted information on technology sourcing needs to be improved. Strategic investments in science, technology and innovation competences and infrastructure are needed. The Finnish government has set a target of 4 percent R&D expenditures by 2030, but China is stepping up the game with its recently announced 14th 5-year plan that includes a 200 percent deduction rule for R&D expenditures. A key observation made in this report is that, compared to its European peers, Finland's high co-owned patent share with China is exceptional and mainly driven by Nokia and Huawei. To understand the cooperation dynamics between Finland and USA and between Finland and China the strategic capability and critical technology development of Finland's heavy weight Nokia has been and is expected to continue to be of crucial importance. At the same time, Huawei activities in EU member states, including Finland, need to be closely monitored. Huawei has been a top patent applicant at the European Patent Office. As part of its new diversification strategy, Huawei has recently announced to set up a new fintech R&D center in Finland together with the University of Helsinki and Aalto university. This latest Huawei investment follows the rising trend of Huawei patent activities in Finland that started with the 2012 set-up of its R&D center in Helsinki. As Finnish research institutes and universities have been confronted with high uncertainty during the last decade, cooperation offers from foreign firms can look especially attractive. However, in terms of national interests, also the industrial espionage risks need to be integrated in the decision-making process on R&D deals between Finnish and non-Finnish organizations.

Specific measures include the following:

a. Setting up an Observatory of Critical Technologies at member state level to cooperate closely with its EU counterpart(s) to inform the government on its technology strategy by leveraging existing networks of technology experts. The aim of the observatory would be to (1) monitor developments in the technology domain, and (2) develop and update roadmaps on critical technologies.
b. Reinforcing EU-US cooperation in technology and global standard-setting, including the EU-US Trade and Technology Council, with the aim of adopting common principles on export controls, cooperation on artificial intelligence and semiconductor supply chains, and exchanges of information on investment screening.
c. The launching of strategic investments in science, technology and innovation activities with the aim to ensure productivity growth and future comptences.

1.5.3 Promoting trade cooperation

As with many EU member states, Finland is critically dependent on international trade, wherefore an open and rules-based international trading system is matter of central importance. Not only does Finland benefit from being part of the largest common market in the world, but the EU also wields significant influence in international negotiations. For the EU as a whole, but especially for its smaller, export-oriented member states such as Finland, extending trade agreements remains vital. Trade agreements are an important means in ensuring the resilience of supply chains. The EU also needs to continue advocating for reforming the multilateral trading system, embodied in the World Trade Organization, to mitigate the escalation of the geoeconomic chain reaction. The restoration of the WTO's two-step dispute settlement mechanism could ensure that geoeconomic rivalry does not escalate uncontrollably into a security conflict.

Specific measures include the following:

a. Pushing forward with EU's bilateral trade agreements with African, Asian and Latin American partners, and ensuring that existing agreements are efficiently implemented.
b. Advocating reform of the WTO, the restoration its dispute settlement mechanism and the upgrading of global rules and norms with regard to digital trade.

1.5.4 Ensuring a level playing field for European companies

A renewed emphasis on establishing level playing field is needed to ensure Europe's future competitiveness. At present, this level playing field is challenged in a number of ways. First, global technology giants', particularly US-based but increasingly also China-based, growing number of aggressive acquisitions in Europe risk slowing down European innovation and kill potential European competitors. Particularly Chinese-based, heavily government-subsidized companies may gain an unfair advantage over European companies due to public subsidies, with detrimental consequences for fair competition within the EU. The *EU-China Comprehensive Agreement on Investment* (CAI) was intended as EU's countermove against these Chinese state-led acquisitions and as a restriction on uncommercial market behaviour. Yet, the agreement remains unratified and its coming into force is in serious doubt.

Second, the EU struggles to adapt and reap benefits from the digital revolution due to the balkanization of the digital economy and ensuing competition over global standards. Chinese and US-based global technology giants, by specializing in technologies essential for gathering, storing and analyzing personal data, have gained a technological advantage over Europe, including Finland, in crucial sectors such as ICT. The number of applied EPO and USPTO patents by the big Chinese technology companies have been growing expeditiously in recent years, and neither Europe nor Finland any longer seems to be at the global technological forefront. Part of the problem in Europe seems to be what has been referred to as "knowledge valorization" – or lack thereof. The European Union, including Finland, has struggled to effectively bring knowledge and technologies to the market, and the economic benefits of European innovation often seem to be realized outside Europe.

Third, standarization is emerging as a critical field of geoeconomics competition. Technical standards not only set the technical procedures for interoperability, which is vital for safeguarding global market access to technologies, but also set the norms that guide the codification of privacy and security of technology. Due to the divergence in basic values, China's increasing domination in standard setting organisations is a potential strategic risk. Consequently, Europe and Finland should become more strategic about technical standards and be prepared to defend European values also in the context of technical standard setting.

Specific measures include the following:

a. Approving the Digital Markets Act regulation in the proposed format regarding the technology giant's data sharing obligations. This would mean that data which is exclusively in the possession of technology giants would become available to European companies in digital markets and provide them with possibilities to compete and innovate in digital markets.
b. Enacting new EU-wide regulation to address: (1) "killer" acquisitions of technology giants, and (2) acquisitions using public subsidies outside the EU area.
c. Implementing a strategy for increasing participation in technical standard-setting bodies and collaboration with other EU member states and other parties that share values with Finland and the EU. For instance, cooperation with the United States should be enhanced in order to safeguard a Western value-base in technical standards.

PART I

2 Assessing evolving geoeconomic risks for European businesses

2.1 Background

Recent years have witnessed the acceleration of geoeconomic competition characterized by the broad use of economic tools to achieve strategic and security goals. As China and the United States ramp up this competition, economic interdependence is cast in a new light. What was once heralded as a barrier to conflict has now, at least momentarily, turned into a currency of power, as economic interdependencies are leveraged for power political ends (Leonard 2016; Scholvin and Wigell 2018).

As the major powers, chiefly in Europe, China and the United States, are waging this geoeconomic battle, they need and seek to leverage businesses that make up the present-day networked global economy. For both public and private firms, the threat is that they increasingly become used as pawns in these great-power ambitions. For companies around the world, this introduces a new source of business risk that combines geostrategic interests with economic dynamics (Fjäder, Helwig and Wigell 2021).

In this report, we refer to this new phenomenon as "geoeconomic risk". More specifically, we see geoeconomic risk as denoting the risks associated with economics being used by states for power political objectives. This not only affects US and Chinese companies but reverberates throughout the networked global economy. States defend themselves against this geoeconomic power politics by increasing their control over businesses in strategic sectors of the economy. It manifests itself in the panoply of new means of trade and export controls, investment screening mechanisms, data localization measures, sanctions and subsidies (Choer Moraes and Wigell 2020). Some of these measures include:

- Increased public scrutiny over direct investment and foreign state subsidies in order to prevent the foreign control of critical infrastructures or technologies, and to ensure fair competition.

- Controls regulating the export of certain technologies with a dual-use potential, and thus deemed to pose a risk to national and international security.
- State incentives aimed at the redesign of global supply chains, with the purpose of ensuring the supply of sensitive technologies.
- Actions to discourage universities and research centres from hosting students from certain countries so as to prevent the dissemination of knowledge considered strategic.
- Measures to limit access to fresh capital, such as the US delisting Chinese companies from stock markets, or redirecting government pension funds.
- Public infrastructure and R&D investment in disruptive technologies, such as the EU's efforts to boost the digital transformation (cloud computing, AI).
- EU tools to unilaterally enforce trade obligations (e.g. through tariffs), bypassing the paralyzed WTO dispute settlement system.
- EU instruments to shield companies from economic coercion, such as US extra-territorial sanctions (Blocking Statute, INSTEX).

These measures defy the market-liberal logic that has underpinned global economic relations in recent decades in the post-Cold War era. They illustrate the broad readoption and use of economic tools by states to attain strategic and security goals, and the way the relationship between economics and security is changing. States are increasingly concerned about the security risks that "hyper-connectivity" and interdependence pose for state sovereignty, economic resilience and even the fate of democratic governance (in democratic countries), while still simultaneously recognizing the positive opportunities they offer. This increased convergence of economic and security interests is putting pressure on the rules that govern the international economy, and by extension the operating environment of both public and private economic actors. A key driver of change seems to be the digital transformation. It is kick-starting a new form of economy in which data is becoming the most important factor of production (Vuorisalo and Aaltola 2021).

These developments also challenge the rules-based free-market principles that have provided a foundation for Finland's economic success. As a small trade and technology dependent country, Finland is particularly exposed to the geoeconomic strategies of other states. States' pursuit of strategic and security interests is gradually encroaching upon the economic realm, largely led by market actors since the end of the Cold War. Strategic interests, such as controlling access to critical technologies, increasingly clashes with profit and efficiency. This collision expresses itself in the emergence of geoeconomic risk that both companies and states need to address. States are faced with the challenge of balancing between safeguarding their strategic interests and sovereignty while trying to minimize economic damage at the same time. For businesses, this means that they need

to update their risk assessment framework and make sure that they keep track of the sector-specific strategic and security-related developments.

This chapter looks at the emergence of geoeconomic risk and provides some tentative thoughts on its implications. In particular, it shows how three geoeconomic drivers – the securitization, balkanization, and weaponization of the global economy – are refashioning the operating environment for European businesses.

2.2 Geoeconomic dependence: the securitization of the economy

The increased rivalry between major powers is taking place at a time when the level of global connectivity and interdependence is unprecedented. It casts the concept of interdependence in a new, more nuanced light than the positive angle from which it has predominantly been viewed during the post-Cold War period.[4]

As recently stated by EU High Representative Josep Borrell, "today we are in a situation where economic interdependence is becoming politically very conflictual" (Borrel 2020). Hence, for states, global interdependence has emerged as a national security issue. There are two principal drivers of this trend.

First, the centralization of global economic networks creates an infrastructure in which economic exchanges flow in a hub-and-spoke-like manner. Contrary to earlier expectations, globalization has not produced a "flat" world of diffuse power relations and reciprocal dependencies whereby states will refrain from coercive strategies to avoid damaging themselves. Instead, global economic relations and networks have tended to generate ever more asymmetric dependencies that can be manipulated, exploited and leveraged for strategic benefit by the less vulnerable parties in these relationships (Leonard 2016; Farell and Newman 2019; Scholvin and Wigell 2018). States that fail to recognize and counterbalance these dependencies run the risk of having their strategic autonomy circumscribed and, by extension, becoming pawns in the game of 21st- century power politics. The new data-driven economy seems to be heightening this tendency, with the control of data and its exchange becoming ever more centralized (Ciuriak 2021). Later, in Chapter 5 of this report, we will see how the related issue of technological sovereignty has become a subject of rising concern for all major powers in the international system.

4 For a discussion, see Fjäder 2018.

Second, the privatization of critical infrastructures has broadened the scope of national security to the economic realm. Today, many of the critical infrastructures of society are owned and operated by private sector actors, who in turn are highly dependent on global supply chains and markets (Fjäder 2018). Relatedly, the notion of security of supply has also gained increasing salience recently, especially in the wake of the Covid-19 crisis, with states starting to pay more attention to self-sufficiency, extended supply chain security and national resilience. In most countries, critical societal and economic functions cannot be secured by the state alone, as a result of which various forms of comprehensive and whole-of-society approaches to security have proliferated (Wigell, Mikkola and Juntunen 2021). These arrangements also tie companies into the national security frameworks of their host countries. In the worst case, such linking will create pressures to choose sides, as links to national security in one country become increasingly viewed as a potential risk in others.

China's push to excel in critical technologies, for instance, is driven by these security concerns. Firstly, the *14*th *Five-Year Plan* in March 2021 not only highlighted the importance of critical technology, but also data as a critical "factor of production" for China's prosperity and security, making broad categories of technologies subject to national security oversight and control (Grünberg and Mussee 2021). Secondly, the new national data security law that entered into force on 1 September, 2021 aims to protect Chinese critical networks and data against external threats. As such, it is principally protective in nature and focuses on reducing the risk of the loss of critical data that could compromise "state security". However, the new regulations also permit the government to stockpile "zero-day" vulnerabilities that could also potentially become weaponized and utilized for hostile purposes.[5] This is yet another good example of the securitization of international flows of data, and it may put international companies operating in China in a difficult position of either violating Chinese law or, if they comply, laws in other countries in which they operate. Considering that the new law requires companies to report vulnerabilities within 24 hours to Chinese authorities, and to refrain from disclosing them to other parties overseas, the risk of such conflict cannot be easily dismissed.

5 See Thorne and Hoffman (2021) for further details.

Chinese FDI activity

Acquiring the latest technology and improving R&D capabilities through investments and purchases is a key factor in China's Made in China strategy. Despite increased foreign direct investment (FDI) screening and the common blocking of Chinese acquisition attempts, which China tries to counter using the new dual circulation strategy, mergers and acquisitions (M&As) in particular are an important financial tool for China to drive its industrial upgrade as the deals are a powerful means of acquiring know-how and technical expertise, in addition to the opportunity to obtain new customer bases and resources. A good example of such strategic acquisitions is that of Finnish semiconductor manufacturing technology company Beneq in 2018 by Chinese SRI Intellectual, a company 50% owned by the Military-Civilian Development Fund (Datenna 2021). Between 2005 and 2015, the value of Chinese cross-border acquisitions rose from less than US$10 billion to US$60 billion, only to more than double to US$140 billion in 2016 – or 14% of the global cross-border M&A value (USA leading with a 19% share) (White and Case n.d.). Chinese state-owned enterprises (SOEs) have, historically speaking, played a key role in outbound direct investments (OFDI): some estimates point to a share as high as 90% of China's OFDI coming from SOEs (Wang et al. 2017).

China's FDI activity has been slowing down since 2016 due to increased political opposition in destination countries as well as domestic constraining of outbound capital flows, with a 13-year low occurring in 2020 largely due to the pandemic. China's outward FDI (OFDI) development shows that China has been investing more in the European Union than in the United States, although in 2020 the completed Chinese FDI in Europe reached a lower total than in North America for the first time since 2016 (Kratz et al. 2021).

In spite of public opposition to Chinese investments, the financial impacts of these on the recipient country can be significant, especially considering smaller economies such as Finland. Despite its size, with EUR 13.3 billion in received investments, Finland ranked on the top 5 list of the highest cumulative value of completed FDI transactions from China in the EU 27 and the UK between 2000 and 2020. As such, Finland is only slightly behind France (EUR 15 billion) and Italy (EUR 16 billion), with the top destinations being Germany (EUR 24.8 billion) and the UK (EUR 51.9 billion) (Statista 2021b). Such economic incentives can be difficult to refuse, even if the Chinese OFDI could have ulterior motives, such as affecting EU policies and institutional processes, as well as stirring transatlantic competition vis-à-vis the USA (Meunier 2012).

In addition to tightening data security regulations, the Chinese Communist Party (CCP) appears to be tightening its hold on Chinese technology companies by other means. More specifically, the CCP has utilized anti-trust and other market regulations to discourage national technology champions from listing their stock overseas, and thus from increasing their exposure to foreign influence. A recent example of this is Chinese ride-sharing giant Didi, which was slammed with the full wrath of the Chinese authorities after it launched an initial public offering on Wall Street in late June 2021 in order to go global. Only two days after launching the IPO, which increased its stock value to a whopping USD 70 billion, the Cyberspace Administration of China (CAC) launched an investigation into the company on the basis of its practices of collecting and using data. Didi's app was consequently removed from app stores in China and it lost approximately USD 22 billion in value within a week.[6] Other Chinese technology giants launching IPOs overseas, such as the Ant Group and Tencent, have also experienced similar retaliation measures. In August 2021, Chinese authorities revealed a plan to ban Chinese companies that handle sensitive consumer data from going public in the United States (Zhai 2021). The CCP has also applied the same rules in order to remind tech tycoons where their loyalties should lie, as demonstrated by Jack Ma's fate (Ryan 2021).

It therefore appears that China's strategy is at least partially driven by a pervasive sense of vulnerability. China has perceived a critical vulnerability in its dependence on high-end components in particular, such as semi-conductor chips, an issue where the geoeconomic risk has materialized from China's perspective. From the geoeconomic perspective, China views it as an example of a vulnerability to coercion by the West, which could be used for pressuring it into changing its policies regarding, for example, the Uyghur minority, Taiwan or the South China Sea. Although Beijing has intensified efforts to ensure supply, both from external sources and by boosting domestic production (in the spirit of the "dual circulation" strategy), its level of self-sufficiency in semiconductors is expected to reach only 19.4% by 2025 (Cho 2021).

Taken together, these trends are elevating economic security to the scale of strategic priorities for most states around the world. The economy is being "securitized" as states intervene out of strategic and national security concerns to safeguard "strategic assets", "critical infrastructures" or "emerging technologies" against the free operation of market forces. New trade and export controls, investment screening and data localization measures are being adopted in order to reduce vulnerabilities to geoeconomic dependence. Take the EU's framework for foreign direct investment screening which has been fully operational since October 2020, for instance. While it does not bind member states to any specific mechanisms or industries to protect against foreign acquisition,

6 For details, see e.g. The Economist 2021; Li and Zhu 2021.

it may well give rise to a wave of tighter public scrutiny across the EU. Finland's *Act on the Monitoring of Foreign Corporate Acquisitions* has already been in force since 2012 (updated in 2020) and gives the government the possibility to prohibit, fully or conditionally, a foreign acquisition if it is considered to present a risk to national defence or security.

For the private sector, the increasing securitization of the economy entails a new source of business risk. Firms can no longer safely assume that the state will adopt an arm's length approach to markets. Market-led transactions are coming under increasing scrutiny, motivated by national security considerations. Interpreting this simply as a traditional political risk would be misleading. Due to the critical importance of open markets for economic competitiveness, state interventionism in the developed world will not become as broad as in traditional state capitalism, but likely will remain more targeted and selective, mainly focusing on safeguarding the control of strategic assets (Choer Moraes and Wigell 2020). State leverage will vary significantly depending on the economic sector and can be abruptly adjusted as the strategic environment experiences a change. In sectors considered strategic and security-sensitive, states will attempt to coordinate business operations and exchanges to a larger degree, whereas other sectors will be left to operate according to market-oriented principles. Those sectors that will be considered security-sensitive in the future are often unpredictable. As interdependence in economies and supply chains increases, the pressure for the state to secure more sectors increases.

A timely example of this is the proposed new *Critical Entities Resilience* (CER) *Directive* by the European Commission (2020b), which would broaden the focus to ten sectors from the two sectors in the 2008 *European Critical Infrastructure Protection Directive* (Council of the European Union 2008). The same trend is evident in an increasing number of similar national legislations and strategies. It is likewise notable that intangible assets can also be security-sensitive, meaning that data, research and know-how relating to security-sensitive assets are increasingly considered targets of national security measures. Consequently, geoeconomic risk is subject to dynamic change and requires constant monitoring throughout the entire value chain. This will place a new burden on companies in an increasing number of fields.

To respond to these new realities, Finland will have to carry out more thorough analysis and monitoring of its own dependencies and make sure that new problematic dependencies are not formed. To this end, Finland will face added pressure to determine more clearly which sectors it considers strategic and what this definition duly means for those sectors. As Finland's trading partners are taking a more interventionalist approach to the economy, growing tension in trade and investment relations can be expected. Finland needs a clearer strategy regarding which relationships it wants to deepen in different areas, such as trade, investment, security, climate and development, as well as

how it wants to manage the US-China tensions, which can limit its possibilities to seek closer cooperation with both parties in all areas. So far, Finland seems to be aiming for the middle ground, focusing on economic cooperation with China in order not to complicate existing relations, while at the same time maintaining strong relations with the US, including in security and defence (Gaens and Kallio 2020). Whether such a balancing act will be feasible in the future, especially if the current dynamics accelerate, remains to be seen. As the European Union builds its defences against economic coercion and sharpens its trade policies to beef up its strategic autonomy, Finland needs to consider what the risks and opportunities associated with hedging behind EU policy frameworks are. Chapter 3 of this report will explore these aspects in greater depth.

2.3 Geoeconomic competition: the balkanization of the economy

The growing propensity to see global interdependence through the lens of geoeconomic dependence breeds antagonistic dynamics in global economic relations, which is currently evident in the decoupling of technology value and supply chains.[7] While principally taking place between China and the United States, it has global implications and the potential to become globally pervasive as global technology value and supply chains are not neatly organized around the United States and China.

As the race for global dominance in technologies deemed critical for economic competitiveness and national security extends to global value and supply chains, the likelihood of disruptions increases simultaneously. While the "great decoupling" is primarily seen as a strategic-level great-power game, it also inevitably has a negative impact on the norms and processes of global trade. It will therefore also impact private businesses and consumers.

An emerging area of geoeconomic competition is global technical standard-setting, which takes place in various regimes specializing in the task. These regimes and the standards they produce function as key enablers of global markets in technology products and services. In many ways, standards have served as the backbone of globalization. Without technical standardization and the interoperability it establishes, many of the technical solutions that we have grown accustomed to would not work, or even be available globally. After all, the interoperability established by technical standards allows us to utilize our mobile phones overseas, make payments and cash withdrawals overseas,

7 See e.g. Inkster 2020.

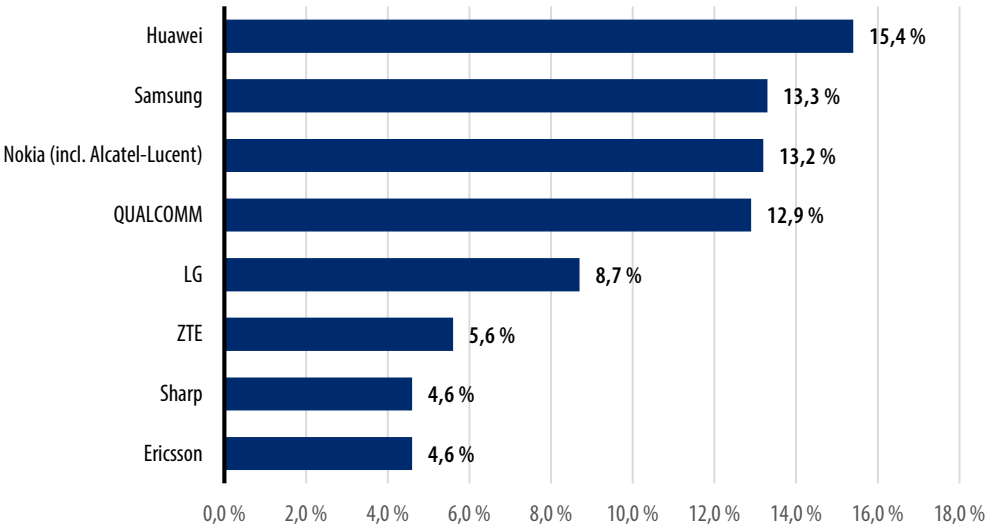
and purchase products and services from global markets with the expectation that they will work safely in any location. Technical standards have also enabled global flow infrastructures, such as airports, ports and standardized shipping containers.

Despite their strategic significance, the traditional approach to technical standards in the developed nations has been a bottom-up effort led by standardization associations and technical experts, organized in voting committees making decisions based on the consensus principle. As such, technical standards have been primarily industry-led and voluntary in nature. This technocratic approach seems to be changing, however, as we are witnessing a renewed effort by states to engage in standard-setting.

The hitherto prevailing Western paradigm of technical standards has largely been based on a market-based and bottom-up approach. In sharp contrast to the traditional Western approach, China views technical standards as an instrument to advance strategic goals. These strategic goals are directly related to the *Made in China 2025* strategy and making China a global innovation powerhouse by 2035. China wants to become a technological superpower and technical standards are a tool for securing its place in the global technology race. Consequently, standards in China are determined by ministries and their subordinate agencies, at both national and local levels. The rest of the world needs to be aware of the risks involved with incompatibility between Chinese aspirations and the underlying principles of the voluntary standards-setting regime, including the geoeconomic risks associated with it.

The Chinese approach to technical standards is distinctly strategic. The *China Standards 2035* strategy aims not only to increase standardization in critical technologies recognized in the *Made in China 2025* strategy, including 5G, cloud computing, Artificial Intelligence (AI), quantum computing, industrial robotics and semiconductors but, in doing so, to internationalize them as well. Consequently, the presence of Chinese representatives has increased in many international standardization bodies and their committees and subcommittees. These positions also increasingly include chair and co-chair positions, and have not only given Chinese representatives the possibility to influence the agendas of the committees, such as the International Telecommunications Union (ITU), and the International Organization for Standardization (ISO), but also a number of industry-specific standardization associations. Huawei and ZTE, for instance, have managed to increase their presence in the 3rd Generation Partnership Project (3GPP) – the industry association responsible for the bulk of global telecommunications standards, including 5G-related standards, while probably also eventually playing the same role in 6G. As of February 2021, Chinese companies accounted for 38% of approved 5G patents, in comparison with 17% by US companies (Yan 2021, 46). Huawei is currently leading the race in 5G patents (see Figure 1 below).

Figure 1. Share of 5G patents by manufacturer



Note: The categorization of 5G technologies varies somewhat in different statistical sources. In general, however, the share of Huawei in applied, granted and active patents appears to be increasing sharply. Huawei also leads in patent filings according to WIPO Statistics Database (February 2021). Source: Statista 2021a.

China has also been particularly active in SC42 – the standardization association for Artificial Intelligence (AI), as well as those concerning other emerging technologies, such as the Internet of Things (IoT) and blockchain. While China's increased participation in international standards has its positive aspects as well, the recent surge in Chinese representatives has raised concerns in the West that China could utilize standards not only to dominate technology ecosystems but also to compromise the principles of privacy and security that have thus far been based on Western values and norms. In any case, China's increasing dominance in standards may be inevitable; as the country's innovation capacity grows in key technologies, its capability to influence international standards will grow on a par with it.

China's race towards global patent dominance is logical from an economic and industrial policy point of view, as innovation arguably accelerates productivity, which leads to economic growth. As effectively stated in the *Made in China 2025* strategy, China wants to climb the proverbial ladder of global value chains to become an innovator in its own right and start earning fees for itself. Thus far, the global value chains have been organized in such a way that the United States and Europe have occupied the higher rungs on the ladder and have also controlled the technical standards as a consequence. In the course of China's success as a global trading power, it has distinctively been a follower and paid licence fees to its Western counterparts (see Figure 1).

China now feels that this position has become increasingly unfair. By pouring double-digit investments into research and development for decades, China has subsequently produced its fair share of leading technologies. Yet from China's point of view, the West continues to block market access for Chinese technologies, hindering its ability to climb the global value chain and overcome the risk of a "middle-income trap". Chinese observers have, for instance, pointed out how Huawei has invested more in R&D than its European competitors Nokia and Ericsson. In this context, it is not surprising that China aims to increase its control over global technical standards.

The ongoing 5G security debate and Huawei's troubles in the West is another good example of what geoeconomic risk looks like from the Chinese point of view. Whereas Huawei and ZTE have principally been blocked from certain markets on national security grounds, allegations of intellectual property theft and unfair competitive practices are also rife. Consequently, the list of Chinese entities subject to export controls is constantly growing. The "Entity List" of US Export Administration Regulations currently includes over 400 entities (and their subsidiary organizations) in China that are subject to export controls and trading, which requires a licence for exports, re-exports, and transfers in country (US Department of Commerce 2021a). In addition to the entities listed in China, the list contains Chinese entities registered in other countries. Consequently, a growing number of Chinese companies deemed to have an intimate connection with the government have been excluded from trading in much of the world.

While all eyes are focused on 5G security, it is worthwhile noting that the same issues are likely to be replicated in connection with the development of 6G. Whereas 5G has sparked national security issues due to its importance for critical infrastructures and services, 6G is expected to bring about new critical capabilities for public safety organizations and the increasingly data-dependent militaries. Consequently, cyber security is emerging as a major focus area with "embedded trust" as the ultimate goal. Embedded trust requires universal standardization of 6G security. In the event that decoupling has not become a problem of the past by the time 6G security reaches the standardization phase, security issues in 5G may actually become multiplied in 6G. While 6G is still in the embryonic stage and networks are expected to be deployed no earlier than the 2030s, dividing lines are already appearing. Finland is emerging as a frontrunner in the race for 6G development with the 6G Flagship project hosted by the University of Oulu emerging as one of the major hubs. The 6G Flagship, which organized the world's first 6G summit in 2019, recently announced that it has joined forces with Japan's Beyond 5G Promotion Consortium, involving major Japanese telcos, such as NTT Docomo, SoftBank Group, KDDI and Rakuten Mobile. Nokia is also expected to join soon. Indian companies, such as Tech Mahindra, are also already involved. The competing consortium – the Next G Alliance – involves US tech behemoths, such as Apple, Google and ATT, but also the South Korean LG Electronics. China, on the other hand, has chosen a government-driven approach and established

a 6G R&D Working Group under the guidance of the Ministry of Science and Technology (MOST). Thus, we could again be witnessing an emerging competition between two competing approaches to technology development, involving two relatively loose coalitions between academia and industry in the West and a government-driven approach in China. Hence, the risk of competing standards and, therefore, competing ecosystems that would decouple from each other could potentially emerge in 6G even more forcefully than in 5G. Ericsson's CEO Börje Ekholm recently warned that should this happen, China is quite likely to dominate the race (Bicheno 2021). While the race is still in its early stages, and thus uncertain, there is some evidence that China is certainly making progress, at least by its own account. According to the China National Intellectual Property Administration (CNIPA), China currently leads in 6G-related patent applications with a 35 per cent share of the total, in comparison to 16 per cent in the United States (Yang 2021). What is notable, however, is that the majority of patents in China's accounts have been filed by foreign firms, such as NEC, Samsung and Qualcomm (Clark 2021).

The accelerating geoeconomic competition for controlling standards as well as notions of self-sufficiency and economic autonomy risk leading to a balkanization of the global economy, namely to its disintegration into regional economies largely decoupled from each other. The decoupling that is underway, particularly in the technological sphere between China and the United States, may in some scenarios be followed by the splintering of Europe into its own economically autonomous sphere of control.

The risks for European businesses depend on the extent of this balkanization. A modest differentiation of standards would already increase development, production and distribution costs. However, as the experience around 5G security standards and the banning of Huawei from the US market shows, the balkanization may go much further. In fact, the United States has been active in convincing its allies to not only ban Huawei and ZTE from national networks, but also to take measures towards coordinating 5G security risks and even deployment, as well as diversification of supply chains (reducing dependence on China) and reshoring the development and production of critical materials and components, such as semiconductors. In NATO, the United States has actively promoted a NATO approach to 5G security, although thus far it remains the only NATO state that has banned the two suppliers. The NATO Communications and Information Agency (NCI Agency), however, recently announced that it is commencing an assessment of 5G's implications for the Alliance and its military applications (NATO Communications and Information Agency 2021). Another increasingly relevant grouping in this context is the "Quad", involving the United States, Australia, India and Japan. The Quad has made headway in coordinating the grouping's actions towards emerging and disruptive technologies with strategic importance. For instance, the Quad Critical and

Emerging Technology Working Group,[8] announced during the leaders' summit in March 2021, is exploring coordinating the members' 5G deployment, as well as the diversification of the supply of critical materials, possibly setting up a "rare-earth procurement chain". The *Supply Chain Resilience Initiative* (SCRI), signed by India, Japan and Australia and backed by an executive order by President Biden to review semiconductor supply chains, aims at reshoring critical chip development in order to reduce critical dependencies on China (Kim 2021). Furthermore, the SCRI may potentially be extended under the umbrella of the "Quad Plus" framework, involving South Korea, Israel, New Zealand, Brazil and Vietnam.

In the worst case, should the process of balkanization broaden and deepen, companies will be forced to either give up one market, or rather extensively tailor products for individual markets. As the sanctions, export licensing regulations and other related regulations not only concern finished products and parts, but also intangibles and data, this would not even mitigate geoeconomic risk effectively. The spread of the decoupling into data and cloud services will also further risk a splintering of technology development into separate technology ecosystems. This poses a particular risk to European businesses, as these ecosystems are primarily led by US or Chinese champions.

Decoupling will continue

Experts interviewed for the project believed that decoupling between China and the West is likely to continue. Most experts argued that the West should also further decouple from China in critical technologies, so as not to indirectly support the technological development of the Chinese military. It was argued that decoupling should be carried out in collaboration between like-minded countries, in that the EU, the USA and others, such as Australia and regional groupings like the Quad, should coordinate the decoupling process.

The decoupling of supply chains can already be observed in the way in which technological products designated for export to the US are not allowed to include certain Chinese parts, or when US authorities restrict certain parts for export to China. China may also seek to protect its domestic market by standard-setting, in line with the "dual circulation" strategy, to the detriment of Western companies. Uncertainty with regard to planning, the monitoring of regulations, and the detangling of supply chains comes

8 See e.g. Australian Government 2021.

with a steep price tag. Finnish companies have already been reported as having to make changes to their supply chains due to the intensifying rivalry between the US and China.[9]

2.4 Geoeconomic disruption: the weaponization of the economy

Both the increasing securitization and balkanization of the global economy are closely related to a third trend – the weaponization of the economy. Recent years have seen a proliferation of the use of economic sanctions. These include trade sanctions, export controls, boycotts, aid suspensions, financial sanctions and asset seizures. In fact, all types of economic links and flows – aid, trade, finance, investment, travel and currency – can be used to threaten or actually disrupt economic exchanges and impose economic costs. For the United States, the use of economic sanctions has become a centrepiece of foreign policy. In the aftermath of 9/11, the US developed a new kind of economic warfare involving "the use of financial tools, pressure and market forces to leverage the banking sector, private-sector interests, and foreign partners in order to isolate rogue actors from the international financial and commercial systems and eliminate their funding sources" (Zarate 2015, xi). Subsequently, the range of sanctions tools has broadened further, and both China and the European Union are increasingly using them as a strategic means independently of the UN sanctions frameworks.

China has also adopted a policy of retaliation against parties that are accused of conducting "harassment" against Chinese companies, in addition to attempting to enhance its self-sufficiency and tighten controls over domestic companies. A radical recent example of what this could mean in practice is the so-called "hostage diplomacy" that China has increasingly engaged in since 2018. Hostage diplomacy has also materialized as a geoeconomic risk, as the case of two Canadians, Michael Spavor and Michael Kovrig, demonstrates. When Spavor and Kovrig were arrested in China on espionage charges in 2018, observers quickly suspected that their detention was in retaliation for Huawei's Chief Financial Officer Ms Meng Wanzhou's detention in Canada on bank and wire fraud charges. While China has consistently denied any link between the two cases, it was thought that China intended to use the arrest of the two Canadians as a means of restraint against the potential extradition of Wanzhou to the United States. These suspicions were largely confirmed when China decided to release the two Canadians almost immediately after

9 See Ministry for Foreign Affairs of Finland and the Confederation of Finnish Industries 2021.

Wanzhou was released against a plea bargain that was reached with US prosecutors.[10] Similar instances of hostage diplomacy are likely to happen again.

For the private sector, the game changer is the accelerating use of so-called secondary, "extra-territorial" sanctions. While primary, "regular" sanctions prohibit citizens and firms of the sanctioning country from doing business with companies or individuals of the target country, secondary sanctions, by contrast, have been designed to bar citizens from doing business not only with sanctioned targets, but also with any third parties dealing with them. So, for instance, US citizens would be prohibited from dealing with a French bank giving a loan to an Iranian company, even if the loan was legal under French law. Foreign companies can be effectively shut out of the US financial system. As most businesses around the globe are either involved in the American financial system or are active on the US market, secondary sanctions "give U.S. policymakers a far longer reach than they would otherwise enjoy" (Lew and Nephew 2018).

The US has also extended its use of export controls to limit the transfer of new technologies to China. The US and the EU have traditionally used export controls to ensure that exports of dual-use items that can have both a civilian and a military purpose are not contributing to illegal weapons of mass destruction programmes or, more recently, acts of terrorism and human rights abuses. During Trump's presidency, the US was seen to use export controls to contain China. China responded with a new export control law that allows it to take measures against domestic and foreign companies, or other parties that are perceived to be abusing export controls and threatening China's interests and national security. More recent criteria for inclusion in the US entity list now include "activities sanctioned by the State Department and activities contrary to U.S. national security and/or foreign policy interests" (US Department of Commerce, 2021b). As such, the race to weaponize economic transactions and networks is being stepped up.

The weaponization of economic networks risks further propelling the balkanization of the global economy as actors start to hedge against the risk of being strong-armed by foreign actors. China is already seeking to create a parallel financial infrastructure to the largely US-controlled global financial system. China has launched the China International Payment System (CIPS) as an alternative to the US-dominated global payment system SWIFT, and is gearing up for the internationalization of a digital yuan as an alternative to the dollar. Even Europe has created its own Instrument in Support of Trade Exchanges, or INSTEX (albeit with limited reach and success), as an alternative payment instrument to process transactions with Iran. The euro is also increasingly promoted as an alternative currency to facilitate energy imports. This competition is likely to continue in the sphere

10 See e.g. BBC 2021.

of digital currencies, as China's plans for the digital yuan and renminbi take hold. China is also strengthening its own stock exchange capacity and planning to establish a new stock exchange in Beijing (He 2021).

Financial technology companies as an emerging battleground

Financial technology companies (fintechs) in particular are likely to be of central importance in the battle between the US and China for dominance of the global financial markets. While the Chinese market is highly concentrated in comparison to that of the US, China is heavily involved in the sector, and is making significant investments in blockchain technology and piloting a central bank digital currency. Seen against the backdrop of rapid technological development, fintechs offer a lever for gaining greater control over the digital economy and, crucially, for reaping data in various forms, not only on consumer behaviour. A key objective for China is also to attempt to set the standards for the nascent fintech technology and the future global financial infrastructure.

Currently, Alipay and WeChat Pay make up approximately 98% of China's mobile payments market (Bloomberg 2021), the largest in the world. These apps are also increasingly used in several countries, especially those favoured by Chinese tourists; the applications can be used for selected services even in Finland. Combined with a digital yuan, local merchants might be tempted to switch from US dollar transactions, especially in South-East Asia, which in turn could allow China to increasingly do business with its trade partners and emerging market economies using the digital yuan instead of the dollar. Further, by gaining prevalence, these companies attempt to embed themselves into the host countries' economic systems, potentially opening doors for Chinese access to other areas, such as insurance and consumer credit. The looming introduction of a digital yuan might then accelerate the development which Morgan Stanley predicted in 2020 would lead to the yuan increasing its 2% share of global foreign exchange reserve assets to 5–10% by 2030, making it the third largest currency behind the US dollar and the euro, overtaking the Japanese yen and pound sterling (Cheng 2020).

The weaponization of economic networks incentivizes private businesses to differentiate their markets and choose between the US, for example, or the rest of the world as a primary market for their economic activity. This extra-territorial aspect is at the core

of the new geoeconomic risk scenario. The crucial implication for the private sector is that the development of global politics needs to be tracked even more carefully than in the past. Foresight into possible future scenarios and conflicts between major powers becomes more valuable, as political developments can have immediate and direct implications for business operations. This, however, demands novel and improved capabilities from corporate risk managers, and the elevation of geoeconomic risk to the boardroom agenda.

Open economies are particularly vulnerable to coercive practices, which are increasingly used to alter other countries' policies, violating their national sovereignty (see Wigell 2019). The EU is particularly open to economic coercion not only because of its open economy but also because of its relative lack of centralized decision-making structures in comparison with external actors such as China and Russia, as was highlighted in expert interviews carried out for this project. The EU's trading partners can drive a wedge between the member states by hitting individual EU countries asymmetrically. Russia has for instance been leveraging its energy resources to cement political alliances and drive wedges within the EU. Its manipulation of energy flows is causing divisions in the EU's approach to Russia in general, and the Ukraine crisis in particular (Wigell and Vihma 2016). Both China and the US have also threatened the EU and its economic interests if the EU fails to take a position they respectively demand. The recent Chinese conduct against some EU member states such as Sweden (Duxbury et al. 2021) and Lithuania (Lau 2021a) shows the Chinese readiness of carrying out economic coercion in this respect.

Although Finland has chosen a somewhat different approach, the Swedish example is particularly relevant for Finland. In October 2020, the Swedish telecommunications regulatory agency PTS, citing national security concerns, instituted a ban on using Huawei 5G equipment in Swedish telecommunications networks. Huawei immediately challenged the ban, but it was nonetheless upheld in a Swedish court in June 2021. While it is still somewhat unclear what China's threat to "take all necessary measures" is going to mean in practice, it is clear that diplomatic relations are at an all-time low and that Swedish companies doing business in China, such as global telecoms giant Ericsson, are increasingly concerned about China's upcoming response.[11] Ericsson's market share in China is nonetheless already in decline (O'Dwyer 2021). Other countries that have banned Huawei from their 5G networks have also experienced strong counter-actions from China.

The 5G security issue is a good example of the dilemma over balancing between genuine national security concerns and economic interests. The epitome of the new geoeconomics crystallizes at the intersection of security, strategy and economic interests

11 For more details, see e.g. Lau 2021b.

of states. It also underlines the major challenge for the European Union in dealing with increasing geoeconomic risks. The European Union has not traditionally favoured market discrimination based on security concerns. So far, the principle of market neutrality has trumped security concerns in the EU, as is evident in its response to 5G security threats. New counter-measures, such as anti-coercion instruments are, however, being considered and prepared. Unlike the so-called Five Eyes countries (US, UK, CAN, AUS and NZ), for instance, the EU decided not to name Huawei or other suppliers individually. In consequence, the 5G toolbox produced in 2020 promoted neutral risk assessments for technical systems, regardless of where the supplier originated from. The US, on the other hand, has exerted its influence more actively by lobbying against Huawei, for instance (Gaens and Kallio 2020). Huawei has also sought to exploit the EU's sensitivity and claimed in its response to the Swedish ban that it was based on "trumped up" national security concerns by Swedish authorities and violates the principles of non-discrimination stated in Article 18 of the *Treaty on the Functioning of the European Union* (TFEU). If the European Union is serious about achieving "digital sovereignty", it will probably have to become less sensitive about responding to geoeconomic risks.

2.5 Emerging geoeconomic risks to Finnish and European businesses

Finnish, European and foreign companies in general face increasing market access restrictions and regulatory challenges as China implements its policy of self-sufficiency and increases the government's control over markets. The risks for European businesses largely depend on the extent of the decoupling. A modest differentiation in standards might increase costs in the development, production and distribution of products to different markets. However, the balkanization might not stop there, as the experience around 5G security standards and the ban on Huawei from the US market showed. The spread of the decoupling into data and the cloud will further risk the balkanization of global technology into the blocification of technology ecosystems. This poses a particular challenge to European businesses, as these ecosystems are primarily led by US or Chinese champions.

As the Finnish Ministry for Foreign Affairs has indicated in *the Finnish Government Action Plan on China*, businesses cannot trust in market access being reciprocal, and market conditions may change abruptly due to the ongoing changes. The ministry consequently urges Finnish companies in China to be more mindful of political, societal and economic policy-related changes in China (Ministry for Foreign Affairs of Finland 2021, 14–15). The report also specifically draws attention to the risks stemming from the global race for technological leadership, pointing out that it will increase regulations in China. These

are likely to include restrictions on the use of data, intellectual property rights, and uses of information networks normally taken for granted (Ministry for Foreign Affairs of Finland 2021, 22). Unless companies operating in China are sufficiently aware of these changes in good time, they risk a very costly impact on their businesses. In addition to the immediate loss of revenue, impacts may include the loss of long-term R&D investments, full intellectual property rights and data. Companies that operate in business areas that have the potential to be considered national security-sensitive, or that gather, store and utilize considerable quantities of consumer or other data potentially considered sensitive, need to be particularly mindful of the new emerging regulations. Foreign companies that operate joint ventures should also be mindful of the national security and political pressure directed towards their domestic parties, as well as of potential changes in ownership and management. Foreign companies either considering or preparing new joint ventures or acquisitions should ensure that they know as much as possible about their counter-parties, the stakeholder(s) behind them, and their potential motives. They should also be actively monitoring the relevant factors in order to identify any potential significant changes during the due diligence process that could alter their assessment of the risks involved. The due diligence process should also consider political and security risks and make no assumptions about the "purely business" motives of the parties involved. Finally, it is worthwhile noting that such risks are not limited to parties located in China, but also to controlled entities registered in third countries.

Geoeconomic risks are not logically or practically limited to China or Chinese entities. However, the respondents to our survey in Finland were generally less concerned about geoeconomic risk in connection to the United States or business operations there. Many were aware of and somewhat concerned about sanctions, but have seemingly accepted them as a fact of life. Interestingly, it would appear that Finnish companies are somewhat less concerned about the topic since the Trump administration left office. This is rather curious, taking into consideration the fact that US policy has not softened under the Biden administration. On the contrary, it would appear that policies towards China are going to be stricter and continue to expand in coverage and depth. While it is somewhat speculative, this could be due in part to the notion of shared values and norms that make sanctions and other market-restricting measures by the United States more understandable and tolerable than those of China. This would be supported to some degree by factual evidence as well. Chinese sanctions are more ambiguous and elusive in nature, while US sanctions in comparison are relatively direct and clear in argumentation. It is easier to deal with something that you understand, even if undesirable, than something that is ambiguous and thus uncertain. The United States is also clearly more important to Finnish technology business as a market and partner than China, as shown in Chapter 5 of this report. Thus, the explanation is likely to be a mix of shared values and interests.

Conflicting values as a root cause of risk

While the competition between the EU and the United States will probably intensify, it does not represent a major geoeconomic risk due to shared values. China's values are conflicting, and cause a conflict of interest. If China becomes a hegemony on a par with the United States, the competition may turn ideological, resembling a "new Cold War".

There are also good reasons for focusing on geoeconomic risk originating from China. First of all, while concentrating much of its efforts on economic development, the Chinese Communist Party is also simultaneously ramping up its military power.[12] At least part of the motivation behind controlling critical technologies and harnessing their economic potential stems from this goal. Since there are historical precedents that indicate a link between economic and military power, there is nothing new here as such. What is new, however, is that for the first time in modern history an authoritarian national security state is also a major global economic power. This is what distinguishes China from the Soviet Union during the Cold War, or even Russia in the contemporary era. Hence, it is not unreasonable to view China's increasing control over global technology as a strategic risk. Secondly, there are systematic risks involved in China's dominance of technology value chains and technical standards, specifically in terms of how technology and the standards governing it are used towards authoritarian surveillance or as dual-use technologies for military and security applications. Thirdly, the concerns about Chinese conduct include the alleged intellectual property theft by Chinese state organs and companies, forced technology transfers that foreign enterprises are subject to as parts of forced joint ventures in order to operate a business in China, the intelligence law that obliges Chinese companies to assist the intelligence services if requested to do so, and the Chinese hacking groups that target Western governments and businesses. These are all real and significant risks that cannot be ignored.

Based on our survey and interviews, Finnish companies appear to be somewhat aware of geoeconomic power politics and the ensuing risks, but at the same time feel somewhat uncertain as to what it precisely entails and what its implications are. Most seem to associate geoeconomics with sanctions, while not being particularly concerned about other aspects, such as the risks associated with the changing norms and regimes of

12 The People's Liberation Army (PLA) is the armed wing of the Chinese Communist Party (CCP), not a national army on a par with its Western counterparts.

technical standards. This is rather surprising as standards not only influence market access but may also lock companies into norms that may become contradictory to their own interests and the norms of their principal markets. Such risks exist, for example, in relation to data privacy and security.Significantly, companies are also unsure howthey should address geoeconomic risk.

Companies are aware of geoeconomic risk but uncertain how to address it

Based on the survey conducted as part of this project, it would appear that companies are relatively aware of the decoupling and the risks associated with it. Companies operating in both Chinese and US markets view US sanctions as a risk when operating in China. However, respondents also indicated that they are somewhat uncertain how to respond to geoeconomic risk. Most indicated that they would expect authorities to provide more information about the risks and the possible mitigation measures.

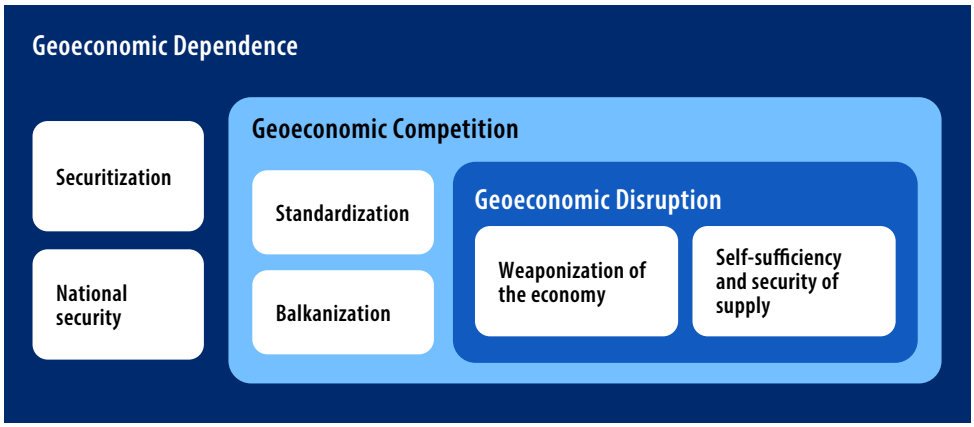
Consequently, there seems to be a clear need for more information about the causes, manifestations and implications of geoeconomic risk, as well as about potential mitigation strategies. While businesses expect more information from the authorities, academics, think tanks and other experts, companies should also share their experiences, concerns and mitigation strategies with each other, as well as with the authorities and experts. This would ensure the formation of a more holistic understanding of geoeconomic risks and help authorities and experts to improve their analysis, and fine-tune the information they provide for businesses to better meet their needs.

2.6 Conclusion

Geoeconomics refers to the geostrategic use of economic power (Wigell 2016, 137). As a state practice, it functions by leveraging economic networks and interdependencies for strategic goals. Unlike during the Cold War, the present-day great-power competition between China and the United States is predominantly being waged by economic means, with the ultimate goal of gaining control of the networked global economy and using that control for strategic benefit.

By operating many of the economic hubs, networks and flows that make up today's global economy, businesses are the most important vehicles for carrying out geoeconomic power projection (Gertz and Evers 2020, 117). Not only China, but also the US and the EU are therefore increasingly seeking to increase state leverage over strategic sectors of the economy. This manifests itself in the panoply of new means of trade and export controls, investment screening mechanisms, sanctions and subsidies. The technical standard-setting regimes are also currently emerging as a new battlefield in this new reality.

Figure 2. Geoeconomic Risk in a competitive age



The three geoeconomic drivers introduced above – the securitization, balkanization, and weaponization of the global economy – are together refashioning the operating environment for economic actors around the world. By hollowing out the predominant market rules prevailing until recently, the risk picture for many businesses is undergoing major change. Importantly, this not only concerns private and public corporations in sectors of immediate and obvious strategic importance. The inclusion of data, research and development information and know-how in the sphere of national security further complicates this picture.

What are deemed strategic assets may also vary extensively from one context to another, making it difficult for businesses to assess their own sector-specific risks (and opportunities). For example, the production of certain medical equipment and vaccines suddenly became a strategic asset with Covid-19, having largely been outsourced overseas, including to China, by most countries previously. Yet in most corporate risk management frameworks, these geoeconomic risks remain unaccounted for. In effect, as a concept, "geoeconomic risk" remains largely undefined and the precise risk picture unclear.

Consequently, there is an increasing need to develop typologies for geoeconomic risk that both public and private sector parties can utilize towards identifying, assessing and mitigating such risk. Currently, companies appear to be relatively aware of the geoeconomic risks, but somewhat unsure about how to mitigate them. This is likely to be due in part to the increasing complexity and novelty of geoeconomic risks. In light of this, the traditional enterprise risk management and political risk frameworks do not necessarily capture the essence of geoeconomic risk. In order to gain sufficient capabilities to identify, analyze and mitigate geoeconomic risk, businesses need to gain a better understanding of societal and especially national security risk in various markets, as well as the shifting strategic interests of states. National security "risk" is problematic to forecast because it may carry a very different connotation from business risk.

In practice, such approaches to "risk" are vulnerability-based and focus on treating vulnerabilities that may lead to an unacceptable outcome like "risks". Moreover, societal definitions of "risk" are essentially political and are intended to reflect the values and norms of society rather than any "technical" assessment of risk. National security assessments are thus not necessarily objective and based on observations of occurrence alone. They are nonetheless reflected in legislation, regulations and policy, and as such carry real consequences.

Geoeconomic risks, by contrast, are usually transnational and transboundary, as in the case of the US-China decoupling that is reverberating across the global economy. Here, the drivers are not the changes in domestic political preferences, but rather international, often more detached developments (for example, the Ukraine crisis led to export restrictions on certain dual-use goods for European companies). Moreover, since the global value and supply chains are detached from nation states, geoeconomic disruptions are a concern for more than just the parties directly targeted. US sanctions targeting China will therefore not only affect Chinese companies but companies from anywhere operating in China, or ones that trade in goods and services that are targeted with such measures. As a result of the transnational nature of global value chains (GVCs), virtually any organization deemed part of the system can be impacted, if not directly then indirectly. In order to enable businesses to account for "geoeconomic risk", it needs to be better defined and supported by an appropriate universal typology. More data and a better understanding of the root causes, agents, means and implications of geoeconomic risk are therefore required.

3 Managing interdependence: the EU and Finland confront geoeconomics

3.1 Background

In recent years, the European Commission – in coordination with member states – has been remarkably active in reassessing the European Union's economic relations with the wider world and in making them more strategic. The EU's traditional perspective on international economic relations has been influenced by its own experience as a market integration project. As such, the EU has viewed economic globalization as an overwhelmingly positive and manageable process. Recently, however, the tide has been turning and calls for better management of interdependencies are growing throughout different policies and instruments.

The European Commission uses the concept of "open strategic autonomy" as the broad heading under which it is bundling the reforms of its trade and economic policy. The term emerged as a reaction to the ongoing debate on European strategic autonomy and represents a typical compromise between competing objectives of EU member states (Helwig 2020). Some member states (such as France), with an economic structure that benefits from a more protective industrial and trade policy, broadly emphasize the autonomy aspect. The more market-liberal and trade-reliant member states (including the Nordics) highlight the openness of the European economy.

The weighing approach of the European Commission exemplifies that the EU's contemplation of strategic autonomy should not be misrepresented as a simple quest for independence or global decoupling (Helwig 2021). Across its entire policy spectrum, the EU's approach is built on interdependence and cooperation, whether through its pursuit of free trade agreements, its reflex for multilateral solutions, or its cooperation with NATO on security and defence matters. However, behind the current policy debates and reforms lies the realization that interdependence comes with risks attached. Rather than turning unilateral and protectionist, the EU is currently attempting to mitigate these risks by managing and fine-tuning its interdependencies.

The options in the economic sphere are manifold, as Table 1 shows. While there is no clear dichotomy, the emerging instruments can be broadly divided into two categories. The defensive policies aim at protecting the EU in a more competitive international

environment, while the strategic instruments aim at translating the EU's economic power into international leverage to realize its interests and norms.

The following two sections will detail the EU's approach and progress on various instruments. The final two sections before the conclusion will focus on the distinct Finnish approach to geoeconomic risks. In contrast to the EU's current agenda, the Finnish approach to managing global interdependencies is less focused on trade and industrial policies and more focused on further developing security of supply and societal resilience.

Table 1. The EU's defensive and strategic policies and instruments

Defensive policies	Strategic policies
Internal reforms & investment	*Economic binding*
Deepening of the single market (under debate)	External regulatory effects ("Brussels effect")
Competition policy reform (under debate)	Free Trade and Investment Agreements
Industrial policy update	European Neighbourhood Policy
European Chips Act (proposed)	Global Gateway
Important Projects of Common European Interest (IPCEIs)	
Countering external coercion & distortion	*Promoting values & interests*
Foreign direct investment screening	Restrictive measure
Trade defence instrument	Human rights sanctions
Blocking statute	Due diligence
Foreign subsidies instrument	Export controls
International procurement instrument	EU-US Trade and Technology Council
Enforcement regulation	Carbon Border Adjustment Mechanism (CBAM)
Anti-coercion instrument	

Source: Authors' compilation.

3.2 The EU's new economic defence capabilities

Better management of economic interdependencies involves mounting an effective defence against coercive or distortive economic practices by third countries. In order to avoid a situation in which the Union is overly dependent on external economic actors and constrained in its sovereignty to make autonomous decisions in line with its preferences, the EU is slowly but surely ramping up its economic defence capabilities.

This process is, however, marked and partly hampered by salient policy differences between member states.

An effective defence against risks in global economic relations starts with a more resilient and competitive economy at home. The global dimension of single market policies has gained more relevance in recent years and internal market policies are no longer seen solely through the prism of economic efficiency and integration dynamics. Most member states have realized that the EU needs to improve its competitiveness to enhance its standing in the ongoing geoeconomic and technology competition. Yet they have different economic philosophies on how to go about upgrading the EU's global market status. On the one hand, the European Commission has promoted industrial and digital strategies to increase the EU's competitive advantage. These proposals are very much aligned with the ideas from smaller and more market-liberal member states, which perceive that the best way to ensure global competitiveness is to ensure internal competitiveness in a more deeply integrated single market. Just recently, the heads of government from Germany, Denmark, Finland and Estonia sent a letter to the Commission, urging it to speed up the digital transformation of the single market (Merkel et al. 2021).

On the other hand, one can also observe initiatives that follow a more market-interventionist philosophy. A prime example is the Franco-German call for an EU competition policy reform to foster European champions (Federal Ministry for Economic Affairs and Climate Action of Germany and Ministry of Economy and Finances of France 2019). If China is heavily subsidizing its giant companies, the least that the EU can do is to relax the rules on mergers to create globally competitive enterprises, so the logic goes. This logic, in turn, raises eyebrows in the market-liberal member states, which prefer policies that benefit the "next Spotify" rather than the "established Siemens". The path to a more globally competitive single market is thus not a straight line, but rather characterized by substantial policy debates.

As the Covid-19 pandemic hit Europe, voices grew inside the EU calling for reshoring manufacturing as a way to enhance the EU's standing amid the geoeconomic rivalry. In the context of the EU's industrial policy update, the EU conducted in-depth reviews on six strategic areas (raw materials, active pharmaceutical ingredients, lithium batteries, hydrogen, semiconductors, and cloud and edge computing) representing 6 per cent of the EU's imports to identify potentially problematic dependencies in its supply chains, but also areas where others have strategic dependencies on the EU (European Commission 2021a). Only 0.6 per cent of the EU imports by value were found to cause strategic concern, undermining the voices calling for more drastic state interventions and self-sufficiency. However, shortages in some of the sectors, such as semiconductors, can have detrimental ripple effects through industries, as the microchip shortage and production slowdown in 2021 exemplified. As a consequence, European Commission President Ursula von der

Leyen proposed a *European Chips Act* in summer 2021 to increase the EU's technological sovereignty (von der Leyen 2021). The idea is in line with previous policy measures to address these strategic dependencies, which emphasized diversification of supply chains in cooperation with like-minded partners, but also stockpiling and pooling member states' resources for Important Projects of Common European Interest (IPCEI) in next-generation cloud, hydrogen, low-carbon industry, pharmaceuticals and a second IPCEI on cutting-edge semi-conductors.

The potential security risks related to foreign investment had already been recognized earlier. With a strong push from Germany, France and Italy, the Commission proposed an EU-level framework to monitor foreign direct investment in 2017. The proposal was preceded by a sharp increase in Chinese investment in the European tech sector. Unlike the US, the EU's mechanism, which became fully operational in October 2020 (European Commission 2020c), doesn't directly imply limiting Chinese investment, but is rather the EU's internal tool for information-sharing and creates certain minimum requirements for member states' investment screening. It also applies to all foreign investment that could undermine the continent's security regardless of its origin. Nonetheless, it gave other countries a clear signal that the EU is mitigating its geoeconomic risks.

In the past few years, there have been several other initiatives designed to protect EU interests by limiting access to EU markets, duly reinforcing the message that the EU is more willing to use unilateral action in defending them (Gehrke 2021). The EU sharpened its trade defence instruments in 2018 to better protect the EU industry from dumped and subsidized imports. The same year, the EU's updated blocking statute came into force as an effort to protect its companies from the extraterritorial effect of US sanctions. The latest initiative came in May 2021 when the Commission proposed a new instrument to address distortive foreign subsidies in the EU's internal market, bringing competition tools into the trade policy arena (European Commission 2021b). When adopted, the regulation gives the European Commission tools to investigate third states' contributions of public resources to companies in order to prevent them acquiring an unfair advantage in competition with European companies already subject to more stringent public subsidy rules. Perhaps the most revealing case of the EU's shifting balance between free trade and state intervention was the agreement reached by the Council in June 2020 after nine years of debate on a new procurement instrument (Council of the European Union 2021). Once in force, the new International Procurement Instrument (IPI) is designed to give the EU a stronger hand in negotiating to open third countries' government procurement to European business. If reciprocity in market access is not reached by increasing openness in the third country, it will be reached by the EU limiting the access of the country in question to the EU's public procurement markets.

In addition to defending its economic interests more forcefully, the EU is trying to build up its defence against economic coercion. In February 2021, the EU's beefed up enforcement regulation came into force, enhancing its ability to impose countermeasures against third countries when they violate international trade rules (European Parliament 2021). The scope of the EU's countermeasures was extended for the first time to include services and certain trade-related aspects of intellectual property rights (IPRs), giving the EU more leverage to pressure the US as well by potentially targeting its big tech companies. However, the enforcement regulation gives the EU powers to act only when it obtains a favourable ruling in the WTO or in its bilateral agreements' dispute settlement and, thereby, doesn't adequately address the rapid use of economic coercion. The Commission proposed a new anti-coercion instrument in December 2021 that would make it possible for the EU to apply trade, investment or other restrictions towards any third country that is interfering in the policy choices of the EU. The Commission assures that such action would be in accordance with international law despite acting outside the WTO.

These developments illustrate the fact that there is growing awareness in the EU of the geoeconomic risks stemming from the securitization, balkanization and weaponization of the economy, and their potential harm to the EU's sovereignty. To deal with these risks, the EU is showing a new willingness to leverage the internal market policies. How this should be done specifically and where to strike the right balance between state intervention and a more liberal market-oriented model is under debate between the member states, as our interviews for this study with member state and EU officials duly confirmed. At the same time, the EU is also balancing between two potentially contradictory strategies: defending the multilateral rules-based system and resorting to unilateral action more often. As the quest for this new balance continues, the EU's approach to economic defence remains undefined.

3.3 The EU's strategic use of economic policies

The EU's options in confronting the new context of geoeconomic power politics are not limited to defensive measures alone. Instead, the European Commission and member states are contemplating how they can use the size of the single market and the economic power of European economies more strategically in their relations with external actors to promote the Union's values and interests.

Connecting other countries to its sphere of influence is where the EU's strength lies. The European Union has an extensive network of bilateral trade agreements, it is widely considered to be a regulatory superpower with an ability to influence third countries' regulation, and it is the world's largest donor of development aid. Despite this strong

basis, the EU has seldom explicitly tried to leverage its economic power for strategic ends and position itself as a geoeconomic actor.

Although the EU's regulatory power extends outside its borders, it is mainly achieved through market mechanisms whereby global companies, not the EU, export the EU's rules around the world as it is cheaper for them to apply the same rules globally. As this "Brussels effect" (Bradford 2020) is based, among other things, on the large size of the internal market, the EU is concerned that as its share in the global economy is shrinking, its regulatory power will diminish along with technological development, which is happening in many areas mainly outside its borders. In February 2021, the EU published a new trade policy strategy (European Commission 2021c), which identifies the need for the EU to strengthen its regulatory influence by developing a more strategic approach to its regulatory cooperation. This need is further amplified by the EU's interest in incentivizing nearshoring to diversify its supply chains, which would need to be supported by regulatory alignment. However, it remains unclear what the practical implications of this new-found interest in regulatory cooperation will be, and whether the EU is willing to develop new models of cooperation for other countries to extend the benefits of its internal market and bind them to the EU's regulatory sphere.

The EU's bilateral trade and investment deals have considerable strategic potential. Through these deals, the EU has mainly been promoting economic objectives, but at the same time the EU's network of free trade agreements (FTAs) has the effect of binding other states more closely to the Union and its rules and norms. Yet while the EU recognizes this strategic element of FTAs, the steering effect often remains partial. In December 2020, the EU reached an agreement in principle with China on a new investment deal, the *Comprehensive Agreement on Investment* (CAI) (European Commission 2021d). Yet only after the negotiations were concluded did a heated debate ensue inside the EU on the geostrategic impact of the agreement. Partly as a consequence, its ratification remains in doubt.

The EU has always been more strategic in its approach to those countries geographically closest to it. Through its enlargement and the *European Neighbourhood Policy* (ENP), the EU has made it economically attractive for neighbouring countries to bind themselves to the Union and its rules and norms. In the current situation, there have also been calls for the EU to use such geoeconomic binding more broadly at the global level. The most evident case would be with the African Union, with which the EU aspires to build a comprehensive partnership with a long-term prospect of a continent-to-continent trade agreement (Berger et al. 2020).

Considering the EU's market and regulatory power, and its reluctance to use coercive means, geoeconomic binding would appear to be a smart strategy for the EU to pursue in

geoeconomic competition. In order for the EU to be able to use it effectively, it will need to recognize its inherently competitive nature.[13] Through its *Belt and Road Initiative* (BRI), China is also attempting to use geoeconomic binding towards countries in the European neighbourhood, making them more dependent and in that way gaining strategic leverage over them (Tskhay 2021). So far, the EU has seemed unwilling to clearly state what its approach is to such Chinese geoeconomic action. Through the BRI, China's role in the developing countries is also expanding as it has been offering to address the major funding gap related to infrastructure, which has been hindering the economic growth in the developing countries. At the same time, fears are increasing that the BRI will become a debt trap for recipient countries and a way for China to expand its territorial control.

Even though China adopted its Belt and Road strategy as early as 2013, the EU is still struggling to form a clear response, raising questions about the Union's ability to advance its geostrategic interests – or even identify its geostrategic goals. In her 2021 State of the Union address, Commission President Ursula von der Leyen announced the EU's own connectivity strategy, called the *Global Gateway* (European Commission 2021e). The work on a European response to the BRI has been ongoing for years. In 2018, the EU adopted a joint communication on *Connecting Europe and Asia – Building blocks for an EU strategy* (European Commission 2018). It was seen as the EU's response to the BRI, although in her introductory remarks High Representative Federica Mogherini denied this. The strategy recognized the significant investment gap in connectivity in developing countries and offered an approach to investments that was based on transparency, sustainability and international standards – the same aspects that were criticized for being missing from China's BRI.

For the EU, the question persists as to whether or not it wants to become more of a geoeconomic actor, and thus also start leveraging its economic power for politico-strategic purposes more widely beyond its immediate neighbourhood. Currently, the EU's connectivity strategy showcases how taking a more strategic approach to its "binding agenda" role is causing an internal conflict between the institutions. Interviews for this study revealed competing voices within the EU. The member states are pushing for a more geopolitical use of the EU's partnership instruments so as to create a "Western" alternative to the Chinese *Belt and Road Initiative*, possibly closely coordinated with the US. The Commission, on the other hand, is pursuing a more traditional, technocratic approach to its partnership programmes and is resisting the Council's push to add a stronger political element.

13 On geoeconomic binding, see Wigell and Soliz Landivar 2018.

The strategic use of the EU's economic power discussed here thus far has mainly focused on the soft power attributes of the EU's trade policy and the attractions of the Single Market for others. However, economic policy can also be used as a more coercive lever to advance interest and values internationally. The EU's characterization as a "market power" (Damro 2012) – the ability to use the size of its Single Market and its centralized regulatory power to shape global politics – is nothing new. However, the external effect of the EU's Single Market has largely remained limited to economic issues, such as the external adoption of EU production standards or market access for EU businesses abroad. The EU's attempts to promote non-trade policy objectives, such as human rights standards, through its free trade agreements or general scheme of preferences (a set of rules that set EU market access for developing countries) have been limited as well.

There are signs that the EU's ambition regarding the use of its economic power is changing. In her 2020 State of the Union address, Commission President Ursula von der Leyen made it clear that trade is "not an end in itself" but should also serve "to promote our values and standards" (von der Leyen 2020). The statement indicated a substantial change in the EU's trade policy orientation, which was previously focused on championing international trade liberalization. Next to increasing prosperity and eliminating trade barriers, the need to promote the EU's security interests and political values moved up the priority list of EU trade and economic policies.

The most tangible example of this development remains the EU's sanctions policy. In the 2010s, the EU's restrictive measures took a qualitative leap (Helwig et al. 2019). In particular, the 2014 sanctions on Russia in connection with the Ukraine crisis showed that the EU is willing to introduce sanctions with a measurable economic impact and a potential for collateral economic damage. EU sanctions regimes used to be limited in scope, addressing mostly democratic backsliding and armed conflicts in third states. Today, the EU's sanctions regimes are used in promoting a variety of goals, including nuclear non-proliferation or cyber deterrence.

The promotion of human rights globally has recently been a focal point of the EU's sanctions policy. The EU introduced a new horizontal sanctions regime, which allows violators of human rights to be listed regardless of their domicile, and their financial assets to be frozen, for example. Unlike state-based sanctions, the new procedure appears to be more flexible and speedier. The first use of the new sanctions regime suggests that it indeed helps to diversify the EU's toolkit. In early 2021, the EU adopted sanctions against four individuals involved in the arrest of Alexei Navalny. This was done while largely avoiding fundamental discussions on the EU-Russia relationship.

At the same time, the EU is considering a more comprehensive push for human rights and environmental standards abroad through tighter control of international supply chains.

National legislation already exists in some member states, and for some sectors companies are required to practise due diligence regarding labour and environmental standards towards their foreign suppliers and subsidiaries. The European Commission is currently preparing EU-wide legislation, with the first proposals expected in early 2022, as well as a proposal for a complete ban on goods produced with forced labour. An EU-wide due diligence law would be a step towards ensuring that standards with regard to forced or child labour, climate protection, land grabbing or corruption would be upheld elsewhere. Similar regulation has only been introduced at the EU level regarding timber and mineral imports so far. The move would turn a system of voluntary due diligence by companies, which has been criticized for being inefficient, into a binding framework. Support also comes from the private sector, with business favouring a uniform EU approach over a hodgepodge of national legislations.

Another way of addressing human rights abuses abroad with the help of trade policy entails EU export controls on dual-use goods that could be used, for example, in the oppression of opposition movements. Five years after the first announcement, the EU updated its export control box in summer 2021 to better respond to evolving security risks and emerging technologies. Next to addressing new technological developments related to cyber surveillance, for example, the new regulation also aims to make licensing in Europe more efficient and coherent and to increase global cooperation on export controls.

The EU-US Trade and Technology Council can also be interpreted as a means of finding a common approach with the US on regulatory standards connected to the digital transformation. The motivation behind the setup of the transatlantic coordination mechanism is not restricted to economic liberalization. Instead, the idea is to seek closer economic cooperation "based on shared democratic values" (European Commission 2021f) in what is perceived as growing competition with China.

The *European Green Deal* and the EU's ambition to become a green leader triggered a discussion on the extent to which the EU should use coercive economic instruments to push for green goals. The risk of carbon leakage and the reallocation of carbon-intensive production outside the Single Market led the Commission to propose the introduction of a Carbon Border Adjustment Mechanism (CBAM) in July 2021 (European Commission 2021g). Under the proposed scheme, importers of carbon-intensive goods will have to acquire CBAM certificates, which are priced in line with the EU Emissions Trading Scheme. The system is supposed to become fully operational in 2026, after which time the free allowances for emissions will be gradually phased out until 2035. Initially, it will apply to a limited number of sectors, namely cement, iron and steel, aluminium, fertilizer, and electricity. Imports from these sectors only cover 3.2 per cent of goods imported into Europe, making the impact on overall trade negligible. Yet they amount to 47 per cent of the free emission allowances given to European producers (Assous et

al. 2021). Rather than coerce third states into green policies through a carbon tariff, the hope is that the announcement itself will incentivize closer cooperation with the EU on climate-friendly policies.

Using the EU's Single Market to push politics and values abroad does not come naturally to the EU. This is a result of its deep commitment to international trade liberalization and heavy dependence on international markets. The new agenda also sometimes sits uncomfortably with the EU's obligation to sustain the rules-based international order and multilateralism. Accordingly, the EU is assiduously trying to keep sanctions or trade tools in line with UN and WTO rules. Hence, due to the sensitivities related to trade liberalization and multilateral cooperation, the EU's economic weaponry is more likely to continue to resemble, metaphorically speaking, the scalpel rather than the sword.

3.4 The Finnish approach: a focus on security of supply and resilience

Given Finland's economic and political characteristics, it has developed a distinct approach to the management of interdependencies. While it shares some of the features of the EU-level policy mix, Finnish solutions focus more on managing the risks of an internationally connected economy rather than state interventions in industrial sectors or trade relations. Nevertheless, Finland attempts to implement its security of supply approach together with partners in the EU, NATO and Nordic countries.

Finland's position on economic and supply security stems from a combination of a high degree of dependence on global trade and supply chains and a deep-rooted sense of vulnerability to disruptions in its exogenous connectivity to such critical flows. The result has been a rather rare mix of liberal economic policy that emphasizes the importance of open and rules-based global markets on the one hand, and a strong tradition of security of supply and economic resilience within the framework of a "comprehensive security" model on the other. In order to mitigate the risk of losses in connectivity that could damage the economy and endanger the economic and basic wellbeing of its population, Finland seeks to secure the supply of critical materials and essential goods to ensure economic security under all circumstances.

Whilst the Finnish approach to security of supply has traditionally been focused on material preparedness, the emphasis has gradually shifted towards "continuity management", aiming at securing the continuity of critical supply chains. As the Finnish economy has become increasingly digitalized, the importance of data and technology as critical factors of production has become a new norm. Consequently, immaterial aspects

of security of supply have become increasingly central, leading to measures aimed at securing critical know-how and guarding against disinformation. The Parliamentary Committee on Commerce, for instance, stated in September 2021 that for "a small and highly networked country" like Finland, it is increasingly critical that it has the capability to conceptualize international trade and finance flows and understand their dynamics. The committee also emphasized the importance of continuous connectivity to global value chains for the Finnish national economy, acknowledged the risks associated with asymmetric interdependencies and called for a holistic whole-of-society approach to their mitigation. The committee specifically points out that the critical finance sector infrastructures are principally extraterritorial in nature, and hence the Finnish regulatory measures must be in line with the European regulatory framework (Parliament of Finland 2021).

International cooperation has been a core element of the Finnish security of supply approach. Consequently, Finland has actively promoted a European regime in security of supply and collaborates broadly multi- and bilaterally with, for instance, the EU, NATO, the OECD, and other Nordic states. Finland also has bilateral security of supply agreements with Sweden and Norway (National Emergency Supply Agency 2022a; 2022b). While other European countries have not been enthusiastic about security of supply or economic resilience regimes in the past, at least partially due to hesitance towards securitization of economic activities, the Covid-19 pandemic served as a wakeup call for the risks associated with external dependencies in critical goods, materials and services. Consequently, a number of new security of supply-related initiatives are emerging.

One significant new initiative, albeit not directly Covid-19 related, is the European Commission's 2020 proposal for a new directive for "critical entities resilience" (*CER Directive*), which aims at ensuring that entities that provide critical services are able to prevent, resist, absorb and recover from disruptive incidents, regardless of the source of the disruption (all-hazards approach). The proposal covers ten sectors, namely energy, transport, banking, financial market infrastructures, health, drinking water, waste water, digital infrastructure, public administration and space (European Commission 2020b). Whereas the proposed directive focuses on improving resilience principally and primarily in the internal market area, it does connect with the pursuit of the EU's strategic autonomy, as the ability to ensure the delivery of critical services to Europeans also depends on the continuity of the external supply chain of the "critical entities" highlighted in the directive. As such, it could be argued that at least to a certain degree the *CER Directive* and the concept of strategic autonomy both support and depend on each other.

The *CER Directive* would provide Finnish security of supply with the European framework that it has longed for and within which it could further modernize its own approach. The directive would also improve Finland's preparedness against geoeconomic risks

by lowering its vulnerability towards weaponization of the economy and providing an updated approach to its "networked security" approach to mitigate the impacts of potential disruptions in cooperation with the private sector. Another relevant development is the OECD's set of initiatives to establish resilient supply chains that ensure the supply of essential goods, while maintaining the open trading systems and shunning protectionism and mercantilism. To this end, the OECD has recommended a number of tools ranging from domestic to international cooperation (see OECD n.d.).

The Covid-19 pandemic is also opening new horizons for Nordic cooperation in security of supply and resilience. For example, the Nordic Council of Ministers and the Nordic Council, mandated by the Prime Ministers, have started initiatives aimed at discovering and implementing new forms of cooperation in the region in order to improve crisis preparedness and resilience. Significantly, the Finnish presidency of the Nordic Council has stated a goal to enhance security of supply cooperation in the Nordics. Intensified Nordic cooperation could offer Finland an instrument for hedging against the balkanization of the global supply chains.

It is worth noting that NATO has also increasingly focused on resilience since its 2016 Warsaw Summit, where it announced its "Commitment to enhance resilience" across the Alliance and its partners against a full spectrum of threats, whether military or non-military, or a combination thereof (i.e. "hybrid") in nature. The stated objective was to improve the necessary individual and collective capabilities to resist an armed attack, but also to improve its civil preparedness in order to ensure that NATO's collective defence could not be paralyzed through an indirect attack against civilian infrastructures. Consequently, NATO launched the so-called "seven baseline requirements for resilience" in order to expedite and enhance the development of civil preparedness in its member states with the aim of guaranteeing the ability to maintain critical civilian functions and infrastructures under all circumstances, as well as to utilize civilian resources to enable military operations required for maintaining collective defence (NATO 2020). NATO's *Seven Baseline Requirements for Resilience* duly set the desired resilience standards for the member states and partners in seven critical areas of civil preparedness: 1) assured continuity of government and critical government services; 2) resilient energy supplies; 3) ability to deal effectively with uncontrolled movement of people; 4) resilient food and water resources; 5) ability to deal with mass casualties; 6) resilient civil communications systems; and 7) resilient civil transportation systems (NATO 2021a).

NATO has also recently tightened its focus on the security and defence aspects of emerging and disruptive technologies (EDT), including 5G security, for example, and the surging strategic competition presented by China. While NATO principally focuses on resilience within its specific mission, 21 NATO countries are also EU members. Consequently, NATO-EU cooperation has been deemed critical in both organizations

with a new level of ambition pledged in the 2021 NATO Brussels Summit. NATO Deputy Secretary General Mircea Geoană announced at a European Parliament event that NATO was committed to increasing transparency, trust and mutual situational awareness with the EU in areas such as resilience, new technologies, climate change and strategic competition (NATO 2021b). Although Finland is not a NATO member, the increasing cooperation related to the developing concept of resilience in both organizations will have an impact on the way in which Finland is likely to develop its approach to resilience and strategic risks posed by issues such as the increasing competition in critical technologies and strategic competition from China. NATO's stricter position towards China could lead to the balkanization of technological value and supply chains.

All of these initiatives provide Finland with the option to utilize the support of multilateral norms-based frameworks to enhance national preparedness and security of supply, as well as to influence them in order to improve its strategic operating environment and secure connectivity to the critical flows that the country depends on. The strategic challenge stems from the combination of Finland's critical external economic interests and dependencies and an inherently challenging geostrategic position, which do not always dovetail comfortably. Traditionally, this friction has manifested in Finland's relationship with Russia, in which it has sought to balance between the opportunities offered by economic relations and gains in regional stability on the one hand, and efforts to carefully monitor and guard the extent of its dependencies on the other, pursuing the latter for instance by managing its energy dependency on Russia.

Frictions emerge, in particular, when such interests do not converge naturally or in the long term. In such cases, for instance in relation to the Nord Stream 2 pipeline and Fennovoima nuclear plant project, the latter of which has been executed in cooperation with Rosatom, Finland has demonstrated innovative flexibility in its policy framework. Consequently, instead of addressing strategic and economic interests and avoiding linking such projects explicitly to security and defence policy contexts, Finland has chosen to address them by applying environmental and technical controls. In the pipeline case, Finland chose to apply an environmental impact assessment procedure as a non-political response to the Nord Stream 2 project. In the case related to the nuclear power plant, nuclear safety and risk management procedures were applied as controls to hedge against geoeconomic risks. This approach, however, neglects the long-term geostrategic risks potentially associated with such projects.

This friction between short-term economic and long-term strategic interests is now surfacing in Finland's relations with China as well. This is due in part to newly emerging national security concerns, structural changes in economic relations and the need to sufficiently synchronize its policies with those of the EU and Finland's Western partners (including the United States) to mitigate against the geostrategic risks of China's rise.

This potentially carries a similar logic that persists between security and strategic concerns and economic interests in the relationship between Finland and Russia, but in a considerably broader and somewhat more complex global context. In practice, the logic has already manifested itself in how Finland has chosen to address security risks related to 5G telecommunication technology, and particularly the perceived risks associated with the Chinese company Huawei. While aligning with the recommendations of the EU toolbox for 5G security, it has chosen a distinctly technocratic approach to implementing it. Unlike the United States, Canada, Australia and Sweden for instance, Finland chose not to impose bans against individual suppliers (such as Huawei and ZTE), but opted instead to stick to technical assessment of risks that exclude geoeconomic risks. On the positive side, such an approach is likely to continue being beneficial in ensuring continuous market access and avoiding the risk of politically motivated payback against Finnish companies operating in China. It has also worked in terms of not disincentivizing Chinese companies from continuing high-tech investments in Finland, as demonstrated by Huawei's announcement about establishing a new Digital Finance and Security Innovation Lab in Finland. On the other hand, such positive developments also invariably create new entanglements that are still unclear in terms of their long-term consequences. As such, the chosen approach to focus on technical instead of strategic risk may become costly if the entanglements are not identified and mitigated before they become too extensive and complex to resolve.

3.5 Beyond security of supply: Finland's stance towards the EU's economic autonomy

Beyond paying increasing attention to the European aspect of its national security of supply, there is also a need for Finland to actively shape the current EU agenda and toolbox on countering geoeconomic risks. In line with EU competences, these tools are more focused on trade and investment instruments, single market reforms, and industrial and competition policy. In the past, the EU's trade and economic policies had largely been guided by market principles and the ambition to extend the European experience of a borderless Single Market to the global level. In recent years, with the great-power rivalry intensifying, the EU sees itself as being forced to adopt the economic playbook of other big powers, soften its market principles, and follow more interventionist policies.

The need for Finland to stay vigilant about these developments relates to its market liberal outlook on the global economy. Nevertheless, increasing political competition between the US and China, and the possible economic fallout therefrom, increase the potential for putting the Finnish economy in a difficult position. The Finnish economy is closely connected to the Chinese market, with about 400 Finnish companies operating in the

People's Republic today. At the same time, Finland also enjoys close trade relations with the US. As a result, a decoupling of the two economic powers would seriously damage Finnish interests (Iso-Markku & Helwig 2021). The analysis of trade statistics also reveals how embedded Finnish companies are in global value and production chains, which in turn highlights the potential negative effects of protectionist measures in the EU or elsewhere (see Chapter 4).

This leads to a rather critical position towards many of the measures under discussion in the EU that go beyond the traditional Finnish model of security of supply. Instead, an often-heard argument in Helsinki is that the introduction of new barriers to trade might lead to a protectionist spiral (Iso-Markku & Helwig 2021). The success of a diversification or reshoring of supply chains would require some sort of subsidies or trade barriers, which – in turn – could prompt other countries to protect their markets as well.

With regard to potential reforms of the European Single Market and competition policy, Finland is also rather critical. This is based on the Finnish industrial landscape with many small and medium-sized businesses. The concern is that the Finnish economy stands to lose from an emerging industrial and competition policy in the EU that would focus on "European champions" that can compete internationally. Yet there are growing concerns about Finnish companies falling victim to geoeconomic meddling, as highlighted in the previous chapter. A functioning – and possibly deeper – Single Market might actually benefit not only Finnish businesses but also the EU itself in global competition. In this vein, Finland is strongly in favour of completing the Digital Single Market, as underlined in a joint letter by the prime ministers of Finland, Estonia, Denmark and Germany (Finnish Government 2021).

The Finnish scepticism also extends to the more strategic elements under debate in the EU. Here the question is not so much whether the EU is pursuing the right goals, but whether it should (mis)use economic instruments. For example, Finland shares the objective of decarbonizing the global economy. However, the potentially harmful effects that a Carbon Border Adjustment Mechanism (CBAM) could have on global trade are highlighted time and again in the Finnish debate (Confederation of Finnish Industries 2021). A recent report funded by the government came to the conclusion that a broad application of such a mechanism could hurt Finnish businesses that rely on intermediate goods for their production (Kuusi et al. 2020). It might also provoke the main exporter of such products, China, to respond with its own trade barriers. On the other hand, Finland would warmly embrace an EU trade policy that pays more attention to the export opportunities of European companies with green and digital know-how by improving their market access and promoting relevant standards (Salmimies 2021, 11). Whether or not trade instruments are the right tool for addressing human and labour rights issues remains a matter of debate in Finland (Iso-Markku & Helwig 2021). Finnish businesses

stand to benefit from the *EU-China Comprehensive Agreement on Investment* as it preserves the progress achieved in the liberalization process in China in recent years, and increases the certainty in the operating environment of companies in China, according to our interviews.

Although Finland has not been among the EU's most dogmatic liberalists (Salmimies 2021), in the debate on "Open Strategic Autonomy" its emphasis is very clearly on *open* rather than *autonomy*. At the same time, Finland is struggling to align its market-liberal outlook with the shifting landscape of global trade and the increasingly state-interventionist political balance in Europe.

3.6 Conclusion

International business has always involved risks and opportunities stemming from political change. However, after a relatively long period of market liberalization and globalization, the opportunities to advance strategic interests and the perceived need to protect the national economy on national security grounds have paved the way for states to increasingly meddle in economic relations and transactions based on such grounds. In some cases, states have opted to merge economic and security interests, while others balance between defending the multilateral rules-based order and free markets and the increasingly complex threat picture. Finland as a small and external trade-oriented open economy invariably belongs to the latter group. As such, it tends to promote policies that strengthen the liberal market order. Finland, however, cannot ignore the increasing risk of its economy and/or Finnish companies trading overseas being targeted by or falling victim to geoeconomic meddling by others. In the era of geoeconomic risk, economic and security policies are becoming increasingly intertwined.

Consequently, Finland should always assess risks that have the potential to impact its strategic and national security interests. In the geoeconomic era, foreign and defence policy choices have an impact on economic relations and vice versa. As a result, national policies on emerging and disruptive technologies (EDT) are not only economic or science policy issues – foreign, security and defence policy aspects must also be considered. Decisions on how policies on such critical technologies are addressed inevitably create both constraints and opportunities for foreign and defence policy, and may carry significant national security importance. In policy formation, this would entail ensuring that foreign, security, defence and economic policies are planned and implemented in a coherent manner, rather than as entirely separate policy areas.

In this regard, Finland has made significant advances in recent years, for example by coordinating the traditionally separate foreign and defence policy parliamentary reviews,

as well as synchronizing the recently approved internal security review with them. This holistic approach has been useful in terms of creating shared situational awareness and strategic objectives for the two clearly interlinked areas, as well as ensuring that policy planning and implementation addresses joint concerns across ministerial silos. As the boundaries between internal and external security are becoming less and less distinct, the need to add national and economic security issues to the mix becomes more pressing.

In this sense, Finland could follow, and further develop, the EU's emerging approach to integrate policy approaches into the strategic environment by addressing both external and internal aspects in the same broader framework. In other words, the EU seems to address the critical external dependencies and strategic challenges by integrating the interests of strategic autonomy into its external policies, while seeking to protect the functioning of the internal market by resilience policy. While it is difficult to confirm that this notion is applied systematically across time and policy areas, it is becoming relatively clear that foreign and defence policies can contribute to internal security and resilience by providing a firewall against internal security and leverages for internal resilience-building efforts. Internal resilience-building, on the other hand, enables autonomy in external policymaking by providing stability and continuity internally. It can also strengthen the impact of external security by providing adaptable capabilities that can also be utilized against external threats. A society that is fragile cannot sustain credible and autonomous foreign and defence policies; nor can it be sufficiently robust if its external security is brittle.

The resilience of the economy is also critical because it provides the resources and many of the competencies required for enacting internal and external security. Consequently, the challenge for small and open societies such as Finland is how to continue operating an open economy and society in an era of increasing turbulence, volatility and uncertainty, and to seize the opportunities offered by the global economy, while avoiding or effectively mitigating the risks posed by the increasing strategic competition. This requires a holistic and whole-of-society approach to security.

The domestic measures to improve the continuity of connectivity and security of supply should include maintaining the traditional cooperative modus operandi and culture of economic resilience, as well as modernizing and improving it by utilizing the public-private cooperative networks for monitoring and sharing information about vulnerabilities, risks and best practices in mitigation strategies relating to critical external dependencies and the geoeconomic risks associated with them.

This should leverage the existing voluntary cooperation between the authorities, businesses and the civil sector, but also seek new transparent means to increase information-sharing between businesses in Finland and in Europe more broadly. The

success of such initiatives would largely depend on the public authorities' willingness and capabilities to increase the amount, quality and accessibility of information for all business sizes. In addition to the domestic network in the context of the National Emergency Supply Organization (NESO) and its pools of experts, Finland could seek to create a similar international network in collaboration with the appropriate business associations in order to enable information-sharing about geoeconomic risks between Finnish businesses operating overseas, as well as with European and other businesses, for instance by utilizing the network of European Chambers of Commerce.

As the EU's internal market is the lifeblood of the Finnish national economy and the European Research Area (ERA) is the critical enabler and multiplier of Finnish science and innovation, it would seem prudent to try to leverage the EU for hedging against various geostrategic risks associated with critical external dependencies, while continuing to work with other partners when interests and values converge. Continuing and deepening cooperation with the United States, one of Finland's foremost economic and security partners, is vital in the current and foreseeable geostrategic environment. This cooperation is, however, invariably influenced by the way in which relations between China and the United States, as well as – perhaps even more critically for Finland – relations between the EU and the United States develop going forward. Hence, Finland's "network security" approach – collaborating in a network of bi- and multilateral partnerships can also be considered an effective hedging strategy. The "network" approach to security, while risking occasional incoherence, can be a source of adaptivity that enables matching threats with the instruments that are most relevant.

PART II

4 Mapping Finnish economic dependencies on China, the European Union and the United States

4.1 Background[14]

Mutual trading relations have helped create a more efficient global production structure, duly leading to lower prices, better products, and an increase in consumer purchasing power. Globalization has lifted hundreds of millions of people out of poverty worldwide. On the other hand, globalization has increased potential risks arising from dependence on international value chains that also rely on production in emerging economies, whose increasing power ambitions may conflict with those of traditional industrialized countries. This has raised security concerns in the latter, especially when it comes to China and its ascendancy in the international system.

The increasing debate on strategic decoupling is a notable expression of these concerns, and technology features prominently in the discussions. However, according to a recent IMF study (Cerdeiro et al. 2021), technological decoupling between the United States and China would be quite costly. The study analyzes six different scenarios using a global dynamic macroeconomic model. According to the results, the negative impact would be bigger for China than for the USA or the euro area. Depending on the scenario, annual GDP would have declined by 2 to 9% in China, by 0.5 to 4% in the USA, and by 0 to 6% in the euro area by the tenth year after the decoupling.

Against a background of global value chains, increasing strategic competition and debates on strategic (technological) decoupling, this chapter will focus on analyzing the economic

14 The analysis in this chapter uses data from the following sources: UNCTAD https://unctad.org/statistics; OECD https://stats.oecd.org/; Statistics Finland https://www.stat.fi/til/index_en.html; BEA https://www.bea.gov/.

dependencies of Finland. In particular, it will review and analyze the flows and structure of the trading of goods and services between Finland (and the EU), the United States, and China, as well as their respective importance in global trading and bilateral relations. The chapter will further review some data on how important these foreign markets are for the multinational enterprises of these countries. This assessment helps in the analysis of the present state and historical development of inter-continental economic relations and interdependencies, with a focus on (their importance to) Finland in particular.

4.2 China, the European Union, and the United States in world trade

4.2.1 Trade in goods

The United States, China, and the European Union are the largest economies in the world when measured by gross domestic product. They are also the three largest trading countries and regions in the world. Figure 3 shows the value and share of the EU27, the USA, and China (not including Hong Kong or Macao) in world goods exports, excluding intra-EU trade.[15]

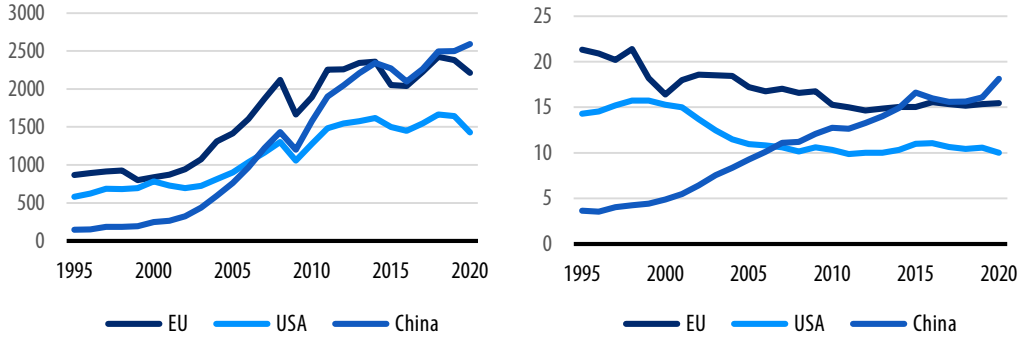
The EU's share in the value of world goods exports (excluding intra-EU exports) declined from around 21% in the mid-1990s to 15% in 2010, and has remained relatively stable since then. The US share was about 15% up to 2001, but subsequently declined to 11% by 2005, and has since stabilized in the 10–11% range. China's share increased steadily up to 2015, when it peaked at 16.6%, then declined by a percentage point before jumping to 18% in 2020. This, however, was the first year of the Covid-19 pandemic and may very well be an anomaly. This is the case for all data presented in this chapter. Consequently, we also show data for 2019, which may be a more normal year also post-Covid-19.

Some 59% of EU countries' exports are intra-EU trade. If we include these exports, we find that the EU's share in world exports is 31%, that of the USA is 8%, and China's is 15%.

Growth in nominal world exports has slowed down markedly. This can also be seen in the graph on the left-hand side of Figure 3 showing the three economies. The value of EU and US goods exports seems to have levelled off, and China's export growth has slowed.

15 Here and throughout the analysis in this section, the EU corresponds to the EU27 countries of 2020, i.e. excluding the United Kingdom. In this way, changes in the composition of EU membership do not affect the results.

Figure 3. Value of total goods exports (left), billion USD nominal, and share in the value of world goods exports (right), %, both excluding intra-EU exports



Note: Excluding intra-EU exports.

Sources: UNCTAD, own calculations.

Following the technology classification by Sanjaya Lall (2000), and using data reported by UNCTAD, Table 2 below shows the revealed comparative advantage, namely the relative specialization, of the EU, Finland, the US, and China global goods exports in 2019. Intra-EU exports are excluded, apart from Finland. As pointed out above, the analysis will focus on 2019 because the first year of the Covid-19 pandemic in 2020 may be an anomaly due to the way it disrupted global trade and value chains. In the analysis in Table 2, a number that exceeds unity (i.e. is greater than one) shows that the country/region has a revealed comparative advantage in the said technology classification in world goods exports. A value below one signifies a comparative disadvantage.

Keeping this in mind, the EU has a comparative advantage in world goods trade in agro-based manufactures as well as medium- and high-tech goods, apart from electronics. The USA likewise has a comparative advantage in medium- and high-tech goods, apart from electronics, in addition to resource-based manufactures (other than agro-based). China's comparative advantage is in low-tech manufactures, medium-tech engineering, and high-tech electronics. Finland's comparative advantage is in agro-based manufactures (forest industries), other resource-based manufactures and medium-tech engineering.

We can see that the structure of comparative advantage in low-/medium-/high-tech manufactures in the EU and the USA on the one hand, and China on the other, complement each other. The only exception is medium-tech engineering, where they all have a comparative advantage.

Despite China's comparative advantage in high-tech electronics exports, it is also – relatively speaking – specialized in importing these products in addition to primary

products and non-agro resource-based manufactures. The EU is specialized in importing primary products, textiles, and other high-tech manufactures.

Table 2. Revealed comparative advantage by technology classes in world goods exports in 2019

Technology class	EU	Finland	USA	China
Primary products	0.37	0.35	0.91	0.19
Resource-based manufactures: agro-based	1.44	3.77	0.88	0.60
Resource-based manufactures: other	0.89	1.18	1.11	0.53
Low technology manufactures: textile, garment and footwear	0.78	0.19	0.26	2.43
Low technology manufactures: other products	0.98	0.98	0.76	2.04
Medium technology manufactures: automotive	1.55	0.98	1.15	0.41
Medium technology manufactures: process	1.10	0.98	1.26	0.85
Medium technology manufactures: engineering	1.48	1.50	1.08	1.24
High technology manufactures: electronic and electrical[1)]	0.49	0.47	0.73	1.91
High technology manufactures: other[2)]	2.44	0.56	1.09	0.45
Unclassified products[3)]	0.79	1.40	2.07	0.13

Note: Lall classification. A value that exceeds unity shows that the country/region has a revealed comparative advantage in the exports of the said technology. The data exclude intra-EU exports, except for Finland. The EU does not include the UK. 1) Office/data processing/telecommunications equipment, TVs, transistors, turbines, and power generating equipment. 2) Pharmaceuticals, aerospace, optical/measuring instruments, and cameras. 3) Electric current, cinematograph films, printed matter, works of art, collectors' pieces and antiques, non-legal tender coins (other than gold), and non-monetary gold (excluding gold ores and concentrates).

Sources: UNCTAD, own calculations.

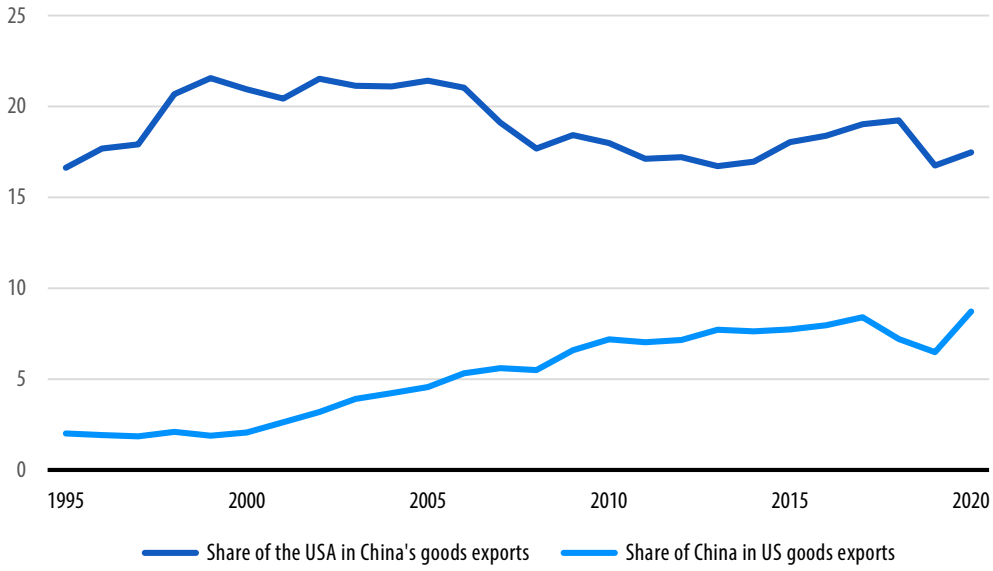
In terms of a destination market for Chinese and US goods exports, bilateral trade is clearly more important for China than for the United States (see Figure 4). In 2020, some 17% of China's goods exports went to the US, while exports to China only accounted for almost 9% of US exports. Historically speaking, the latter is an exceptionally high number and may at least be partly a Covid-19 anomaly. On the other hand, China's share in US exports has been increasing over time. The value of Chinese exports to the US was 3.6-fold that of US exports to China in 2020. The share of the United States in China's goods exports has been relatively stable over time.

In 2019, the US started to raise import tariffs on Chinese products, which was followed by Chinese retaliation, and which together resulted in a decline in bilateral trade flows. The volume of trade probably decreased even more because higher tariffs raised the prices of many traded goods. This shows the possible effects that a trade war or decoupling

induced by higher trade barriers could have on bilateral trade relations. In the end, the main result was probably higher consumer prices for Chinese goods in the US and higher steel prices for US producers.

In 2019, the most important Chinese export products to the US were telecommunications equipment and parts (10.8% of total Chinese exports to the US), automatic data processing machines (9.9%), furniture and parts (5.0%), and baby carriages, toys, games and sporting goods (4.5%). The most important US goods exports to China consisted of cathode valves and tubes (9.7% of total US exports to China), oil seeds and oleaginous fruits (excluding flour) (8.5%), motor vehicles for the transport of persons (7.6%), and other machinery for particular industries (5.0%).

Figure 4. The share of the USA/China in the value of Chinese/US goods exports, %



Sources: UNCTAD, own calculations.

Again, based on the classification by Lall (2000) and data reported by UNCTAD for the pre-pandemic year 2019, Table 3 below indicates that 32% of Chinese exports to the US are electronic high-tech and 21% low-tech products other than textiles and so forth. Low-tech products account for 36% of total exports to the US, with high-tech products not that far behind. Primary products and resource-based manufactures are relatively unimportant in China's exports, and in this respect the country is a major net importer. China's strong net exporter status in world goods trade is based on high-tech electronics, medium-tech engineering manufactures, and low-tech manufactures, as shown above in the analysis of comparative advantage.

US exports to China are more diversified, with primary products accounting for 17%, medium-tech engineering manufactures for 15%, and high-tech electronics for 14% of total exports. As a high-income country, low-tech products are not important in US exports to China. On the other hand, China's huge demand for primary products also boosts US commodity exports.

Table 3. US-Chinese bilateral goods exports by level of technology in 2019, %

Technology class of bilateral exports	From China to USA	From USA to China
Total all products	**100.0**	**100.0**
Primary products	1.4	16.8
Resource-based manufactures: agro-based	2.9	5.7
Resource-based manufactures: other	3.0	5.0
Low technology manufactures: textile, garment and footwear	14.9	1.4
Low technology manufactures: other products	20.6	3.5
Medium technology manufactures: automotive	3.3	8.5
Medium technology manufactures: process	3.3	9.8
Medium technology manufactures: engineering	15.6	15.1
High technology manufactures: electronic and electrical	32.4	14.4
High technology manufactures: other	2.2	8.5
Unclassified products	0.3	11.2

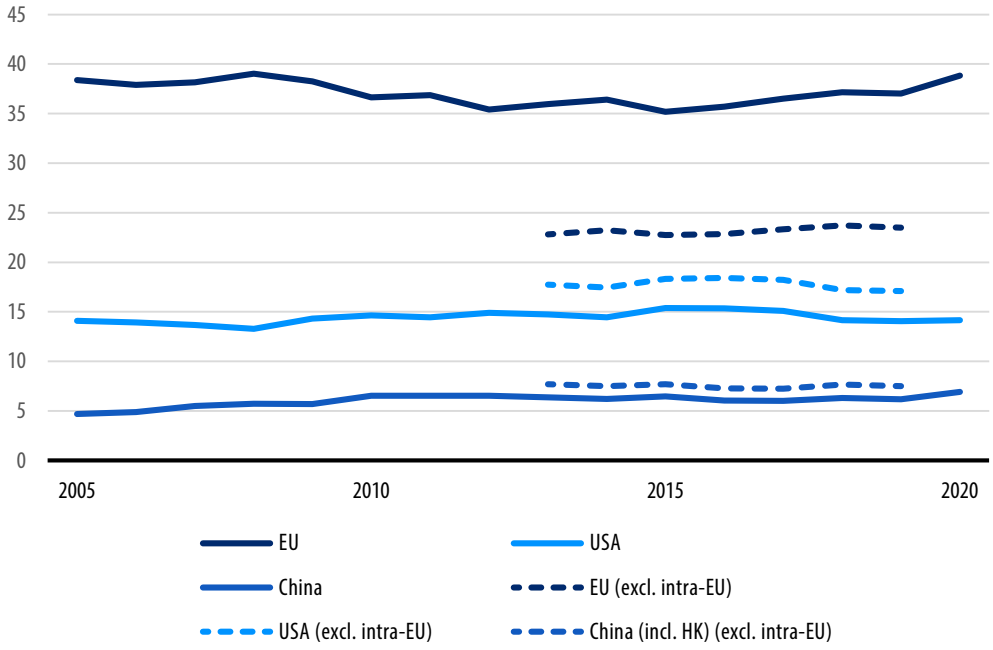
Note: Lall classification.

Sources: UNCTAD, own calculations.

4.2.2 Trade in services

Statistics in services trade are not as disaggregated as trade in goods, and in many cases at least some data are missing for many countries. Figure 5 below shows the share of the European Union, the United States, and China (including Hong Kong) in world services exports. Including intra-EU exports, the Figure shows that the share of the EU was around 35–40% in 2005–2020, and that it has been increasing since 2015. The share of the US has been steady at 13–14%, and that of China increased at first up to 2010 but has been steady at 6–7% since then. When we exclude intra-EU exports, which we can do for 2013–2019 but not otherwise because of missing data even for the EU countries, the EU remains the largest services exporter with a 23.5% share in 2019, followed by the US (17.1%) and China (7.5%).

Figure 5. Share in world services exports, %



Note: Some data are missing from the intra-EU exports that have been used to calculate world trade excluding intra-EU trade. The missing data do not constitute a significant loss of information for the years 2013–2019.

Sources: UNCTAD, own calculations.

Table 4 below shows the structure of EU, US and Chinese services trade in 2019. The data include intra-EU exports. However, a more disaggregated breakdown for services trade such as this already suffers from missing data, as too many intra-EU exports of services by sub-categories are missing from the UNCTAD database.

Notwithstanding these deficiencies, it is possible to conclude that the EU is strong in all services products. The USA has important services exports in maintenance and repair services, air transport, financial services, charges for the use of intellectual property, personal, cultural, and recreational services, and government goods and services. China has a pronounced role in the export of construction services.

Table 4. Share in global services exports (including intra-EU exports) by categories in 2019, %

Export product	EU	USA	China (incl. HK)
Services	**37.0**	**14.1**	**6.2**
Goods-related services	45.2	11.8	12.8
Manufacturing services on physical inputs owned by others	52.8	..	..
Maintenance and repair services n.i.e.*	36.3	25.6	9.7
Transport	39.5	8.7	7.4
Sea transport	34.4	4.4	10.8
Air transport	29.2	17.6	6.7
Other modes of transport (other than sea and air)	67.6	1.8	..
Postal and courier services	42.1	4.3	..
Travel	29.0	13.6	4.3
Other services	39.1	16.0	6.1
Construction	26.9	2.8	25.3
Insurance and pension services	33.8	13.2	4.4
Financial services	32.4	26.3	4.9
Charges for the use of intellectual property n.i.e.	39.6	27.2	1.7
Telecommunications, computer, and information services	48.8	8.0	8.3
Other business services	39.7	13.2	6.2
Personal, cultural, and recreational services	37.2	24.7	1.7
Government goods and services n.i.e.	21.3	28.6	2.1
Memo item: Commercial services	**37.2**	**13.9**	**6.2**

*Not included elsewhere.

Note: Including intra-EU trade. So many intra-EU exports of services by sub-categories are missing from the database that we have to depict these data with intra-EU trade.

Sources: UNCTAD, own calculations.

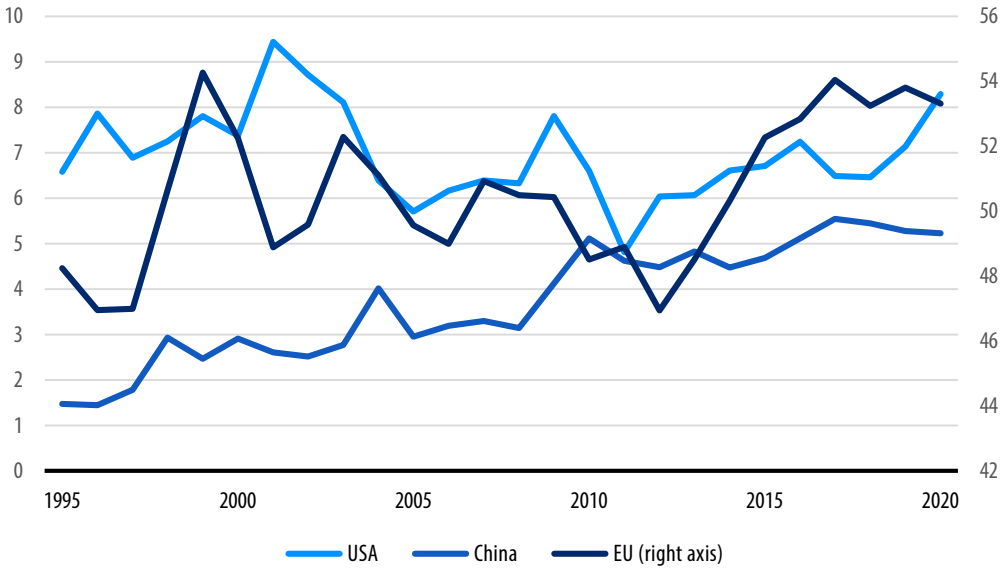
There is a decline over time in China's share of global exports of manufacturing services on physical inputs owned by others and travel services, and a rise in maintenance and repair services, sea transport services, construction services, insurance and pension services, charges for the use of intellectual property, other business services, and government goods and services. The US share has decreased in charges for the use of intellectual property and personal, cultural, and recreational services, and has increased in maintenance and repair services, financial services, and other business services.

4.3 Finland's trading relations with China, the United States, and the EU

Looking at Finnish trade statistics, it is clear that the rest of the EU is by far Finland's most important export market. Some 53% of Finnish goods exports went to other EU27 countries in 2020. The USA was the destination for 8.3% and China for 5.2% of Finnish exports (see Figure 6). The US share has been increasing in recent years. China's rise has been quite steady since it started to open up to the world economy decades ago. The US share increased considerably in 2020, boosted by exports of other transport equipment (ships and aircraft). China's share in Finnish goods exports decreased slightly in 2017–2020.

By comparison, the EU's share in the total goods exports of Sweden in 2020 was 51%, whereas China's share was 5%, and that of the United States 8%. These figures are very similar to the Finnish data. For Germany, we find that exports to the rest of the EU accounted for 52% of its goods exports, while China was at 8% and the United States 9%. China is thus slightly more important for Germany's exports than it is for Finland or Sweden in this respect. On the other hand, these figures are skewed because Germany forms such a large part of the EU and is an important export market for small EU countries.

Figure 6. Share in the value of Finnish goods exports, %



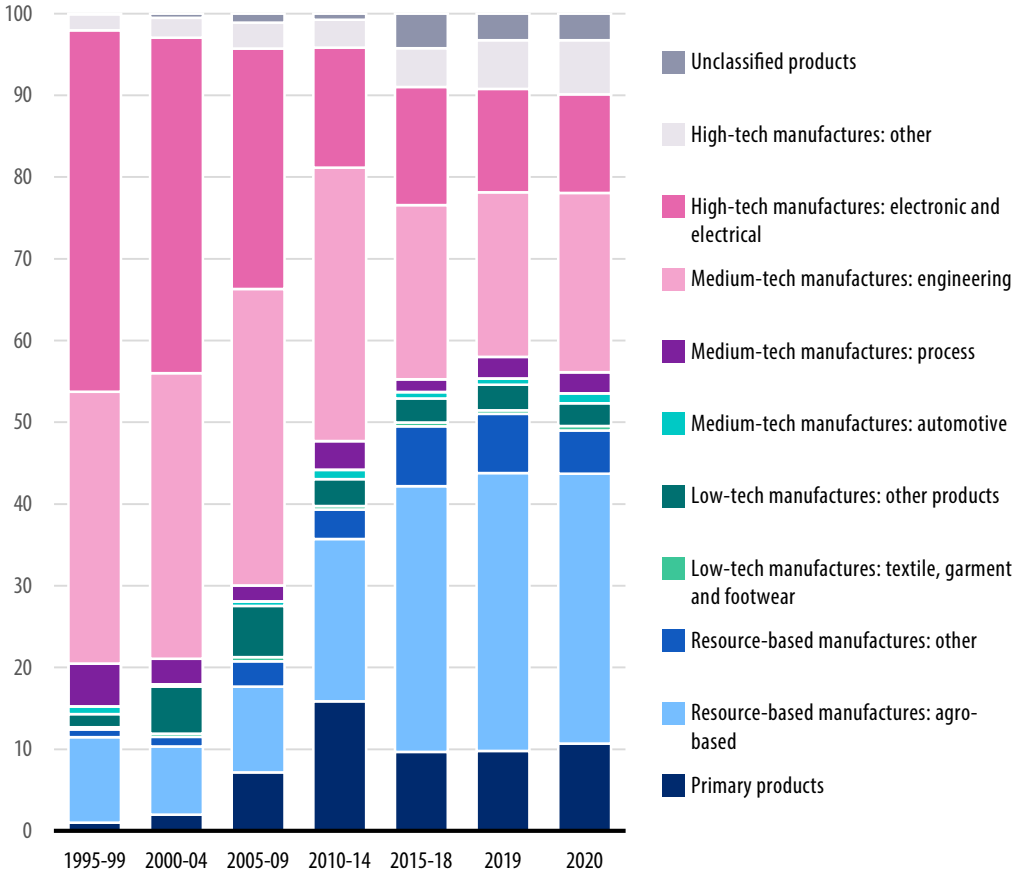
Sources: UNCTAD, own calculations.

Figure 7 below shows the structure of Finnish exports to China, again according to the Lall classification.[16] Whereas high-tech electronic manufactures dominated Finnish exports around the turn of the century, their importance has since diminished markedly and they have been replaced by agro-based manufactures. This basically represents a transfer of exports from high-tech electronics used in Nokia mobile phones to low-tech forest industry products, mainly pulp. The importance of medium-tech engineering manufactures has also decreased. In terms of the Lall classification, 2020 looks very similar to 2019.

The development of the structure of Chinese exports to Finland has been less linear (see Figure 8). While the share of high-tech electronics increased at first, their share has receded again during the past decade. Low-tech textiles were the most important product group in the 1990s. Their share subsequently declined considerably, but has started to rise again. The share of other low-tech manufactures and medium-tech engineering manufactures has been relatively stable. The share of textiles increased in 2020, while that of electronics decreased. Generally speaking, China is an important source of consumer goods other than food products, which is reflected in these figures.

16 We have used 5-year averages, but included 2019 and 2020 separately, 2019 as the pre-Covid-19 year and 2020 as a point of reference, which may be partly affected by the pandemic.

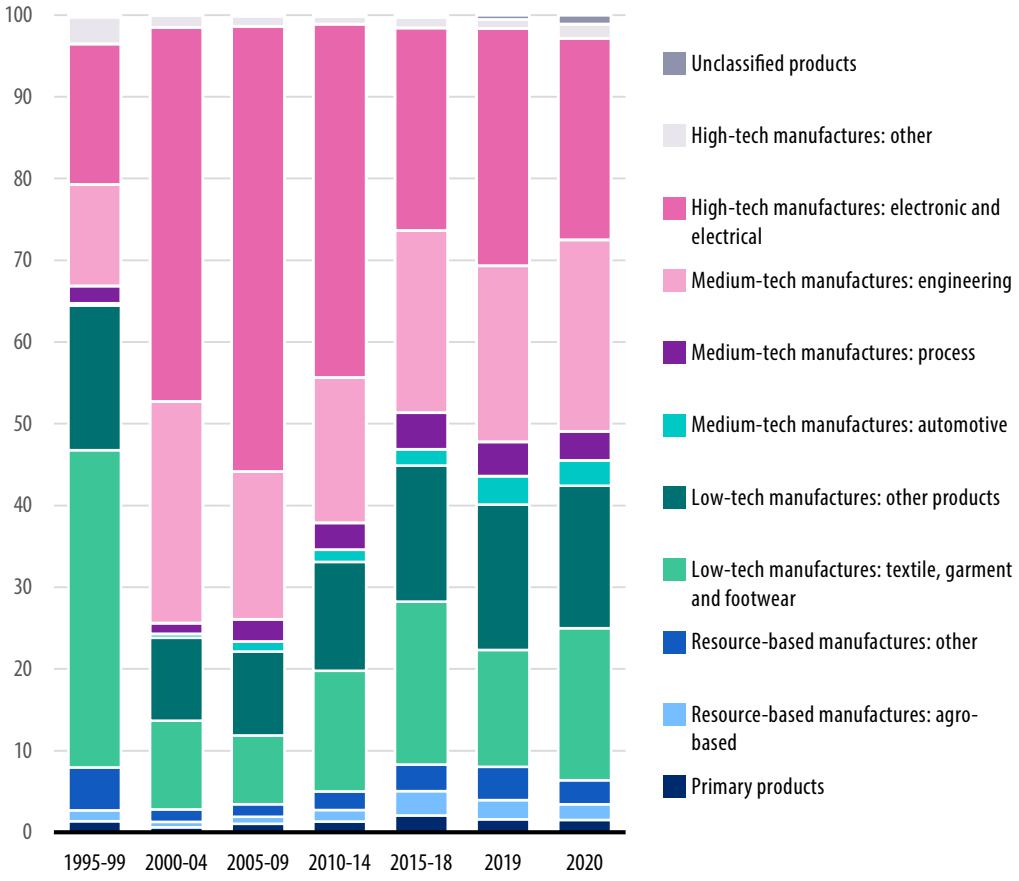
Figure 7. The structure of Finnish goods exports to China by level of technology, %



Note: Lall classification. Period averages have been calculated from annual percentage shares.

Sources: UNCTAD, own calculations.

Figure 8. The structure of Chinese goods exports to Finland by level of technology, %



Note: Lall classification. Period averages have been calculated from annual percentage shares.

Sources: UNCTAD, own calculations.

Looking more closely at export categories, Table 5 below indicates that pulp and wastepaper accounted for 26% of Finnish exports to China in 2019. Another 10% were other forest industry products. Overall, China is a very important market for Finnish exports of furskins (46% of the total exports of these products in 2019, using SITC Revision 3 data), nickel ores and concentrates (40%), pulp and wastepaper (36%), natural abrasives (33%), cathode valves and tubes (32%), musical instruments and so forth (29%), other meat and edible meat offal (26%), and polymers of vinyl chloride or halogenated olefins (26%).

Table 5. The top 10 Finnish goods export products to China in 2019

Product	Export value, MEUR	Share in exports to China, %
Pulp and wastepaper	868	26.2
Nickel ores and concentrates; nickel mattes	229	6.9
Wood simply worked, and wooden railway sleepers	214	6.4
Paper mill, pulp mill machinery	162	4.9
Measuring, analyzing and controlling apparatus	157	4.7
Furskins, raw	137	4.1
Cathode valves and tubes	122	3.7
Telecommunications equipment and parts	93	2.8
Pumps (excluding liquid), gas compressors and fans	85	2.6
Other machinery for particular industries	79	2.4

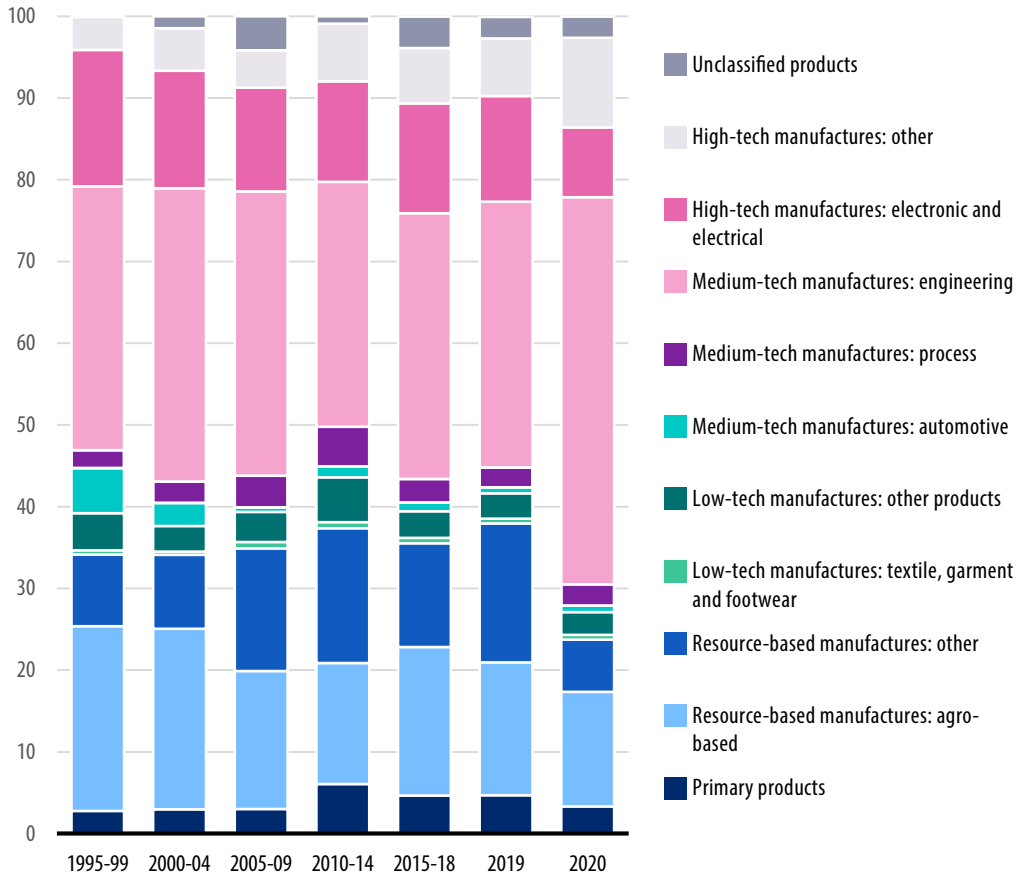
Note: Standard International Trade Classification (SITC) Revision 3.

Sources: UNCTAD, own calculations.

Looking at trade between Finland and the US using the same Lall classification, the structure of goods exports is much more stationary in terms of technological changes. This is intuitive, as the relative level of development between the two countries has not changed as much as between them and China.

Finnish exports to the United States are dominated by medium-tech engineering products, followed by resource-based manufactures (largely fuel and paper). The demise of mobile phone exports is not reflected in the share of high-tech electronic and electrical product exports to the US. Exports of telecommunications equipment to both the USA and China have declined, but they were historically more important in exports to China. Consequently, aggregate exports in high-tech electronics have not recovered in trade with China as they have with the USA. In 2020, the most important exported high-tech electronic products from Finland to China were cathode valves and tubes, and to the USA electro-diagnostic apparatus for medical sciences. On the other hand, the share of high-tech manufacturing exports from the United States to Finland has declined considerably since the 1995–2004 period.

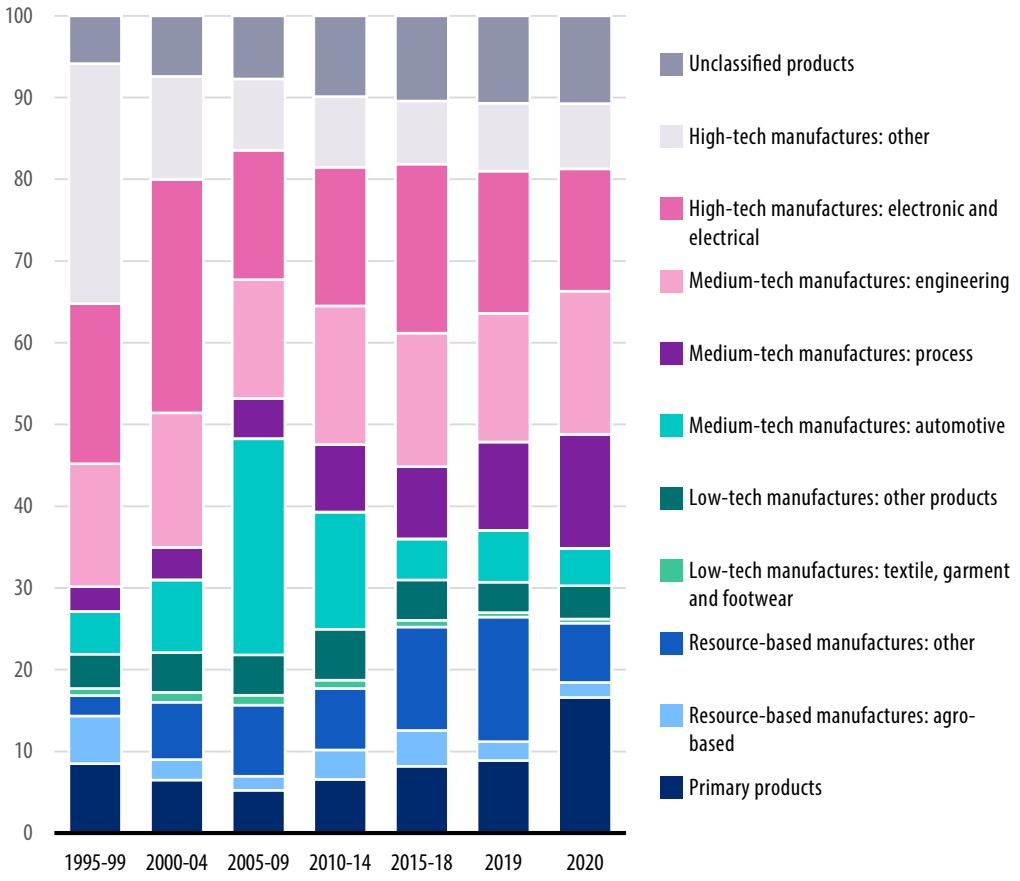
Figure 9. The structure of Finnish goods exports to the USA by level of technology, %



Note: Lall classification. Period averages have been calculated from annual percentage shares.

Sources: UNCTAD, own calculations.

Figure 10. The structure of US goods exports to Finland by level of technology, %



Note: Lall classification. Period averages have been calculated from annual percentage shares.

Sources: UNCTAD, own calculations.

More specifically, the top Finnish export products to the US are petroleum oils or bituminous minerals (largely fuel), paper and paperboard, and instruments and appliances for medical use (see Table 6). The US market is the most important for Finnish exports of synthetic fibres suitable for spinning (79% of the exports of these products in 2019, using SITC 3 data), pearls, precious and semi-precious stones (66%), cinematographic films (54%), instruments and appliances for medical use (53%), natural abrasives (36%), electro-diagnostic apparatus for medical sciences (31%), organo-inorganic compounds (30%), miscellaneous non-ferrous base metals for metallurgy (28%), and nickel (26%).

Petroleum has become a major export product more recently. In the late 1990s, its share was on average 3.5% of total goods exports, while in 2000–2018, its share averaged

10%. Paper and paperboard have occupied a 15–20% share since 1995. Instruments and appliances for medical use did not feature in export statistics in the late 1990s, but have recently become a major export product. Furthermore, the importance of measuring, analyzing and controlling apparatus, and electro-diagnostic apparatus has increased. Compared with the late 1990s, exports of ships and motor vehicles have completely ceased, and these items no longer play any role in direct exports. On the other hand, motor vehicles assembled in Uusikaupunki, Finland, are largely exported to the US market indirectly, via Germany.

Table 6. The top 10 Finnish goods export products to the United States in 2019

Product	Export value, MEUR	Share in exports to US, %
Petroleum oils or bituminous minerals	697	15.4
Paper and paperboard	666	14.7
Instruments and appliances for medical use	617	13.7
Measuring, analyzing and controlling apparatus	232	5.1
Electro-diagnostic apparatus for medical sciences	175	3.9
Paper mill, pulp mill machinery	173	3.8
Nickel	148	3.3
Telecommunications equipment and parts	146	3.2
Other machinery for particular industries	142	3.1
Civil engineering and contractors' plant & equipment	137	3.0

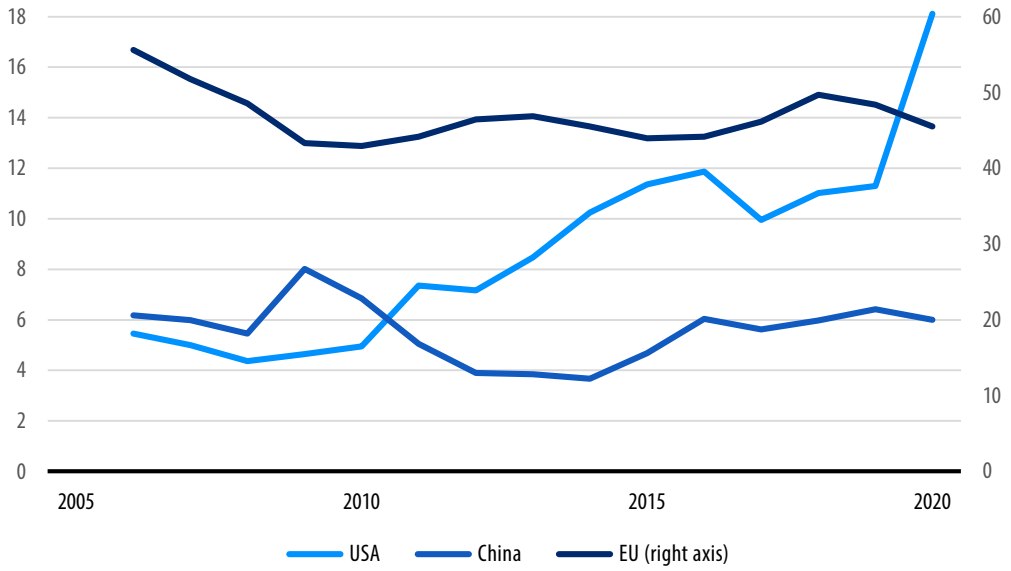
Note: SITC 3.

Sources: UNCTAD, own calculations.

The difference between the US and Chinese markets is greater in the export of Finnish services (see Figure 11). The share of the EU countries, on the other hand, has remained relatively stable since 2009. The US share has been rising since 2010 and was a little over 11% of total services exports in 2019, while China's share declined to just 3% in 2014, after which it started to rise again, reaching 6% in 2019. In 2020, the US share jumped to 18%. This was due to an increase in exports to the US and a decrease in global exports. Exports of telecommunications, computer, and information services to the US increased by 89% in 2020. There was a jump in the exports of these products during one single quarter in 2020, which may indicate that 2020 was to some extent an anomaly in the export of services to the United States.

Tourism receipts are included in services exports, and the number of overnight stays in Finnish hotels between 2014 and 2019 increased by a total of 54% for US and 181% for Chinese tourists, thus contributing to an increase in services exports. In 2019, US tourists accounted for 5% of all nights spent by foreign tourists, while Chinese tourists already accounted for a larger share, 6.4%.

Figure 11. Share in the value of Finnish services exports, %



Sources: UNCTAD, own calculations.

Table 7 shows the value of Finnish services exports in 2020 to the EU, the US, and China, as well as these countries' share in Finland's total exports of each service product. Overall, 46% of service exports were destined for the EU area. The EU's importance was below average in charges for the use of intellectual property, telecommunications, computer, and information services, and personal, cultural, and recreational services.

The United States was the destination for 18% of service exports, a significant jump upwards, as mentioned above. The US was particularly important for charges for the use of intellectual property, and exports of telecommunications, computer, and information services. China's share was less than 6% in 2020. About 40% of these exports were charges for the use of intellectual property. Overall, these statistics show that the US market is much more important for Finnish services exports than China, and that exports to the US are dominated by one type of product, namely telecommunications, computer, and information services.

Table 7. Structure of Finnish exports of services in 2020

	Value of exports, MEUR			Share in total exports of these products, %		
Product	**EU**	**US**	**China**	**EU**	**US**	**China**
Services	**11.5**	**4.6**	**1.5**	**45.5**	**18.1**	**5.7**
Goods-related services	1.6	0.1	0.0	79.6	3.0	0.9
Transport	1.3	0.0	0.1	58.1	2.0	3.7
Travel	0.6	0.1	0.1	55.3	4.4	4.8
Other services	8.0	4.4	1.3	40.1	22.3	6.5
Construction	0.1	0.0	0.0	66.9	0.8	0.0
Insurance and pension services	0.0	0.0	0.0	78.6	7.1	0.0
Financial services	0.2	0.0	0.0	74.7	6.9	0.9
Charges for the use of intellectual property n.i.e.	0.5	0.7	0.6	19.4	27.2	21.8
Telecommunications, computer, and information services	4.1	3.2	0.5	37.1	28.6	4.5
Other business services	2.9	0.5	0.2	53.4	8.8	3.9
Personal, cultural, and recreational services	0.0	0.0	0.0	39.4	15.6	1.8
Government goods and services n.i.e.	0.1	0.0	0.0	44.1	10.2	3.4
Memo item: Commercial services	**11.5**	**4.6**	**1.4**	**45.5**	**18.2**	**5.7**

Sources: UNCTAD, own calculations.

Finland has been running a relatively stable surplus in its goods trade with the United States and an almost equal-sized trade deficit with China. Since 2015/2016, Finland has been running a small surplus in services trade with both countries. While from a broader economic perspective, it is less important whether trade accounts with individual trading partners are in surplus or deficit, the structure of trade can have deep repercussions from a geoeconomic perspective by triggering the sort of risks discussed in Chapter 2 of this report and coupled with current securitization, balkanization and weaponization dynamics.

4.4 The importance of global value chains

For the world economy, and individual economies such as Finland, global value chains have become increasingly important. This means that a given final product is often assembled from raw materials and parts produced in various countries around the world. Their stream from design to an eventual final product is a value chain. Value added is the increment of value that is put into the product by a particular actor, typically a private sector firm, along its value chain. We can calculate value added by subtracting the purchases of intermediate products (including services, energy etc.) from the value of production. Summing up the overall value added produced in a country during a year gives us the GDP produced there.

Specialization has lowered production costs and made production more efficient. This has increased material wellbeing and purchasing power across the world. On the other hand, there may be an increased risk of disturbance in the production process that can affect output, especially as large inventories have no longer been stockpiled due to their cost. This risk has materialized from time to time, for example with regard to semiconductors, which are very important for other industries, but whose production is quite concentrated and dominated by Taiwan, which is an important detail in Taiwan-China-USA tensions. There are a range of natural and human-induced emergencies that may cause severe disturbances to the production process (and the value chain more broadly). Obviously, the most recent disturbance has been the Covid-19 pandemic, which disrupted production in many industries, notably the auto industry in Europe.

Global value chains also reflect countries' capabilities in global production and markets. UNCTAD has analyzed countries' productive capacities, which determine their ability to produce goods and services and enable growth. It classifies these capacities into productive resources, entrepreneurial capabilities, and production linkages. These data are shown in the Appendix for the interested reader and reflect the development of the strengths and weaknesses of the Chinese economy that have enabled it to catch up with Europe and the United States.

Based on OECD data, Tables 8 and 9 show the origin of value added in final demand in Finland and the EU28 – still including the UK – in 2015 (compiled in terms of industries). The figures for domestic value added are, of course, smaller in Finland than for the EU28 aggregate, as they would probably be in any (small) EU country. Out of the total value added in final demand, 73% was domestic in Finland and 88% in the EU28. On the other hand, there is very little difference in the figures for US and Chinese value added. The former is 2.4% in Finland and 2.6% in the EU28, while China's share is 2% for both. The US is consequently not that much more important than China in terms of imported value added.

These figures must also be compared to total imports of foreign value added. China's share in the imports of foreign value added to Finland was 7.5% and that of the United States 9%. *Grosso modo*, these correspond to the gross trade flows reviewed above. Relative to the United States, China's importance lies in manufacturing rather than services: textile industries, basic metals and metal products, and electronics, as we also saw above when using gross trade data. The same pattern can be seen in total extra-EU imports of foreign value added into the EU.

Between 2005 and 2015, the share of US value added remained relatively stable, while that of China almost doubled. In the EU28, the rise in China's share was steady, while in Finland it reached two per cent as early as 2012 and then levelled off.

Table 8. Origin of value added in final demand in Finland in 2015, %

Value added source industry	Domestic	Foreign	USA	China
DTOTAL: TOTAL	**73.2**	**26.8**	**2.4**	**2.0**
D10T33: Manufacturing	49.4	50.6	2.7	6.2
D10T12: Food products, beverages and tobacco	69.0	31.0	0.8	1.3
D13T15: Textiles, wearing apparel, leather and related products	24.1	75.9	0.5	30.6
D16T18: Wood and paper products; printing	70.2	29.8	1.6	3.0
D19T23: Chemicals and non-metallic mineral products	46.8	53.2	3.1	4.8
D24T25: Basic metals and fabricated metal products	47.1	52.9	2.0	6.7
D26T27: Computers, electronic and electrical equipment	50.2	49.8	4.7	11.1
D28: Machinery and equipment, n.e.c.*	52.6	47.4	2.3	4.3
D29T30: Transport equipment	14.7	85.3	4.4	1.5
D31T33: Other manufacturing; repair and installation of machinery and equipment	62.3	37.7	1.4	4.6
D45T82: Total business sector services	69.2	30.8	3.7	1.5

*Not elsewhere classified

Sources: OECD, own calculations.

Table 9. Origin of value added in final demand in the EU28 in 2015, %

Value added source industry	Domestic	Foreign	USA	China
DTOTAL: TOTAL	**87.6**	**12.4**	**2.6**	**2.0**
D10T33: Manufacturing	76.9	23.1	3.7	6.6
D10T12: Food products, beverages and tobacco	89.7	10.3	1.1	1.5
D13T15: Textiles, wearing apparel, leather and related products	53.2	46.8	0.5	22.3
D16T18: Wood and paper products; printing	84.5	15.5	2.8	4.5
D19T23: Chemicals and non-metallic mineral products	73.0	27.0	5.3	5.8
D24T25: Basic metals and fabricated metal products	76.8	23.2	2.8	7.2
D26T27: Computers, electronic and electrical equipment	60.6	39.4	6.1	14.8
D28: Machinery and equipment, n.e.c.	80.7	19.3	3.9	5.4
D29T30: Transport equipment	82.8	17.2	5.5	1.5
D31T33: Other manufacturing; repair and installation of machinery and equipment	86.7	13.3	1.3	4.9
D45T82: Total business sector services	88.5	11.5	3.5	1.5

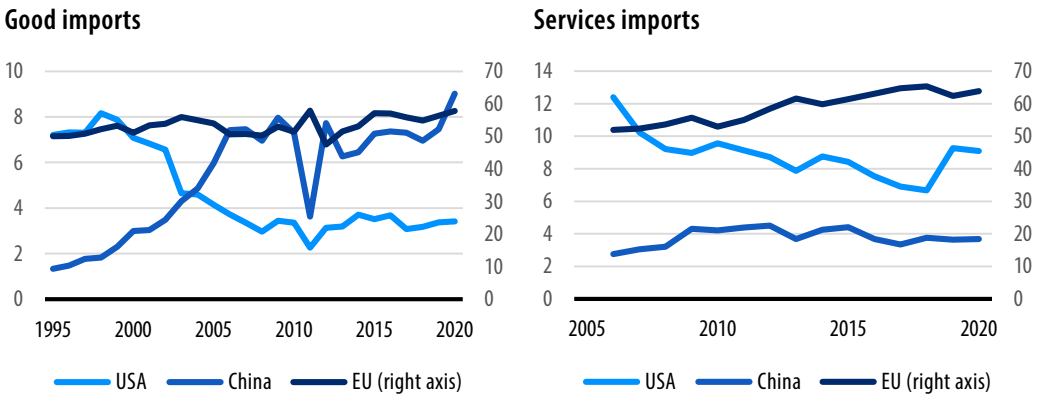
Sources: OECD, own calculations.

Unfortunately, these OECD data are somewhat outdated. However, we may try to infer something from the development in gross imports since 2015 (see Figure 12). China's share in gross imports of goods to Finland (left-hand graph) remained relatively stable between 2006 and 2019, and then increased considerably in 2020, the first year of the pandemic. This was probably a pandemic-related anomaly. Based on this evidence, it is unlikely that China's share in the imports of value added has increased. This is supported by the development of China's (including Hong Kong) share in imports of services to Finland. China's share has actually decreased slightly in recent years.

This also seems to be the case for the imports of value added from the United States. The US share of goods imports has remained stable since 2009. The US share of services imports tended to decline, but went on to recover considerably in 2019–2020, reverting to its 2010 level. The value-added data presented above are thus probably relatively accurate even today.

The share of the EU in the total value-added imports of goods – and especially in the imports of services – to Finland has increased. This is a logical result of increased integration and deeper internal markets.

Figure 12. Share of the value of goods (left-hand graph) and services (right-hand graph) imports to Finland by country of origin, %



Sources: UNCTAD, own calculations.

Based on Statistics Finland data, Table 10 illustrates the exports of domestic value added from Finland. Total value-added exports were 58 billion euros in 2019, which is 24% of GDP. Out of the 58 billion-euro exports, 53% went to other EU27 countries, over 7% to the United States and almost 6% to China. The US share was almost 6% in 2013 and has since risen. China's share rose from over 5% in 2013 and peaked in 2016 at just over 6%. The sectors presented in the Table are the export sectors. It is therefore not necessarily the sector that has produced the exported value added.

As above with the gross trade data, we find that manufacturing as well as information and communication services are important in Finnish value-added exports to the United States. Exports to China are more evenly distributed with important primary and other secondary production.

Table 10. Exports of domestic value added from Finland by exporter sectors, million euros

Exports of domestic value added to the EU, USA, and China	2013–2014	2015–2016	2017–2018	2019	Share in 2019, %
EU27					
Aggregate	21 599	24 008	28 629	30 832	53.0
Manufacturing	16 197	17 206	19 965	21 711	52.6
Primary and other secondary production	616	617	956	963	62.1
Transportation Goods storage	1 362	1 910	2 051	2 496	56.2
Information and communication	1 354	1 870	2 326	2 669	45.0
Other services	1 981	2 280	3 182	2 858	61.6
USA					
Aggregate	2 698	3 205	3 422	4 210	7.2
Manufacturing	2 156	2 425	2 513	3 031	7.3
Primary and other secondary production	13	16	7	6	0.4
Transportation and storage	104	60	69	99	2.2
Information and communication	147	373	478	803	13.5
Other services	267	311	333	251	5.4
China					
Aggregate	2 413	2 713	3 144	3 389	5.8
Manufacturing	1 935	2 064	2 501	2 771	6.7
Primary and other secondary production	267	247	141	65	4.2
Transportation and storage	108	153	157	164	3.7
Information and communication	23	109	161	255	4.3
Other services	71	125	169	121	2.6

Source: Statistics Finland.

4.5 MNEs and their foreign affiliates

After trade, an important part of firms' foreign operations is the foreign affiliates through which they become multinational enterprises (MNEs) and operate locally in foreign markets. It has been established theoretically (Helpman et al. 2004) and empirically (Girma et al. 2005, among others) that home-market-only firms are less efficient or have

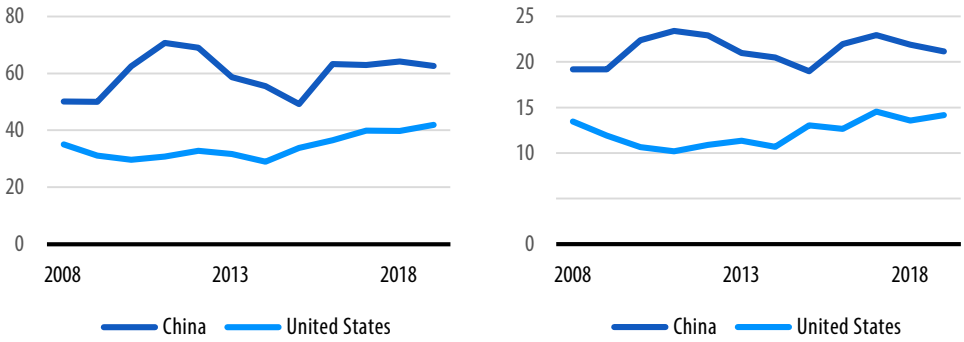
lower productivity than firms that export, which are in turn less efficient or have lower productivity than MNEs with foreign affiliates.

Finnish MNEs have more personnel in China than in the United States, but their turnover in China is smaller (see Figures 13 and 14). This is an expected consequence of the fact that labour costs are lower in China than the US, and therefore more labour-intensive production is present in the former. However, in 2008–2011, turnover was higher in China than in the US, but this was due to Nokia's business activities.

It is notable that the number of personnel in Finnish MNEs in the USA has been increasing since 2011, while the numbers in China have remained relatively stable. Nowadays, the gap in turnover is largely in favour of the US markets. China's share has declined since 2014, even though it has increased in nominal euro terms.

Foreign affiliates of US MNEs are also more important employers and operators in Finland than their Chinese counterparts (see Figures 14 and 15). Finnish companies have been cooperating with US firms for much longer than with Chinese firms, which is reflected in the data. China's share in personnel has been stable since 2007, while that of US MNEs has tended to decline. The share in turnover has been stable notwithstanding the temporary increase in the US share in 2014–2015.

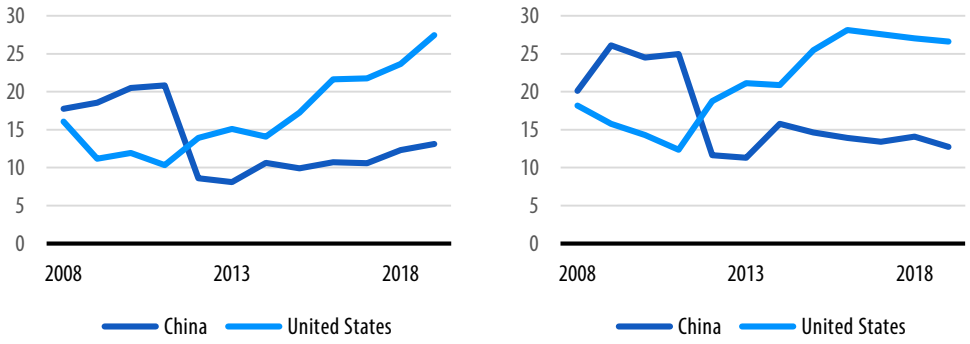
Figure 13. Personnel of Finnish affiliates located in the United States and China, thousands (left), and % share of total Finnish affiliates' personnel abroad (right)



Note: Break in time series in 2013. Ultimate Beneficial Owners.

Source: Statistics Finland.

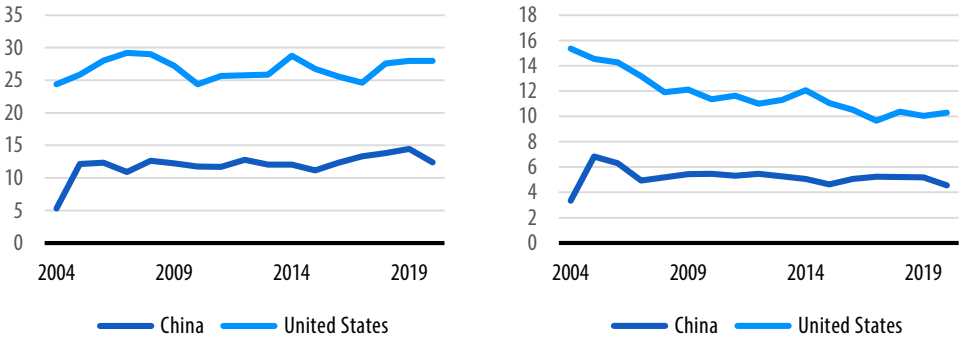
Figure 14. Nominal turnover of Finnish affiliates located in the United States and China, billion euros (left), and % share of total Finnish affiliates turnover abroad (right)



Note: Break in time series in 2013. Ultimate Beneficial Owners.

Source: Statistics Finland.

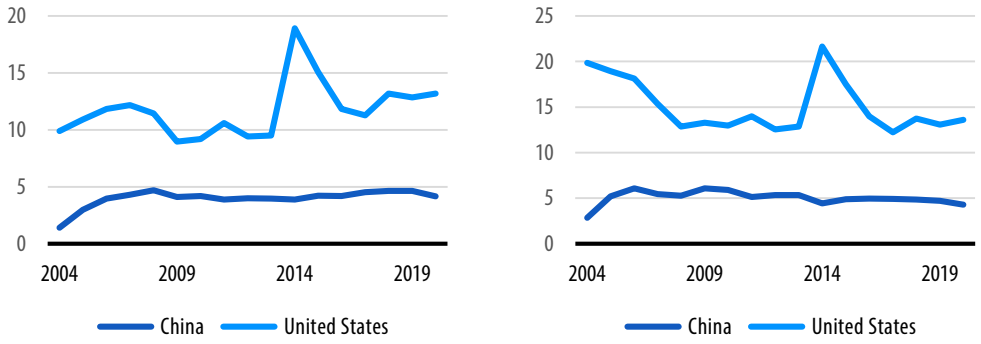
Figure 15. Personnel of US and Chinese firms' affiliates located in Finland, thousands (left), and % share of all foreign firms' total personnel in Finland (right)



Note: Break in time series in 2013. Ultimate Beneficial Owners.

Source: Statistics Finland.

Figure 16. Nominal turnover of US and Chinese firms' affiliates located in Finland, billion euros (left), and % share of all foreign firms' total turnover in Finland (right)



Note: Break in time series in 2013. Ultimate Beneficial Owners.

Source: Statistics Finland.

According to the Bureau of Economic Analysis (BEA) statistics, US firms' total assets abroad were almost 30 thousand billion US dollars in 2018. Of this, 2.6% or 764 billion dollars, was in China and another 1.5%, or 460 billion dollars, in Hong Kong. China's share has increased over time, while Hong Kong's has been relatively stable since at least 2008.

Table 11 below illustrates how China's share in these US assets has developed since 2008 overall, and in different industries. China is an important destination for US foreign affiliates in manufacturing industries, especially transportation equipment, electrical equipment, appliances, and components, chemicals, and computers and electronic products, where its share is 10–12%. China is also relatively important for the wholesale and retail trade. As for Hong Kong, most industry-specific data have been suppressed to avoid disclosure of data on individual companies.

Not surprisingly, the operations of Chinese multi-national enterprises in the USA are smaller in relative terms than vice versa, but the difference is not large. According to BEA statistics, the share of Chinese MNEs in all majority-owned foreign enterprises' US affiliates' total assets was 1.9% in 2019. The share has been stable since 2016. Before that, Chinese affiliates' share of foreign assets in the USA increased rapidly from zero in 2007.

Table 11. China's share in US firms' foreign affiliates' total assets by industries, %

Industry	2009–2011	2012–2014	2015–2017	2018
Total	..	1.8	2.4	2.6
Mining	..	..	..	0.9
Total manufacturing	..	6.2	7.4	7.8
Food	..	..	4.0	2.8
Chemicals	6.8	7.5	8.6	11.1
Primary and fabricated metals	4.3	..	8.2	6.8
Machinery	..	..	..	8.8
Computers and electronic products	..	..	..	10.1
Electrical equipment, appliances, and components	..	..	7.9	11.3
Transportation equipment	6.7	10.3	11.7	11.9
Wholesale trade	..	..	5.2	6.1
Retail trade	..	..	7.5	7.0
Information	..	..	..	0.7
Finance and insurance	..	1.0	1.9	2.2
Professional, scientific, and technical services	2.0	2.5	2.2	1.8
Other industries	..	..	..	0.9

Source: BEA.

In manufacturing, Chinese MNEs' share was 1.2% in 2019 (largest in primary and fabricated metals 1.4%, computers and electronic products 3.4%, and transportation equipment 1.9%). In services, China's share was 1.9% in wholesale trade, 1.6% in finance and insurance, 3.1% in real estate and rental and leasing, 0.5% in professional, scientific, and technical services, and 2.8% in other industries.

4.6 Conclusion

The three largest economies in the world are the United States, the EU27, and China. Thanks to impressive growth, China has caught up with the other two in terms of purchasing power adjusted GDP. In nominal terms, China has caught up with the EU, but not with the US as yet. There are structural weaknesses in China's investment-led growth model, and it remains to be seen how catching up will (or will not) proceed going forward.

On the other hand, China's average GDP per capita remains considerably lower than that in the EU or the US.

Over the past decade, the share of the EU, excluding intra-EU trade (current EU throughout the time period, i.e. excluding the UK), and the US in the value of world goods exports has remained stable, while China's share has increased. The increase in China's trade shares has therefore been at the expense of countries other than the EU or the US. China has now surpassed the EU in the value of global goods exports. Trade, however, is not foremost a zero-sum game and every country has a comparative advantage in some production.

The EU has a comparative advantage in world trade in agro-based manufactures as well as medium- and high-tech goods, apart from electronics. Finland's comparative advantage is in agro-based manufactures (forest industries), other resource-based manufactures and medium-tech engineering. The US has a comparative advantage in medium- and high-tech goods, apart from electronics, in addition to resource-based manufactures (other than agro-based). On the other hand, China's comparative advantage is in low-tech manufactures, medium-tech engineering, and high-tech electronics. We can thus see that the structure of comparative advantage in low-/medium-/high-tech manufactures in the EU and the US on the one hand, and China on the other hand, complement each other. This should hold potential for trade cooperation. The only exception is medium-tech engineering, where they all have a comparative advantage.

The bilateral goods trade relations between the US and China are more important for the latter, but the gap has been slowly decreasing. China exports high-, medium-, and low-tech manufactures to the US, while the US exports high- and medium-tech manufactures and primary products to China. This reflects their comparative advantages and China's large appetite for primary commodities worldwide. This may explain why on a general trade level, there appear surprisingly few signs of any broad-based decoupling between the US and China, although it may mask more specific decoupling in the technological domain, for instance.

In terms of services exports, however, China is a small player compared to the EU and the US. Excluding intra-EU trade in services, the EU is the largest exporter. The relative shares of the three have remained very stable in recent years.

The EU has strengthened its position in Finnish goods exports and imports. This is in line with deeper integration in the internal markets. The importance of the US as an export destination has increased during the past ten years – and it remains more important than China. China's share has also increased despite a slight decline since 2017.

High-tech electronic manufactures dominated Finnish exports to China around the turn of the century. However, their importance has since diminished markedly and they have been replaced by agro-based manufactures. This basically represents a transfer from high-tech mobile phone electronics led by Nokia to low-tech forest industry products, mainly pulp. The share of medium-tech engineering manufactures has also decreased, but not by as much. Finnish exports to the United States are dominated by medium-tech engineering products, followed by resource-based manufactures (largely fuel and paper). The demise of mobile phone exports is not reflected in the share of Finnish high-tech electronic and electrical produce exports to the US.

The United States is far more important than China in Finnish services exports. The importance of the USA has increased continuously, while China's importance has remained stable. The EU's share has also remained stable.

In terms of Finnish goods imports, and especially services imports, the EU's share has increased over time in line with economic integration. The share of the US has declined considerably in both: the share in goods imports declined up to about 2007 and has remained flat thereafter, whereas services imports declined up to 2018 before increasing again considerably in 2019. China's share in goods imports increased rapidly up to 2005 and remained flat thereafter, before jumping again in 2020, which is likely to be a Covid-related anomaly. For both Finland and the EU, the United States rather than China was a more important source of imported value added in 2015. In 2019, the US was a more important export market for Finnish value added than China. Overall, the US is thus a more important trading partner for Finland than China.

The US is also more important than China for Finnish multi-national enterprises' (MNEs) affiliates abroad – with the gap increasing – and vice versa in terms of foreign MNEs' affiliates in Finland.

Overall, while China's economic importance has increased during the 21st century – especially during its first decade – it remains far less important for the Finnish economy than the United States. In many respects, the relative importance of the Chinese economy for Finland has decreased relative to the US economy during the past decade. There are, of course, significant differences at the company level, which cannot be analyzed with the dataset concentrated on the macrolevel that was used in this project. In any case, with regard to the sort of vulnerabilities stemming from economic dependencies discussed in Chapter 2 of this report, it is important to note this relative importance for Finland of the US compared with China.

By far the most important economic partner for Finland, much more so than either China or the US, is the EU. Herein, for Finland's prospects of withstanding intensifying

geoeconomic rivalry, the key is the EU's ability to face geoeconomics and enhance its own competitiveness. For this, it is important to enhance EU competitiveness at the global level, in addition to the policies discussed in Chapter 3 in this report, as well as to foster a competitive EU internal market and free trade relations with non-EU countries.

At the aggregate level, it is difficult to see a decoupling between the three major economies. At the same time, when focusing on the aggregate level, most of the increase in interdependency arguably seems to have taken place and the development has largely levelled off. This is because further advances in global trade liberalization have been rather limited. In many instances, there has even been an increase in non-tariff trade barriers. On the other hand, we do not have a counterfactual. Without the new trade frictions and other measures, there would likely be more trade between the partners than there is at present.

5 Finland's technological competence and R&D cooperation with China and the United States

5.1 Background[17]

Recent years have been a time of significant transition in science, technology and innovation (STI). On the global stage, a transition has taken place to a multipolar system, in which the United States and China compete for STI leadership. China has overtaken the United States in the number of publications and patent applications in STI, while the European Union still leads in the number of scientific publications.[18]

In order to put its global dependencies in balance, the EU (and Finland) declared that it would strive for technology sovereignty, or the ability to develop or source technologies that are critical for its welfare, competitiveness and ability to act without one-sided structural dependency on other countries (Edler et al. 2020; 2021). The EU has recently released an updated list of those critical technologies (see Table 12), simultaneously announcing the set-up of an EU Observatory of Critical Technologies as they are bound to change continuously as new innovations emerge (European Commission 2021h). EU actions have also been taken to further increase support for those technologies by setting up flagship projects that boost synergies between civil, defence and space industries (European Commission 2021h), and by launching an InvestEU programme that pays special attention to them (European Parliament, Council of the European Union 2021).

However, there is a lack of a common understanding and definition of technology sovereignty that is not always conducive to productive debates. In this chapter, we follow March and Schieferdecker (2021) in defining technology sovereignty as "a set of competences necessary to identify, understand, assess, develop, advance, produce, use, and incorporate those key technologies with largest impact on its political and economic sovereignty, as well as an aspiration to acquire those competences". Firstly, this definition

17 We acknowledge that the analysis in this chapter uses the following proprietary data from Elsevier: SciVal https://www.scival.com/; Elsevier: Scopus https://www.scopus.com/home.uri; LexisNexis: PatentSight https://www.patentsight.com/en/ and PatBase Express www.patbase.com.

18 Looking at the time period from 2018 to 2020, China has produced 2,082,493 publications, the United States 2,120,031, and the EU-27 2,473,944. Source: SciVal.

implies that technology sovereignty can only be achieved if policies optimally foster research, education and innovation. Secondly, it suggests that the interdependencies between the technology, economic and policy sovereignty levels need to be handled as a system. Thirdly, technology sovereignty in essence depends on and can be fostered by international cooperation.

Based on this "abilities & ambitions definition" of technology sovereignty, the aim of this chapter is to gain a better general understanding of Finland's technological competences and resources and to map out international STI cooperation with (and between entities in) the two great powers that this report pays special attention to, the United States and China. Based on the observations made, risks for Finland will be mapped out and options as to how to go forward proposed. To map out Finland's technological know-how, the chapter focuses on publication and patent data (see Edler et al. 2020, 18) and in doing so complements the discussions on and insights into standardization and trade balance data obtained in previous and subsequent chapters. Bibliometric analysis can shed light on scientific resources and competences, while the analysis of patent data can illuminate technology competences. Metrics like patenting and scientific publishing are proxies of technological advancement and offer vantage points for analyzing the changing dynamics in the global technology regime. The data used in this analysis also have their limitations, however. In the case of publications, they only capture a part of the ongoing cooperation, whereas in the case of patents they do not capture trade secrets that are of increasing importance.

A central point in understanding the STI proxies of patenting and publications is that the dynamics in great-power competition involve a balancing act between strategic and economic objectives (Kennedy and Lim 2018). While innovation and the advancement of technologies have benefitted from the global increase in scientific and inventive efforts (often) in the private and non-profit sectors, the dynamics between rising and dominant countries are bound to collide on the strategic playing field of states (Kennedy and Lim 2018). However, suppressing collaboration to accommodate strategic objectives can have a detrimental impact on countries' ability to create new capabilities. As Lee and Haupt (2020) point out, if research collaboration between the United States and China-based actors had been excluded from the publication data, the 2.59% growth in scientific publications between 2014 and 2018 would have resulted in a 2.03% decline in scientific publishing by the USA.

Table 12. List of 22 (sets of) critical technologies recently identified by the European Commission

Sector	Critical technology
Electronics & Digital	1. Artificial Intelligence, advanced analytics, big data
	2. Cyber security and cyber defence technologies
	3. Digital forensic technologies
	4. High-performance computing, cloud and data spaces
	5. Photonics
	6. Ultra-low power microprocessors, lightweight printed or flexible electronics
	7. Quantum technologies
	8. Secure communication and networking
	9. Sensors (including electro-optical, radar, chemical, biological, radiation, etc.)
Manufacturing	10. Advanced and additive manufacturing
	11. Advanced materials technologies and sustainable materials by design
	12. Nanotechnologies
	13. Robotics
	14. Semiconductors and microelectronics
Space & Aeronautics	15. Space technologies (including design and manufacturing of launchers and satellites)
	16. Secure precision timing, positioning and navigation technologies
	17. High-definition Earth Observation technologies
	18. Satellite-based secure communication and connectivity
Health	19. Biotechnologies
	20. Chemical, biological, radiological and nuclear technologies
Energy	21. Energy technologies (including energy storage, energy resilience, renewables, hydrogen and nuclear)
Mobility	22. Autonomous systems

Source: European Commission 2021h.

Long-term collaboration always requires reciprocity. China has clearly benefitted significantly from open collaboration with the more developed innovation systems in the United States and the European Union. As shown by Cao et al. (2020), those Chinese scientists who have spent periods abroad have been instrumental for the quality of the Chinese innovation system and for high-level science development in China (Leydesdorff et al. 2014). Collaboration has also enabled China to bring back many of the

top scientists originally from China.[19] A well-known example is the return of Pan Jian-Wei, a physics professor at the University of Science and Technology of China (USTC). He obtained his doctorate from the University of Vienna (under the supervision of Anton Zeilinger) and eventually moved to the University of Heidelberg before becoming China's "father of quantum".

When it comes to Finland, the Finnish story is very much characterized by the country's transformation from a technological laggard into being at the technological frontier. Finland has a strong and varied science system (Suominen and Toivanen 2016) that has been increasingly connected to the European Research Area (ERA) (Toivanen and Suominen 2015a). In technology, Finland is continuously assessed as being at the forefront of development (Toivanen and Suominen 2015b). Moreover, if we look at innovation metrics, partly incorporating metrics of science and technology (S&T), Finland consistently ranks at the top of the list (Gray 2017). In many ways, Finland would seem to be an attractive partner in science and technology development due to its advanced position.

The important question is whether Finland would benefit from such collaboration economically and strategically. The answer is far from straightforward. In the current context of accelerating great-power competition, technology and science collaboration has significant strategic- and security-related undertones (Gaens and Kallio 2020, 62). China has been accused of broad-based economic espionage and of conducting influence operations, including by financing research and technological collaboration (van der Made 2021). In the United States, where the innovation system is built on top of a military industrial complex, it is also hard to distinguish between S&T and the defence sector. In the European context, where the defence sector has traditionally been kept at arm's length in terms of S&T, the interaction between S&T and the defence sector is also visibly increasing.[20] This underlines the view, put forward by recent geoeconomics research (Choer Moraes and Wigell 2020), that there is an increased convergence between economic and security thinking in the strategies of major powers, with potentially far-reaching effects on technological collaboration. It is already catalyzing a renewed focus on technological sovereignty and the need to manage technological interdependencies, as they may entail considerable geo-economic risks (see Chapter 2 of this report).

The remainder of this chapter firstly zooms in on Finland's scientific competences and the science cooperation with actors in the United States and China. Scientific collaboration is one channel through which technology sourcing and spillovers flow. Subsequently,

19 Discussion has been particularly active in Australia, where the growing tension has left research institutions in trouble, as Chinese students are not arriving in the same volume as previously (see Bagshaw, Hunter and Liu 2020).

20 This is visible in e.g. the redesign of the European Union's dual-use regulation (see Bromley & Brockmann 2021).

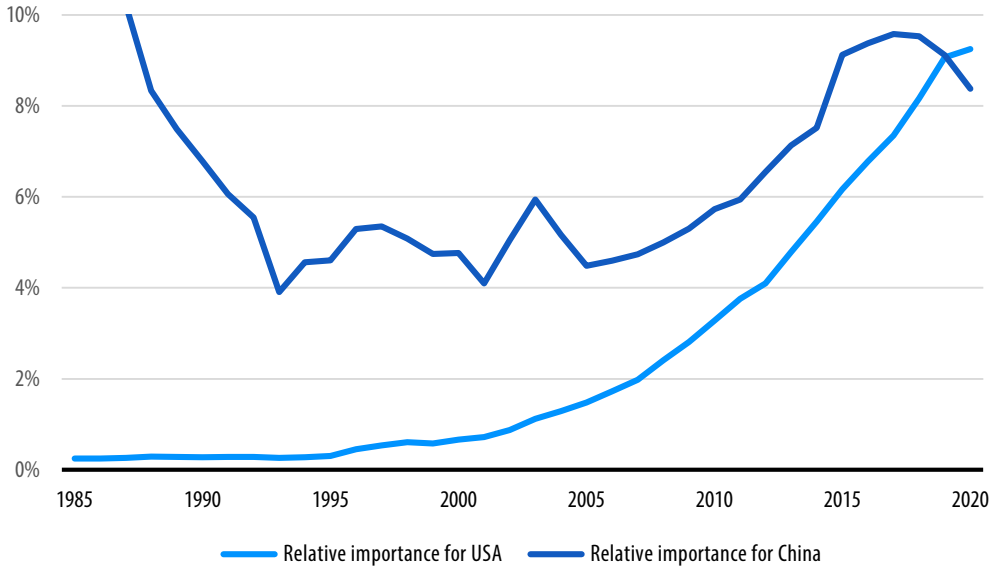
Finland's technological competences and its cooperation with (partners in) the great powers will be reviewed. The patent application data used in the analysis reflect R&D activities that can form another channel through which technology sourcing and spillovers occur (possibly in combination with the joint ventures or merger and acquisition channels). The chapter concludes with a discussion summarizing the main observations from the analysis of the data. While the scope of this chapter and project does not allow us to home in on the 22 critical technologies listed in Table 12, a separate case study was carried out covering emerging quantum technologies so as to demonstrate the complexity and scale of the matter.

5.2 Great-power dynamics in scientific publishing

When analyzing the science links between China and the United States, it is apparent that forms of collaboration have increased and that their science systems have been benefitting from it. These benefits can yield value for all if handled correctly (Schwaag Serger et al. 2021).

Science cooperation between the United States and China has been characterized by continuous growth, as can be deduced from the evolution of the absolute number of annual publication counts. Figure 17 illustrates that also in relative terms science cooperation between both countries has become more important since 2005, as the growth in co-authored publications between US and Chinese researchers exceeded their overall publication growth. Based on publication counts, the Figure further illustrates that the cooperation was relatively more important for China. While for both China and the US co-authored publications recently accounted for at least 9% of their publication output, that share has started to drop for China since 2017. As a result, for the first time, their cooperation became slightly more important for the US in 2020. However, also for the US, the steep rising trend was recently broken as it has started to stabilize since 2019.

Figure 17. Evolution of the relative importance of co-authorship between the USA and China

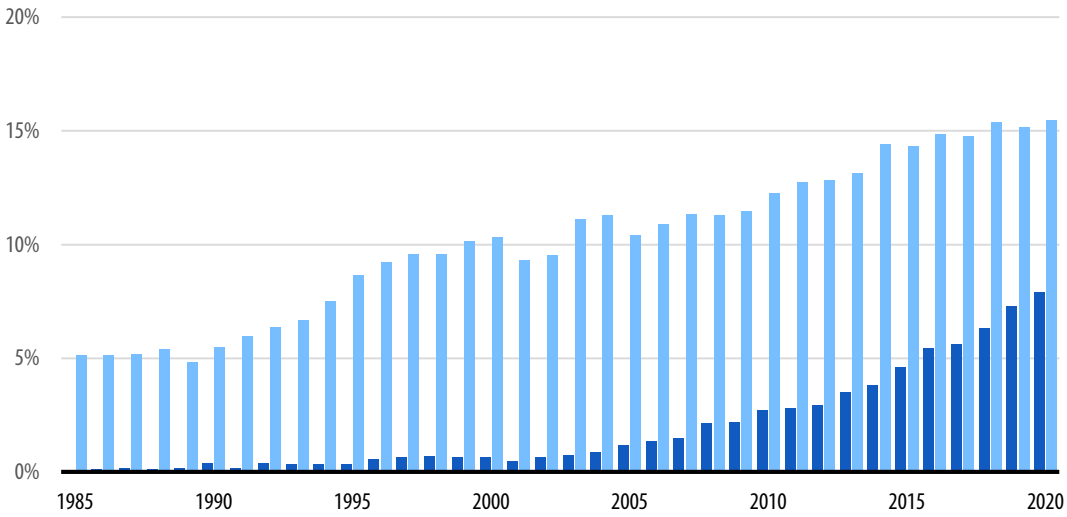


Notes: Based on the number of publications by year. The light blue (dark blue) line represents publications with at least one US and Chinese author as a share of all publications with at least one author from the USA (China) by year.

Sources: Scopus and VTT.

Turning to science output from Finnish authors, Figure 18 highlights that their co-authorship with their US and Chinese colleagues has been growing and is currently at an all-time high. Despite the rapid increase in co-authorship with China, the United States is still almost twice as important as a source of potential research collaborations for Finnish authors, reaching a share of 15.5% in 2020 versus the 8.3% share of China.

Figure 18. Evolution of the co-authorship between Finland and USA (light blue) and between Finland and China (dark blue)

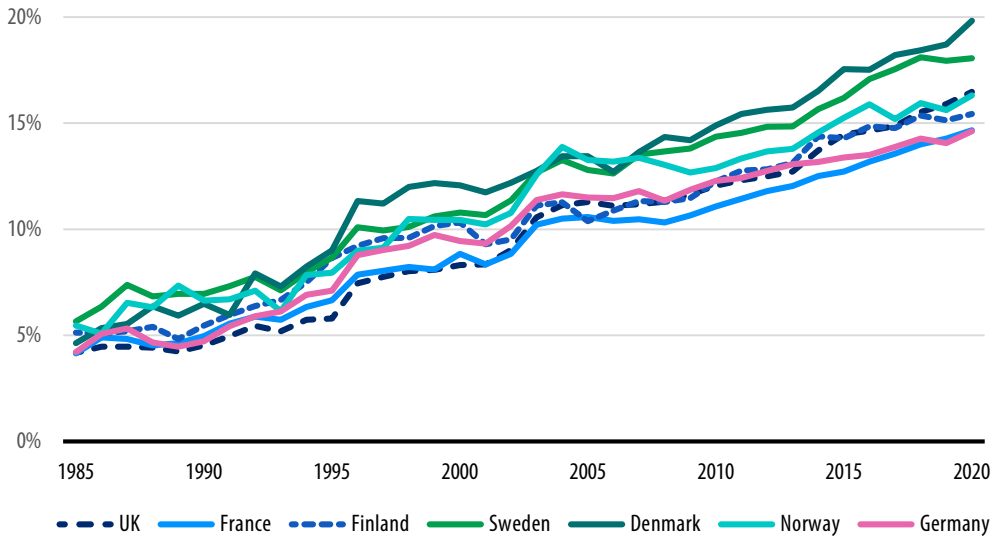


Notes: The light blue (dark blue) bars represent publications with at least one Finnish and US (Chinese) author (as a share of all publications with at least one Finnish author) by year.

Sources: Scopus and VTT.

Figure 19 illustrates that the importance of cooperation with US-based researchers has followed a similar trajectory in the Nordic countries as well as in Germany, France and the United Kingdom. But while in Finland the share tripled from 5% to 15%, in Denmark it nearly quadrupled to 20%. From the benchmark countries mapped below, Denmark and Sweden are clear leaders in cooperation with the US, while its relative importance is lower (but still notable) in Germany and France.

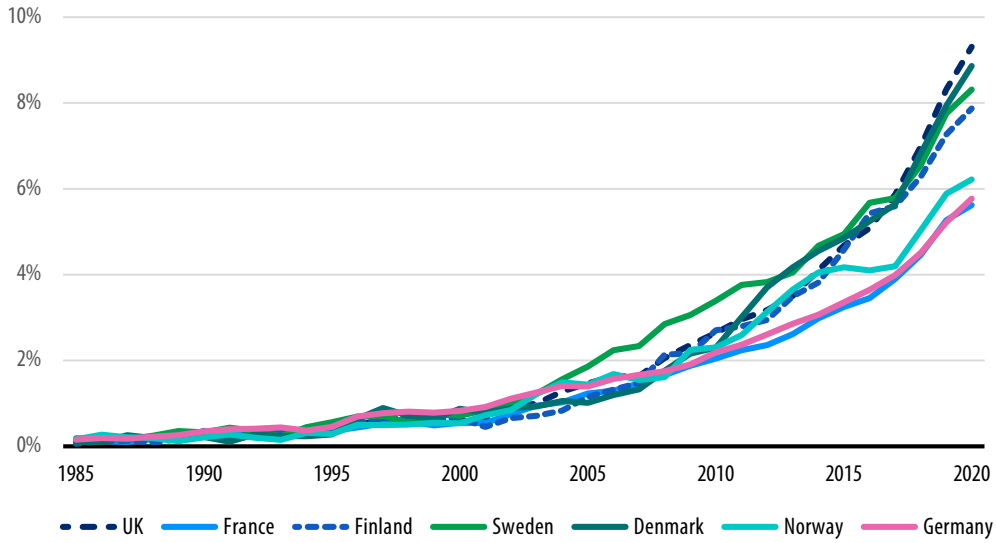
Figure 19. Evolution of the relative importance of co-authorship with US-based researchers for selected Nordic countries, Germany, France, and the United Kingdom



Notes: This Figure shows the annual number of co-authored publications between country x and the USA as a share of the annual number of publications with at least one author from country x.

Sources: Scopus and VTT.

Figure 20. Evolution of the relative importance of co-authorship with Chinese researchers for selected Nordic countries, Germany, France, and the United Kingdom



Notes: This Figure shows the annual number of co-authored publications between country x and China as a share of the annual number of publications with at least one author from country x.

Sources: Scopus and VTT.

The growth in Chinese co-authorship with researchers from Nordic countries, Germany, France, and the UK has been remarkable since 2005, and especially after 2015 (see Figure 20). The Swedes have been forerunners in science cooperation with Chinese partners and were later joined by researchers from Denmark, the UK and Finland – countries which all reached co-authorship shares of 8% to 9% in 2020. A second group of countries – France, Germany and Norway – was characterized by lower co-authorship shares with Chinese partners, hovering at around 6%. In sum, Finnish science cooperation with partners in the United States and China has been very much in line with the overall increasing trend followed by its peers in the Nordics and central Europe. In relative terms, research communities in Denmark and Sweden have been most active in co-authorship with researchers in the US but also in China, whereas the research communities in Germany and France have been less active. While in relative terms the United States is still twice as important as China for Finland and its benchmark countries as a source of co-authors, this ratio is expected to decline further. There are, however, recent signs that academic cooperation with colleagues in China has become more difficult.

While Finnish research cooperation with the United States and China accounts for about one-fifth of all publications, analysis by Toivanen and Suominen (2015a) pointed out some years ago that Finnish research has increasingly been connected to the European Research Area (ERA). In particular, this has meant less impact for the United States, but also that the importance of China might have increased less due to the impact of growing cohesion in the ERA.

Moreover, using the Field-Weighted Citation Impact value[21] which is a citation metric that controls for disciplinary differences, we observe different impact profiles between the countries (see Table 13). Finland leads with the highest citation impact (1.67) while the United States (1.43) comes second and China (0.96) third. Most importantly, we see that on average collaborative work in science pays off for all countries as these co-authored publications have a much higher citation impact (3.43 and 3.77). Focusing on individual scholars participating in the collaborative research, we see that on average co-authored papers with the USA (China) have 3.43 (1.37) more foreign authors than Finnish authors. In sum, the collaboration with Finland pays off for all parties involved as, on average, it leads to more impactful research. Given that collaborative science output is characterized by more impactful outputs, focusing on collaboration is a good strategy for sourcing information on capabilities.

21 Field-Weighted Citation Impact, as defined by Elsevier, is the ratio of the total citations actually received by the denominator's output, and the total citations that would be expected based on the average of the subject field. Exactly 1 means that the output performs just as expected for the global average. More than 1 means that the output is more cited than expected according to the global average. For example, 1.67 means 67% more cited than expected. Publication citation metrics aim to capture and reflect the quality of those publications.

Table 13. Citation impact, publication count, and number of individual authors from Finland, United States and China

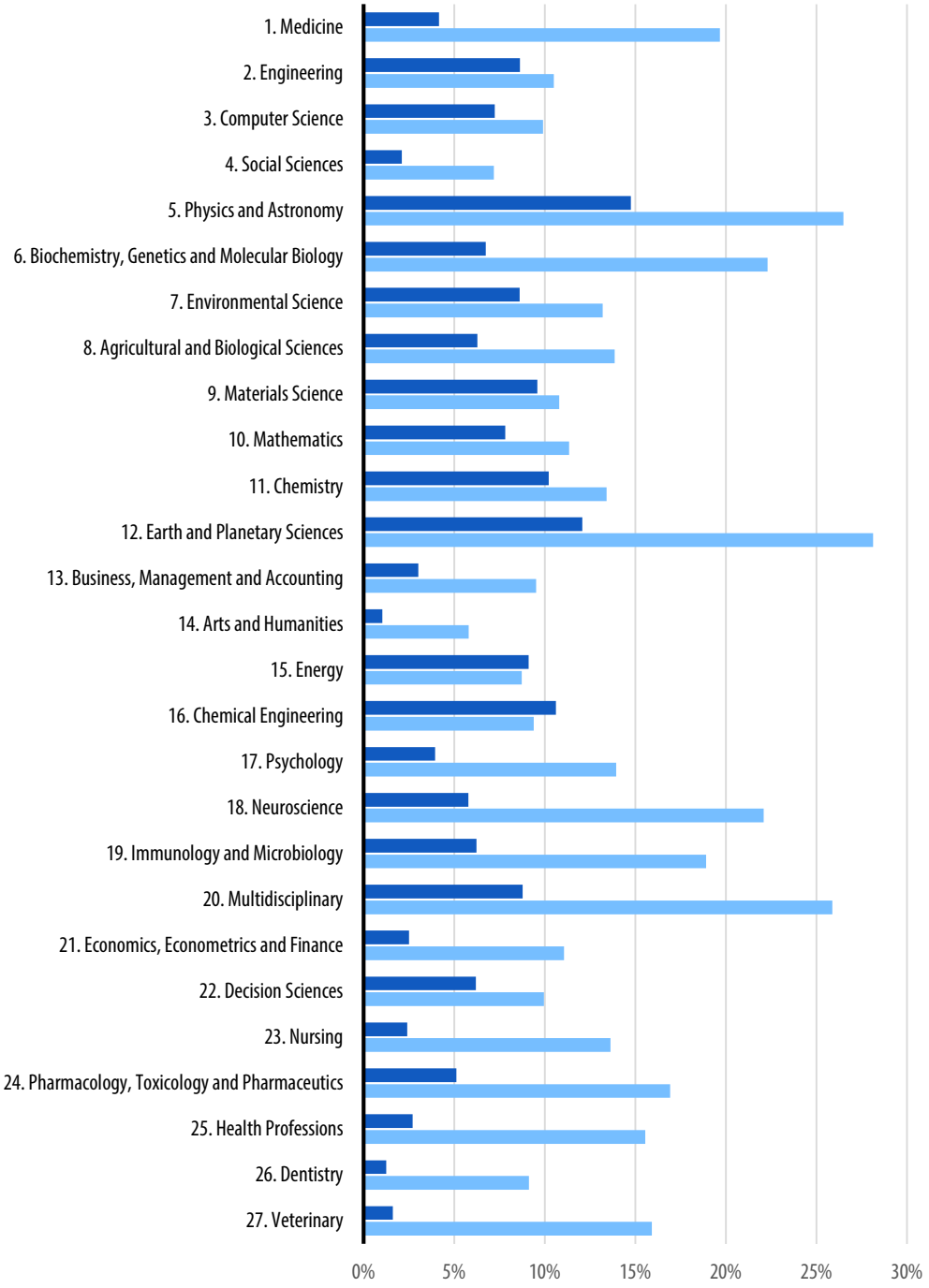
	Field-weighted citation impact	Publications	Finnish authors	Chinese/US authors
Finland	1.67	209,943	83,253	
China	0.96	5,342,140		5,343,755
USA	1.43	6,791,759		3,966,137
Finland/USA	3.43	30,808	20,311	69,681
Finland/China	3.77	10,680	7,251	9,936

Notes: Values are given from papers published in collaboration with Finland. Citation weight is given as Field-Weighted Citation Impact normalizing for disciplinary differences.

Source: SciVal.

When we look at the thematic orientation of collaborative research, we see differences in the scholarly activity carried out between Finnish and Chinese versus Finnish and US researchers. The aggregated figures of Finnish co-authorship with authors from the USA and China mask considerable heterogeneity over science fields (see Figure 21). For the recent period since 2016, the aggregate Finnish share of cooperation with US researchers was 15%, while with the Chinese it was 7%. Fields that stand out with high cooperation shares with researchers from both countries are Physics and Astronomy (26.5% with the USA and 14.8% with China), Earth and Planetary Sciences (28.1% with the USA and 12.1% with China). The relative importance of areas such as Physics and Astronomy and Earth and Planetary Sciences can be partly explained by the importance of "big science" in these fields, resulting in over-representation of collaborative research. For the research community in the United States, cooperation with Finnish authors in these top two fields represented about 1% of their total output, which is double the overall share of US-Finnish cooperation (0.49%). Further science fields that are particularly important for the cooperation of Finnish authors with their US counterparts are Biochemistry, Genetics and Molecular Biology (22.3%), as well as Neuroscience (22.1%) and Medicine (19.7%). Additional fields that have been relatively important in the cooperation with Chinese researchers include Chemical Engineering (10.6%), Chemistry (10.2%), and Material Science (9.6%). From the Chinese perspective, Finnish science cooperation has in relative terms been most important in the field of Psychology (0.78% of all Chinese publications in the field compared to the overall average of 0.24%) (figure not reported).

Figure 21. Relative importance for Finland of co-authorship with the USA (light blue) and China (dark blue) in 27 different science subject areas (for the period 2016 to 9.11.2021)



Notes: Science subject areas are ranked based on their total number of publications with at least one co-author from Finland.

Sources: Scopus and VTT.

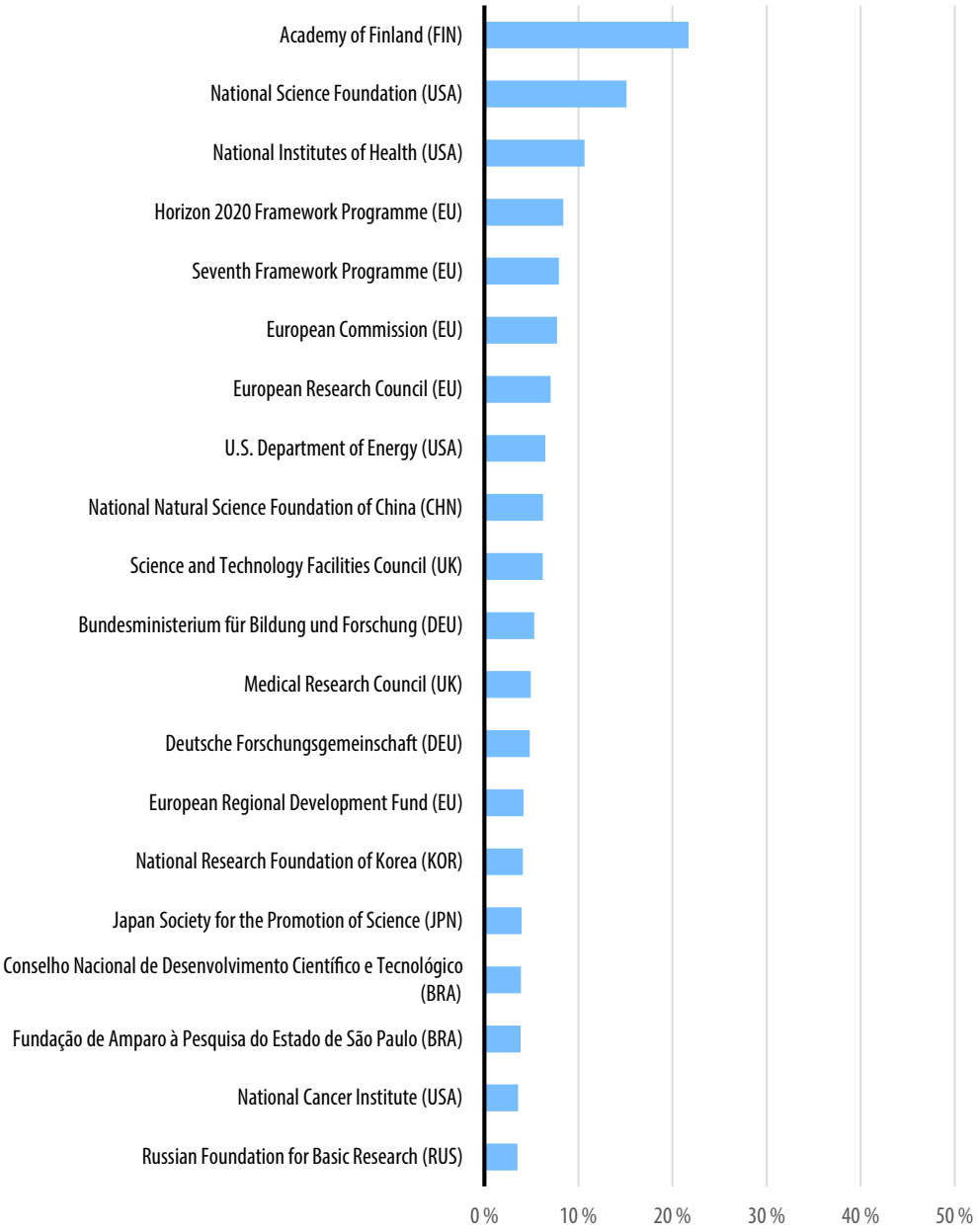
Overall, while the profiles have similarities, the differences in emphasis are important in understanding what is seen as mutually beneficial collaboration. Here we should also note that the collaboration between researchers from Finland and the United States has been developing for decades, while growth in research collaboration with Chinese researchers has been increasing for a shorter period. This can also have a significant impact on the patterns of collaboration.

The collaborative research work can also be analyzed by focusing on who funds the research. While we know that scholars' attribution of research funding, or lack thereof, is somewhat problematic, the dynamics seen in Figures 22 and 23 show some important differences in funding profiles. Firstly, we can see that the funders highlighted in the publications are not solely from the two countries on which co-authoring is measured. This highlights that much of the co-authored research extends beyond the two countries, to one or more other countries. Second, there is a clear difference in the relative importance of Finnish funders for the science cooperation with researcher partners from the United States versus China.

In the case of science cooperation with US-based researchers, the relative importance of the major science funders from Finland – the Academy of Finland – and the USA – the National Science Foundation – is balanced. A key explanation for this balance is the fact that in cooperation with US-based researchers and projects, the Academy of Finland has been using a bilateral research funding model.

In the case of science cooperation with China, its national funder – the National Natural Science Foundation of China – plays a stronger role than the major Finnish funders. This imbalance can be explained by the proactive quest by Chinese researchers to set up new collaborations from scratch. Supporting collaboration in science has been at the top of the agenda in many nations, but China has taken a particularly active role. In China, international collaboration has been declared an important part of the "long-term mission" of Chinese science policy. To that end, China has developed a broad network of science funding organizations and national research institutes that will continue to promote international collaboration (Yuan et al. 2018). During its *14*th *Five-Year Plan*, China aims to increase its share of total R&D expenditure in basic research from 6% to 8%, and to put more emphasis on basic research as the source of technological innovation (Böing et al. 2021).

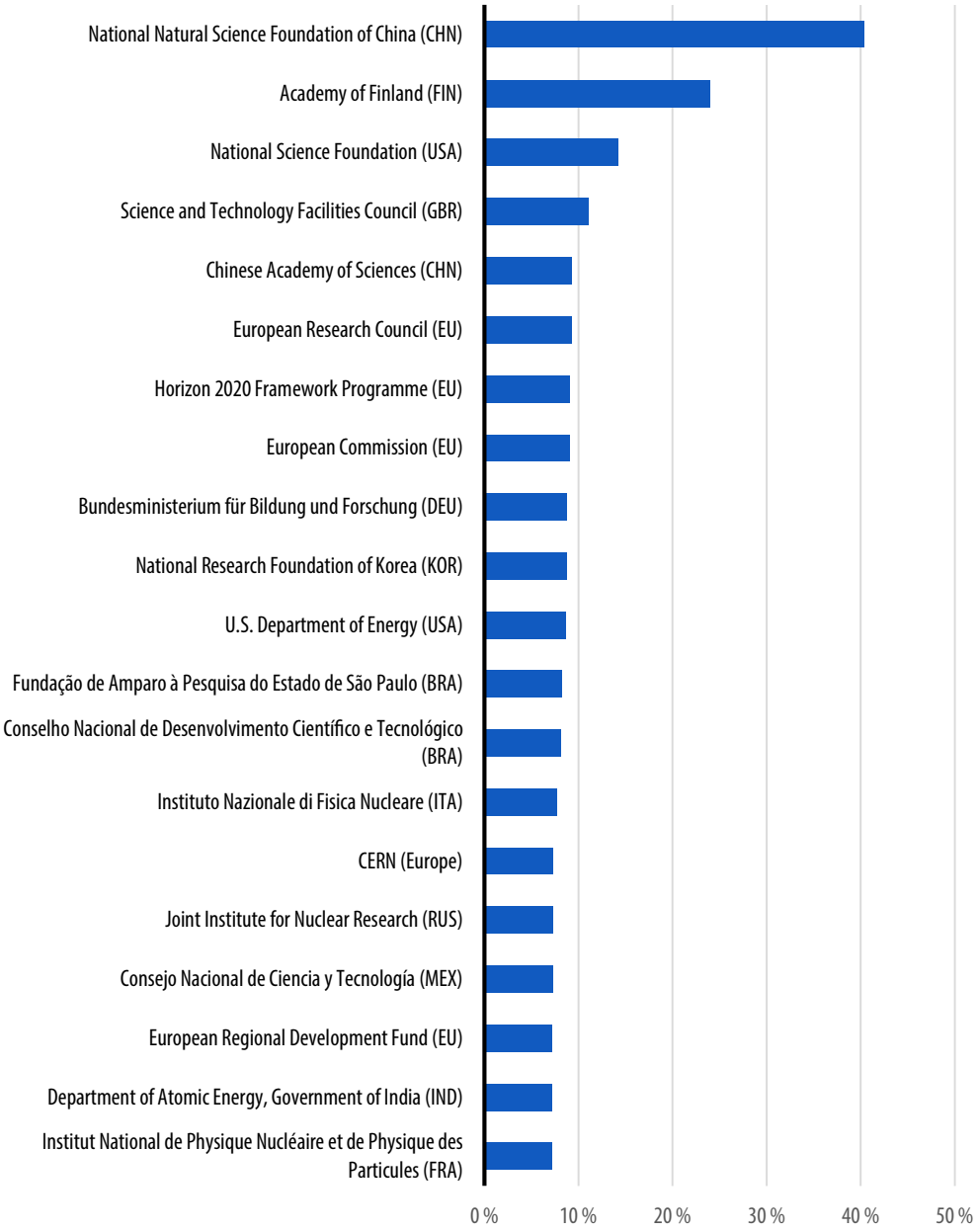
Figure 22. Distribution of funding sponsors for publications with Finland-based and US-based authors in the period 2016 to 2020



Notes: Multiple sponsors per publication (N=16,943) possible.

Source: Scopus.

Figure 23. Distribution of funding sponsors for publications with Finland-based and China-based authors in the period 2016 to 2020



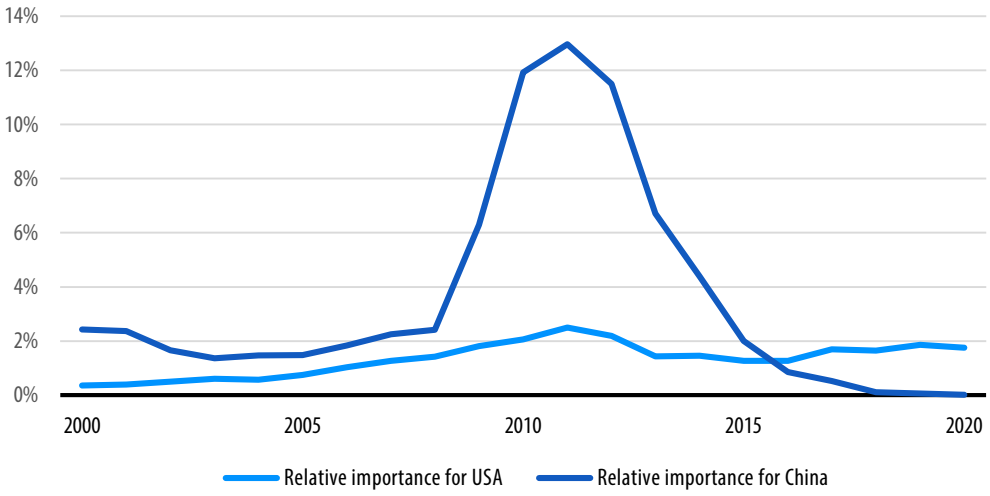
Notes: Multiple sponsors per publication (N=16,943) possible.

Source: Scopus.

5.3 Finnish patent activities and their co-ownership dynamics with great powers USA and China

To map the dynamics of patent activities, this section zooms in on the global patent family data of PatBase and PatentSight. As the analysis seeks to tease out the links between Finnish, US and Chinese patent activities, we look at the countries of origin of the patent applicants and combinations thereof.[22] The patent family data we analyze are not only important because they are an early indicator of the commercialization of inventions by Finnish firms, but particularly because they reflect the technological capabilities and R&D networks of Finland. The analysis provides complementary evidence on possible risks that Finland faces in its position with and between the great powers.

Figure 24. Relative importance of patent co-ownership between great powers



Notes: The patent co-ownership metric is based on the countries of origin of the patent applicants.

Sources: PatBase Express and VTT.

22 To analyze the links between countries, patent applications can offer information based on the inventors involved or based on the applicants (called assignees) involved. Information on the individual inventors is subject to the EU's General Data Protection Regulation, but can give insights into co-inventorship. Information on the assignees can give insights into co-ownership and the organizations behind the patent application. As we are interested in the organizations driving patent applications and eventually owning the granted patents, the analysis mainly focuses on co-ownership based on data from the proprietary PatBase Express database. Note, however, that a complementary short overview on co-inventorship based on data from the proprietary PatentSight dataset is featured in the infobox at the end of this chapter (5.3).

The protagonists of the great-power competition, as countries of origin of patent holders, have co-owned patents for over two decades. Figure 24 illustrates that, on the one hand, the Chinese co-ownership has been of limited relative importance from a US perspective and has hovered around 2% lately. On the other hand, the relative importance of US co-ownership for China has been of greater importance since its share started to grow steadily in 2008. The recent decline in the importance of US co-ownership for China can mainly be explained by the patent application boom in China due to its active national and regional subsidy policies.[23] The objectives of Chinese patent subsidy policies have focused on promoting "real innovation" and developing the Chinese innovation system, which has ultimately led to a 30% increase in patenting, some of which are of low quality (Dang and Motohashi 2015).

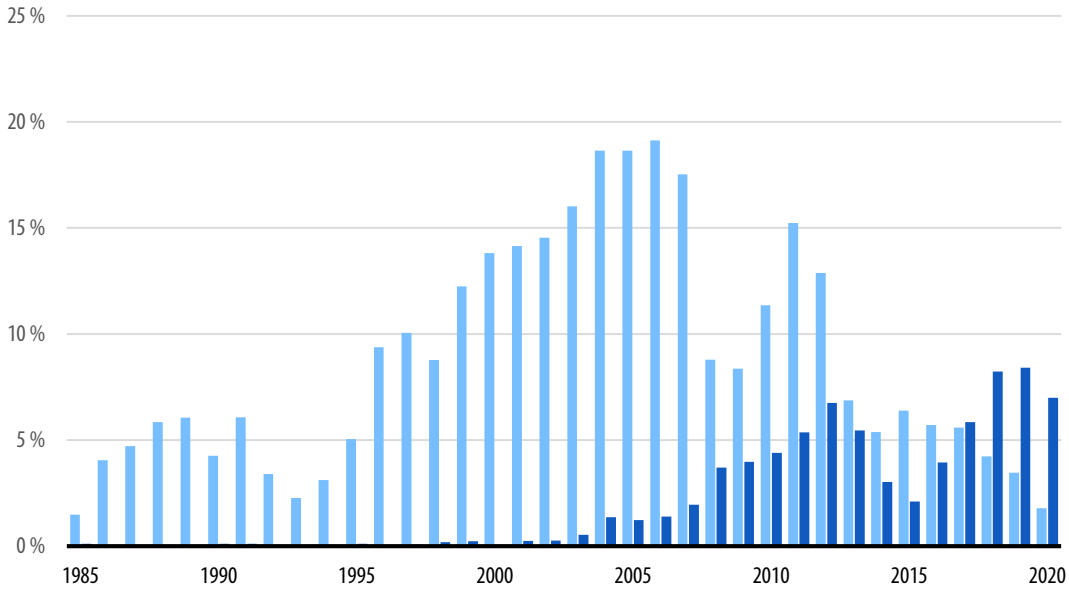
The relative importance of patent co-ownership between actors in Finland and the US and between those in Finland and China can be analyzed based on patent family data.[24] Firstly, Figure 25 shows that while patent co-ownership by actors based in Finland and the United States used to reach shares above 15% for five consecutive years (2003–7), it recently dropped back under 5% to its pre-1995 levels. As the United States is regarded as a tech leader, or as being at the technological frontier,[25] a reduction in Finnish-US collaboration can result in Finnish companies (and other actors) not having access to the technological frontier. In many fields, the US still has the most advanced knowledge, and therefore Finnish companies should continue to collaborate with and learn from the best. Dropping out of those networks with the most advanced knowledge will cannibalize the competitiveness of Finnish firms (and ultimately other actors), especially if the IPR is owned by foreign firms. Secondly, since the early 2000s, the co-ownership between actors in Finland and China has increased steadily for over a decade, and despite a dip around 2015 the relative importance of co-ownership has surpassed that with the US in 2017. In 2018, of all priority patents by applicants from Finland, 4% also had patent applicants from the US, while 8% (double) had applicants from China. Despite China overtaking the US as a more important source of co-owners for Finnish patents activities, the relative importance of both countries is currently limited, and Finnish actors are relying more than ever on their EU partners for their patent activities. Using all patent applications as an alternative metric indicates the same trends.

23 For a reference on Chinese policies, see Gong and Peng 2018.

24 Patent family is used as a term to define a collection of patent applications that all cover similar or the same technical content. For a reference on the definition, see European Patent Office 2021.

25 For a reference on the global patent dynamics, see Toivanen and Suominen 2015b.

Figure 25. Evolution of the patent co-ownership between Finland and the USA (light blue) and between Finland and China (dark blue)



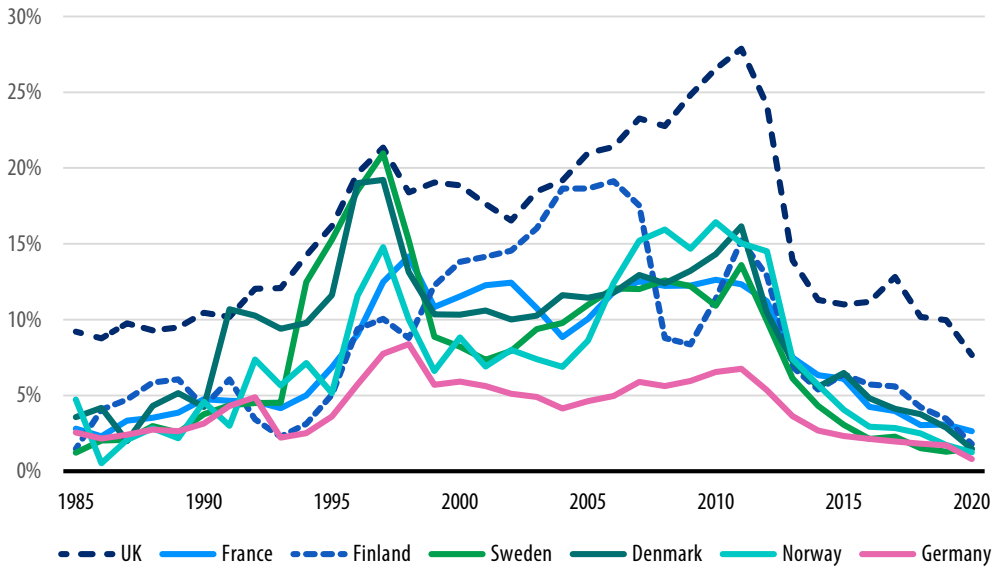
Notes: The patent co-ownership metric is based on the countries of origin of the priority patent applicant/assignee. The light blue (dark blue) bars represent the priority patents that have at least one Finnish and US (Chinese) applicant/assignee (as a share of the total number of priority patents with at least one Finnish applicant/assignee) by earliest priority year.

Sources: PatBase Express and VTT.

While both the lower frequency of co-ownership with US-based and the higher frequency of co-ownership with Chinese partners are interesting observations, an interpretation of these trends is particularly difficult without comparisons with (actors from) Finland's peer countries. Figures 26 and 27 compare bilateral patent co-ownership in a selection of Nordic countries, Germany, France, the UK and both great-power countries.

Figure 26 shows that in the Nordic countries (and in Germany, France and the UK), the relative importance of co-ownership with partners from the United States has been continuously declining for almost a decade. At first sight, it is not clear what explains this trend. Therefore, the following analysis will focus on the role of technological fields and companies in explaining the trends revealed. In most countries in the Nordics, patent co-ownership with partners from China has been of limited importance (see Figure 27). Despite the Chinese subsidies pushing forward patent activities, most Nordic countries do not show a clear growth in their patent co-ownership with Chinese entities. However, in the case of Sweden, and particularly in the case of Finland, co-ownership with Chinese partners is clearly higher than for other selected countries, and has been growing in importance in recent years. To be able to interpret this interrelation more effectively, it is useful to cover the companies that are driving this exceptional pattern.

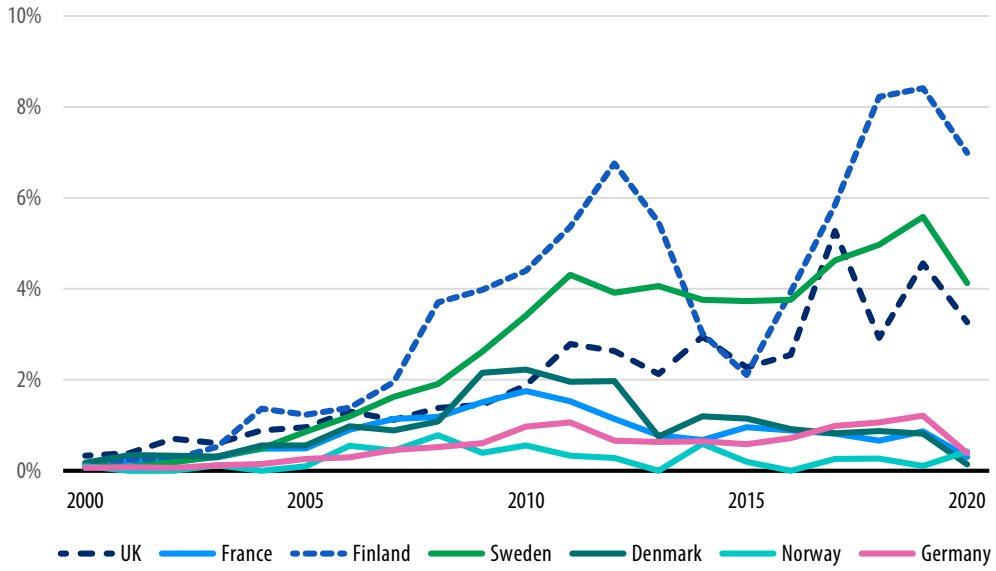
Figure 26. Relative importance of patent co-ownership with USA in selected Nordic countries, Germany, France and the United Kingdom



Notes: Based on number of patent families by earliest priority year.

Sources: PatBase Express and VTT.

Figure 27. Relative importance of patent co-ownership with China in selected Nordic countries, Germany, France and the United Kingdom



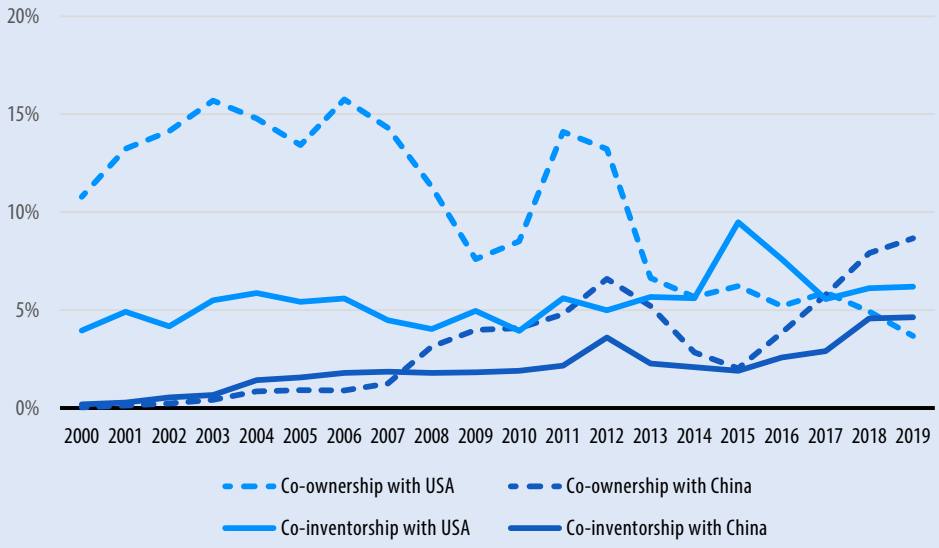
Notes: Based on number of patent families by earliest priority year.

Sources: PatBase Express and VTT.

Overview of the evolution of co-inventorship between Finland and the great powers

This Infobox zooms in on an alternative metric of patent links between countries, more specifically on the co-invention activities between actors in Finland and the great powers. A good source of information on co-invention between countries is the proprietary database PatentSight. Its data show that the coverage of co-inventorship can substantially differ from the coverage of co-ownership. To illustrate this gap in coverage, the number of patent families with an inventor from Finland is 93% of the number of patent families with an applicant from Finland. The number of patent families with an inventor from Finland and China [United States] is only 61% [49%] of the number of patent families with an applicant from Finland and China [United States]. Given this discrepancy in coverage, the Figure below needs to be interpreted with caution.

Figure 28. Evolution of co-inventorship and co-ownership of patent families between Finland and the great powers USA and China



Notes: The above Figure shows the evolution of patent families with inventors [applicants] from Finland and USA (or China) as a share of all patent families with an inventor [applicant] from Finland.

Sources: PatentSight and VTT.

Figure 28 illustrates that based on the analyzed patent dataset, the evolution of co-invention activities between actors from Finland and the USA, and between those from Finland and China, has been at a lower level and more stable than the patent co-ownership activities.

During the last 20 years, the peak in co-inventorship activities between actors based in Finland and the USA was only reached in 2015, after which co-inventorship started to drop. Instead, the peak in co-ownership between Finnish and US entities was already reached in 2006 and the relative importance of co-ownership with US-based actors has recently (in 2018) started to drop below that of co-inventorship. Overall, the above data can be interpreted against the background of the US leaning towards decoupling.

In the case of China, co-inventorship and co-ownership of patents have both followed an upward trend since 2015 and are only recently reaching record shares (in 2019). Note, however, that in the case of patent links between actors from Finland and China, co-ownership is relatively more important than co-inventorship. The rising trend in both indicators is in line with what we would expect based on China's extra push for diversifying access to foreign technology since the launch of its *Made in China 2025* strategy (see also Schneider-Petsinger et al. 2019; Segal 2019).

5.4 Patent classifications of patent families with international co-ownership by technological area

To better understand what drives the dynamics of cooperation, the analysis will pay special attention to the distribution of International Patent Classification codes. This approach can signal information about cooperation and capabilities in critical technologies. Finland has been focusing on communication technology and telecommunications activities, profiling itself as a high-tech and ICT country. Looking into the distribution of patent families by technological areas shows that since 2015 Finland, as a source of patent applicants and holders, has been most active in the following 10 International Patent Classification (IPC) sub-classes: electric communication techniques (H04W, H04L, H04B, H04N) and computing, calculating or counting (G06F and G06T), but also in investigating or analyzing materials (G01N), elevators (B66B), diagnosis (A61B) and image data processing or generation (G06Q) (see first 10 rows of column (C) in Table 14).

Table 14. Patent family ownership by International Patent Classification (IPC) for the period 2015–2021

PATENT FAMILIES:			#	%	%
FI rank (A)		IPC SUB-CLASS (B)	FI (C)	FI-US (D)	FI-CHINA (E)
1	H04W	Wireless communication networks	3716	16.4%	15.9%
2	H04L	Transmission of digital information	3070	15.4%	12.1%
3	G06F	Electric digital data processing	1988	12.9%	5.8%
4	H04B	Transmission	1172	13.2%	11.6%
5	H04N	Pictorial communication	875	11.4%	1.9%
6	G06T	Image data processing or generation in general	707	9.2%	2.7%
7	G01N	Investigating or analyzing materials by determining their chemical or physical properties	641	5.6%	0.5%
8	**B66B**	**Elevators, escalators or moving walkways**	**618**	**0.0%**	**3.2%**
9	A61B	Diagnosis; surgery, identification	595	5.7%	1.2%
10	G06Q	Data processing systems or methods	518	10.0%	4.2%
11	**G06K**	**Recognition of data**	**502**	**6.8%**	**7.4%**
15	H04M	Telephonic communication	442	26.5%	9.7%
16	G02B	Optical elements, systems or apparatus	423	16.8%	2.1%
23	**G06N**	**Computer systems based on specific computational models**	**323**	**7.7%**	**8.7%**
24	**H04R**	**Loudspeakers, microphones, gramophone pick-ups or like; acoustic electromechanical transducers**	**298**	**2.3%**	**3.0%**
29	**G10L**	**Speech analysis or synthesis**	**238**	**1.7%**	**2.1%**
30	H04J	Multiplex communication	231	23.8%	9.1%
48	F21V	Functional features or details of lighting devices or systems thereof	179	14.5%	0.0%
49	H04Q	Selecting (switches, relays …)	178	32.6%	7.3%
	H03M	**Coding, decoding or code conversion in general**	**129**	**8.5%**	**17.1%**
	H01P	**Waveguides; resonators, lines or other devices of the waveguide type**	**76**	**2.6%**	**11.8%**
	H01H	**Electric switches; relays, selectors; emergency protective devices**	**61**	**0.0%**	**13.1%**

Notes: For the period from 01.01.2015 to 22.09.2021, the above Table lists the 10 most important IPC sub-classes for patent families with Finland-based assignees (first 10 entries), for patent families with Finland- and US-based assignees (grey and blue), and for patent families with Finland- and China-based assignees (in grey and pink). For the eight IPC sub-classes highlighted in bold, there are more Finnish-Chinese co-owned patents than Finnish-US co-owned patents.

Sources: PatBase Express and VTT.

Zooming in on patent families co-owned by entities in Finland and the United States shows that the IPC profile of co-ownership differs in part from the overall patent ownership IPC profile of Finland. While the first five most important technology areas for Finland also show up in the FI-US ranking (see column (D) in Table 14), the other top ten fields in FI-US co-owned patents are in order of relative importance: Selecting (32.6%), Telephonic communication (26.5%), Multiplex communication (23.8%), Optical elements systems or apparatus (16.8%) and Functional features or details of lighting devices or systems thereof (14.5%).

Focusing on patents co-owned by entities in Finland and China shows that the overlap with the overall patent ownership IPC profile of Finland is limited (see column (E) of Table 14). In this case, only three of the ten most important IPC classes for Finland are featured in the top 10 of the co-owned patent families. The other top ten fields in patents co-owned by entities in Finland and China are in order of relative importance: Coding, decoding or code conversion in general (17.1%), Electric switches, relays, selectors, emergency protective devices (13.1%), Waveguides, resonators, lines or other devices of the waveguide type (11.8%), Telephonic communication (9.7%), Multiplex communication (9.1%), Computer systems based on specific computational models (8.7%) and Recognition of data (7.4%).

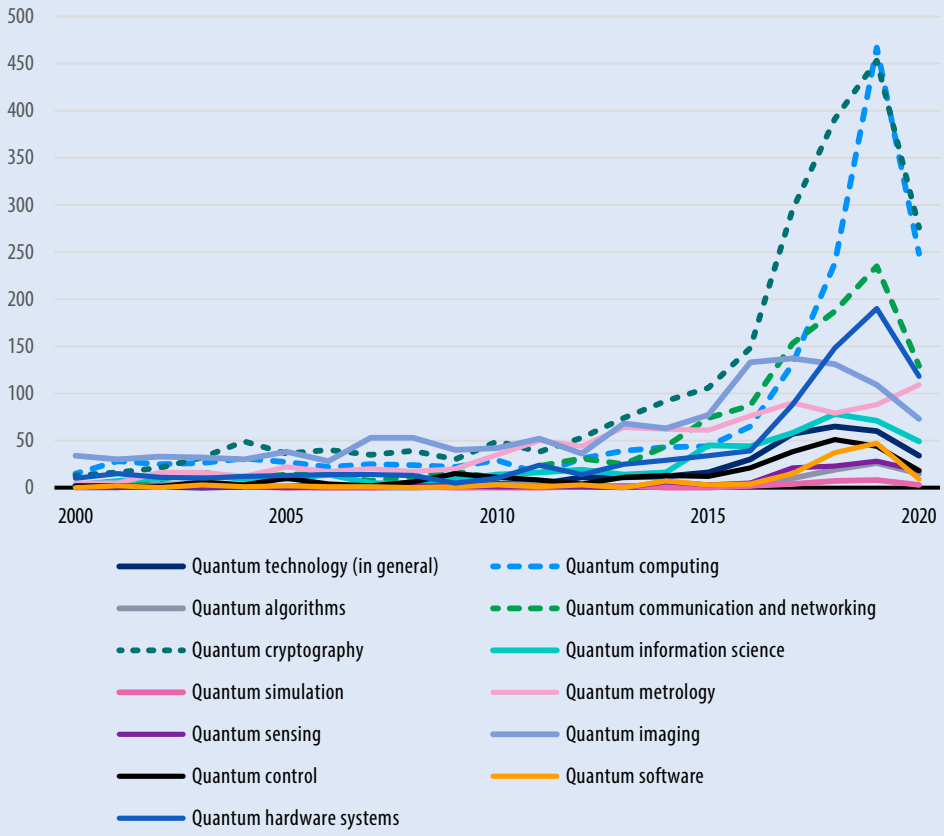
The alternative and more recently introduced Cooperative Patent Classification (CPC) system for patent family classification can reveal important information on new technological developments. Since 2015, the overall importance of related co-owned patent families between actors in Finland and the US and Finland (6%) and China (4%) has been limited. However, for ICT technologies aiming at the reduction of their own energy use, co-ownership is considerable for Finland, reaching shares of 18% (for US) to 20% (for China).

Quantum technologies play a prime role in the arena of great-power competition and are crucial for the open strategic autonomy of Europe (see Cagnin et al. 2021). The capabilities that the great powers and Finland have in those technologies are highlighted in Infobox below. Distinguishing between 13 quantum technologies, we find that there has been a huge global surge in quantum technology patents since 2015 and that this booming trend was largely driven by quantum cryptography and quantum computing. The expansion is driven by China in particular and to a lesser degree by the USA, which is still leading in terms of quantum hardware systems, quantum simulation and quantum algorithms. The fact that the EU is lagging behind is illustrated by the limited number of Finnish patents in this domain. Special policy attention will be needed to close the gap in this highly competitive and strategic technological arena.

Case quantum technology

In terms of the global number of patent families, the quantum technology field has grown enormously since 2015, as seen in Figure 29. In particular, patent activities in quantum cryptography (the dark green dotted line) and quantum computing (light blue dotted line) have skyrocketed. However, Europe is not in the same league as the US and China.

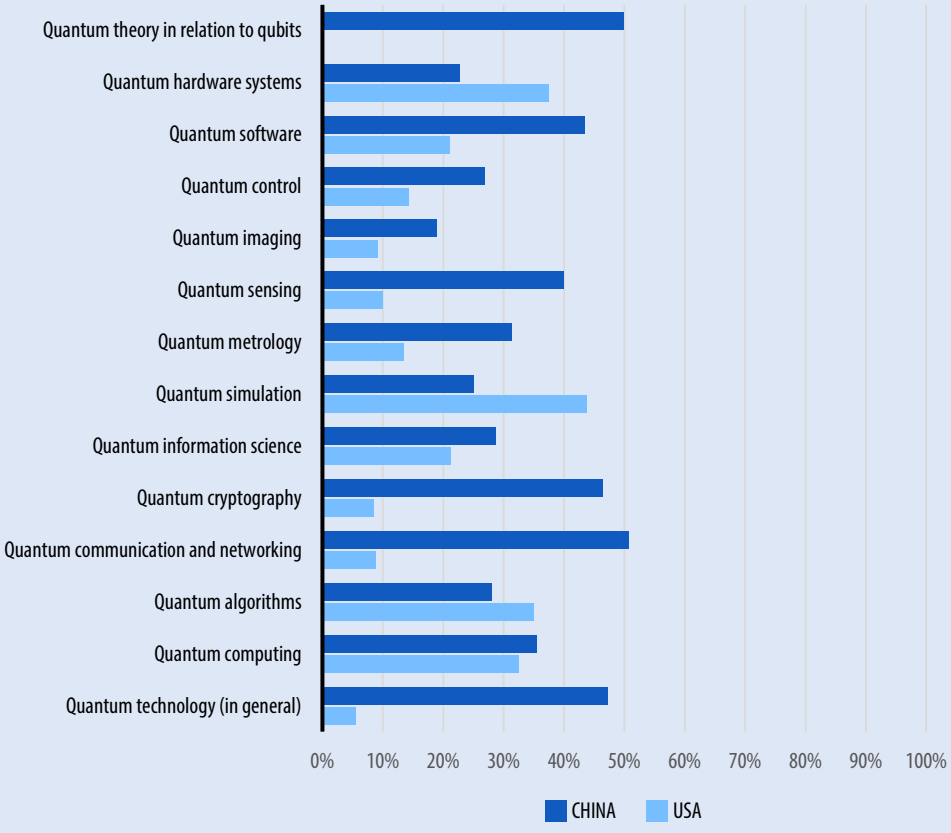
Figure 29. The global number of patent families by 13 fields of quantum technology



Based on the available data Finland has only about 20 quantum technology patent families out of which one-third were filed very recently in 2020. The focus of those Finnish patent families has been on quantum computing (8 patent families) and quantum cryptography (6), but to a lesser extent also on quantum hardware systems (4), quantum imaging (2) and quantum metrology (1). The dominant player in Finland in quantum technologies has been Nokia. Other valuable domestic players include IQM Finland.

When it comes to quantum in particular, patent data reveal very little co-ownership between the great-power nations. Co-ownership between entities in the United States and China that does show up mainly relates to IBM subsidiaries in China. Based on patent data at hand, Finland has no co-owned quantum technology patents with entities in China and very few with those in the US. Given the strategic nature of the quantum field, big players want to own all IPR themselves. As illustrated below in Figure 30, in terms of the number of patent families, Chinese actors have been more active than those from the US. However, in the fields of quantum hardware systems, quantum simulation and quantum algorithms, the US-based actors have dominated.

Figure 30. The global patent family share of USA and China by field of quantum technology data



Source of the Figures in this Infobox: PatBase Express, Bornmann et al. 2019 & VTT.

5.5 Main companies behind the Finland-great power co-ownership of patent families

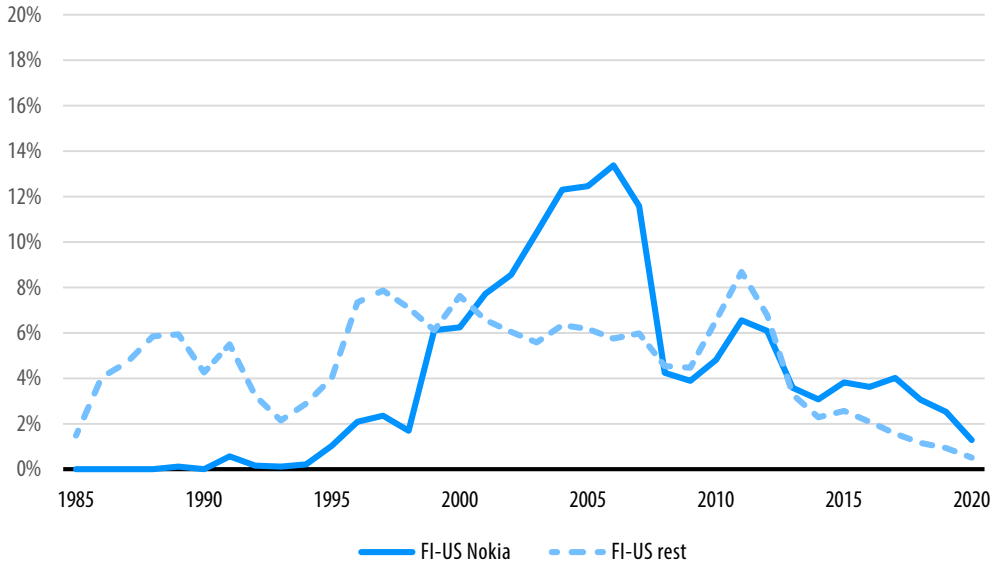
The aim of this section is to shed light on the companies that have been driving the co-owned patent activities between Finland and great powers USA and China. This section first zooms in on the role of Nokia's activities in explaining co-ownership of patent families versus the role of the activities of other companies. Subsequently, the more recent patent activities (since 2015) of other companies of interest are discussed.

5.5.1 Nokia versus the rest

Companies are often the main driving force in co-owned patent activities between Finland and the great powers – the United States and China. For Finland, the role of Nokia in particular cannot be overestimated. The importance of Nokia for Finnish patents reached its all-time high in 2019 when Nokia activities represented 40% of all patents with an assignee from Finland. Nokia is of even greater importance for the co-owned patents in Finland with entities from both the United States and China. Its activities represent 70% to 77% of all co-owned patents between Finnish and US-based and 86% between Finnish and Chinese-based entities since 2015.

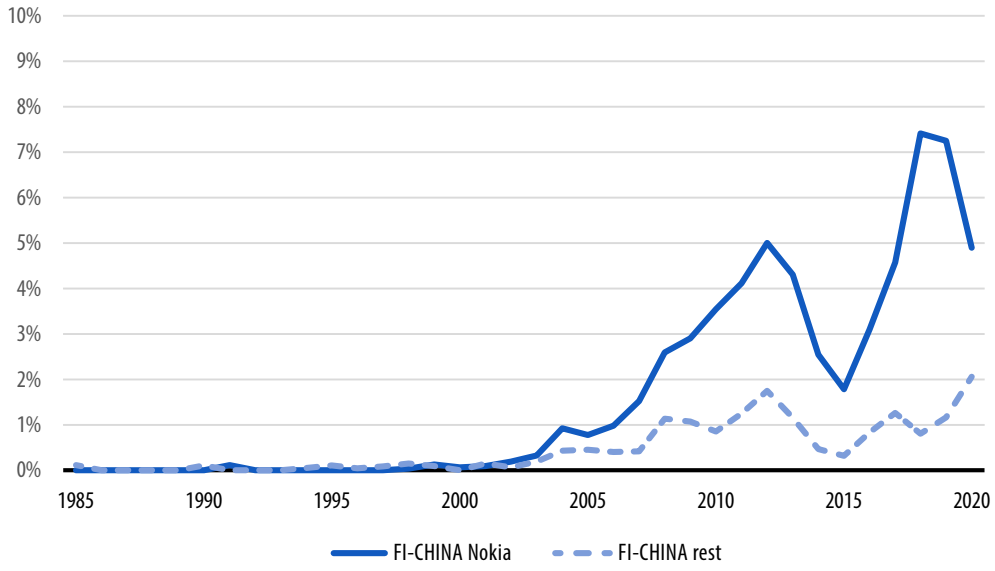
Nokia has been the main driver behind the patent co-ownership with partners based in the great powers as illustrated in Figures 31 and 32. According to our patent metric, the co-ownership between actors in Finland and the US has continuously diminished since 2010, whereas since 2015 in particular the co-ownership between those located in Finland and China has been increasing. Both trends are observable (in the Figures below) for Nokia but also for the other companies.

Figure 31. Evolution of Finland-USA co-ownership of patents: Nokia versus the rest



Sources: PatBase Express and VTT.

Figure 32. Evolution of Finland-China co-ownership of patents: Nokia versus the rest



Sources: PatBase Express and VTT.

It is remarkable that based on the data at hand, the patent co-ownership between actors in Finland and the United States has almost completely disappeared. This holds for co-ownership with Nokia, which imploded after 2005, but also for non-Nokia activities after 2010. The drop in the share of Nokia after 2015 highlighted in Figure 31 can be partly explained by the diminishing number of co-owned patents of the Nokia Corporation.

Most of the growth in activities with and in China has been driven by Nokia. While Nokia has been more active in China since 2005, an additional boost in co-ownership took place after 2015. The post-2015 rising share of Nokia illustrated in Figure 32 can mainly be explained by the patent activities of the new Nokia Shanghai Bell since 2017. Nokia Shanghai Bell is a joint venture between Nokia and China Huaxin Post & Telecommunication Economy Development Center, integrating the Alcatel-Lucent Shangai Bell Co. Ltd. and Nokia's China business. While Nokia has clearly played a significant role, activities by other companies started to grow in 2015, as also illustrated in Figure 32.

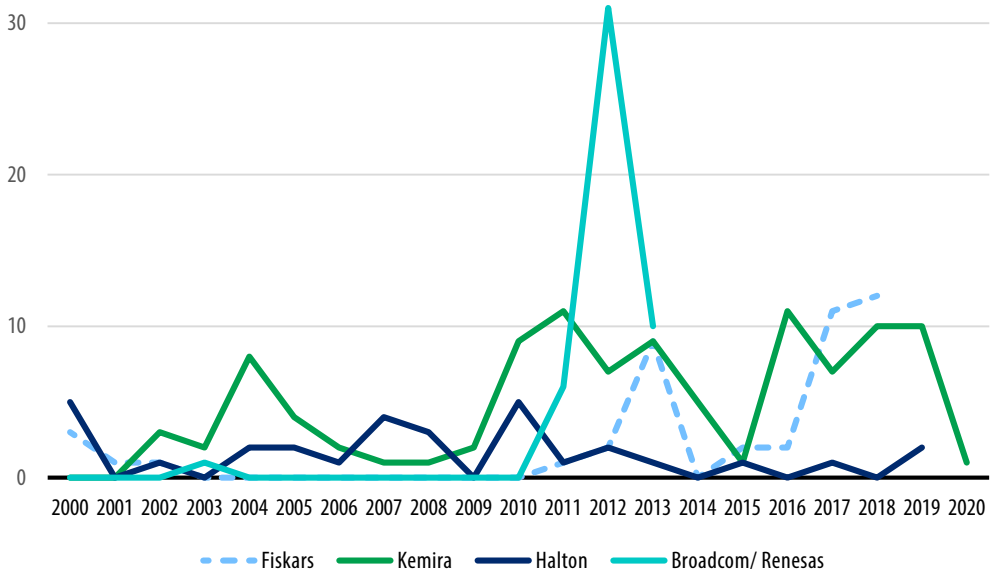
5.5.2 Other key company actors driving co-ownership since 2015

When listing the most active companies in Finland and the great powers (the United States, China) in terms of co-ownership, there are other companies whose patent activities stand out in addition to Nokia. The selection of the companies of interest in this study is based on patent applications since the priority date 1.1.2015. The following Figures plot their activities in terms of the absolute number of patent families by earliest priority year. Overall, the annual numbers of patent families of these companies are low when compared to those of Nokia.

Companies in Finland and the United States that appear to have co-owned patents are Kemira Oyj and Kemira Chemicals Inc., Fiskars Finland Oy Ab and Fiskars Brands Inc., and Oy Halton Group Ltd (see Figure 33).

In addition, Microsoft Technology Licencing LLC and Microsoft Corporation, Intel Corporation, Broadcom Corporation and Renesas Mobile Corporation have co-owned patents.

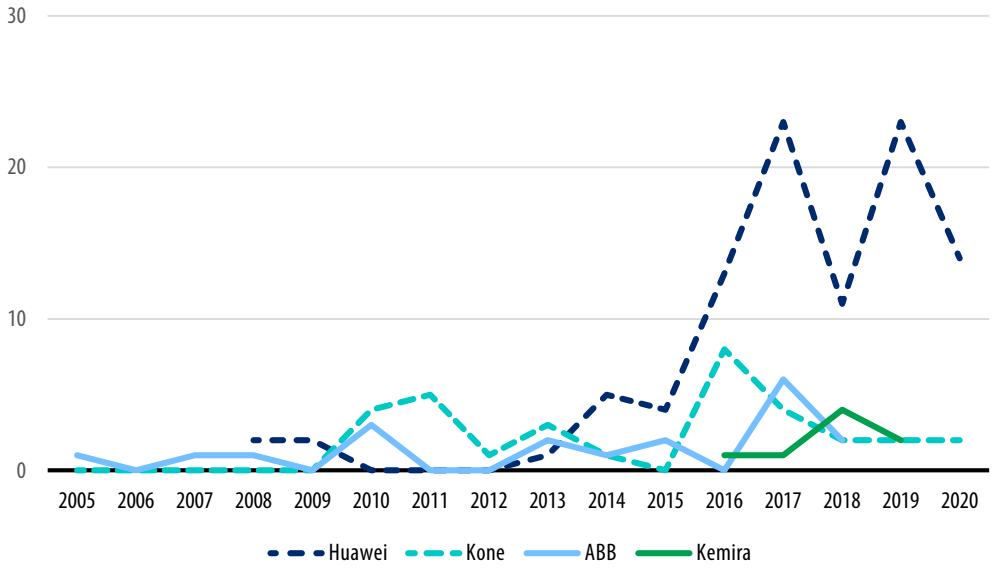
Figure 33. Evolution of Finland-USA co-owned patent families for selected companies



Sources: PatBase Express and VTT.

Figure 34 illustrates that companies from Finland and China that have co-owned patents are Huawei Technologies Co., Ltd. in particular, and to a lesser degree Kone Corp., ABB, Kemira Asia Co., Ltd and Kemira Oyj.

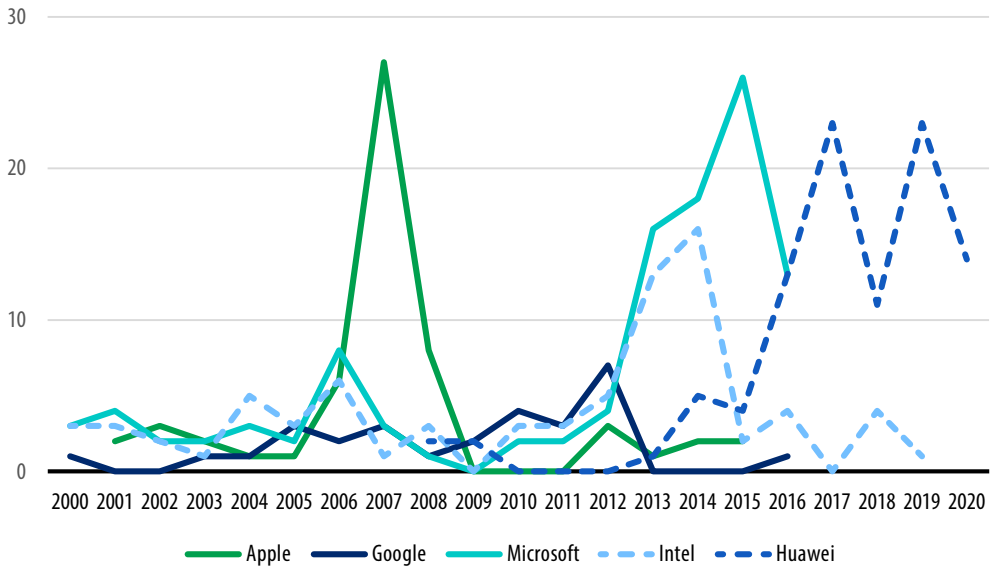
Figure 34. Evolution of Finland-China co-owned patent families for selected companies



Sources: PatBase Express and VTT.

To illustrate the role that tech giants have played in co-ownership with Finnish applicants, Figure 35 plots their absolute annual number of patent families (during the 2000–2020 period) that include at least one applicant from Finland. While there was a peak in Apple activities between 2005 and 2008, Intel and Microsoft activities peaked later on in 2014 and 2015 respectively, whereas Huawei activities started to kick in from 2015 onwards. Interestingly, almost no co-ownership activities with tech giants Facebook and Amazon could be detected based on the patent data approach utilized in this study.

Figure 35. Evolution of patent families of tech giants that are co-owned by applicants from Finland



Sources: PatBase Express and VTT.

All in all, cooperation on patents between actors from Finland and the United States and Finland and China has mainly been driven by the activities of Nokia and Huawei respectively, and hence they deserve particular attention in terms of assessments of potential risks and available options going forward (e.g. in mitigating the main risk factors). Nevertheless, other very successful companies in strategic technological areas have also been active in the past. These include well-known entities, such as Intel, Microsoft and Broadcom. Before moving on to Chapter 6, which will take a more in-depth look at acquisitions of European tech, the concluding section outlines the key takeaways from Chapter 5.

5.6 Conclusion

As the competition between great powers intensifies, it is increasingly difficult to monitor strategic technology developments. This analysis has sought to map out links between (actors and entities in) Finland and the great powers in terms of Science, Technology and Innovation (STI) activities. The analysis undertaken here depends on and is constrained by a set of proprietary publication data (Scival and Scopus) and patent data (PatBase Express and PatentSight). The tools used are not fully able to capture the activities (by actors and entities) in and between the countries, but serve as proxy metrics with caveats. We know that a significant amount of science collaboration exists without joint publishing. Similarly, while patent data are an important source for mapping technology development, one needs to be aware of other forms of immaterial property rights too, such as trade secrets.

Firstly, this analysis shows that co-operation in science is important. The dynamics between China, the United States and the European Union have been changing with the rise of China. What we often overlook is the fact that it is the European Union that is the global science leader, followed by both China and the United States, when measured by publications. This is evident when analyzing Finland, which is truly a science powerhouse relative to its size. The elephant in the room is knowledge valorization. The term refers to being able, in an efficient manner, to bring knowledge and technologies to market. Referred to as the "European Paradox", the European Union has been unable to implement effective "downstream activities in the knowledge valorization chain" (Ala and Portugal 2014). This inability ultimately leaves the European Union in a position where the large investments in top science and capability-building do not translate into broad societal benefits, or at least the economic benefits are reaped outside Europe.

Secondly, this chapter analyzed co-ownership of patent families based on the country of origin of the applicants. This approach enabled us to analyze the organizations that are behind the patent applications and that will own the patent if it is granted. The first key observation is that for patent applicants from Finland, co-owned patents with applicants from the United States used to be relatively important, but current activities are only a tenth of what they used to be in their heyday in 2003–2007. More interestingly, this major decline in visible co-ownership of patents with US applicants also applies to the Nordic countries and Germany, France and the UK, and may well indicate a tendency towards decoupling between Europe and the United States. A second observation is that in terms of co-owned patents between applicants from Finland and China, activities have been growing, especially since 2015 when the *Made in China 2025* national strategic plan was introduced. This rise in activities can also be observed in Sweden and in the UK but has been absent from the other Nordic countries, Germany and France. Technological activities in telecommunications in Finland and Sweden (e.g. 5G) have attracted considerable attention from China and are the main drivers behind the surge in

intertwined activities (Ruehlig et al. 2019; Schneider-Petsinger et al. 2019). So while our data indicate potentially accelerating technological decoupling between parts of Europe and the United States, there seems to be stronger technological coupling between parts of Northern Europe and China at the same time.

Indeed, the majority of patents of applicants from Finland that are co-owned with applicants from the United States and China are related to the activities of Nokia. While in 2019 Nokia accounted for 40% of patent applications from Finnish applicants, its activities represented 70–77% of the co-owned patents between Finland and US-based and 85–86% of the co-owned patents between Finland and China-based actors. The above-described declining trend of co-ownership with US-based actors relates to the changing role of the Nokia Corporation as a patent assignee, while the rising trend of co-ownership with Chinese entities relates to a new joint venture of Chinese Nokia activities as a result of the merger with Alcatel Lucent. However, while the role of the patent activities of other companies has been less significant in numbers, these companies have also been subject to the same trends.

One interesting case in the analysis above focused on key quantum technologies as they are expected to play a key role in what the future geopolitical map will look like. Both the United States and China have been active in the development of quantum technologies but, strikingly, patent co-ownership in these technologies between both countries is quasi-absent. In terms of the number of patent families, China has overtaken the US except in the fields of quantum hardware systems, quantum simulation and quantum algorithms, where the latter still has the lead. From a European perspective, it is alarming that Europe totally lags behind the leaders in quantum technologies. This is perhaps also illustrated by the fairly low number of patent families from applicants from Finland.

While falling global technological cooperation due to tendencies towards decoupling may slow down innovation at first, the massive competition between the great powers is expected to give an overall boost to global innovation. This technological rivalry is why Europe also needs to step up its innovation game. But only by coordinating their actions can European countries channel and scale up their investments in technology and strengthen their global negotiation power. Our analysis shows that it is precisely the European Research Area and the European partners that are most important for Finnish companies. Looking forward, advice by Ruehlig et al. (2019) is likely to be highly relevant in times of intensifying strategic competition (also in the digital domain): It is only a "united Europe that will be able to forge its own path in terms of digital technology and protect itself against possible Chinese or American retaliation".

As a key policy conclusion, the analysis suggests that the ability to develop and access critical technologies can offer a valuable rationale for innovation policy to effectively

guide investments in STI competences and infrastructure, but also in cooperation (e.g. Edler et al. 2020; Edler et al. 2021; March and Schieferdecker 2021). While national strategic investments are important to scale up efforts, coordinated European actions will be needed. However, more policy-relevant information will be needed in terms of mapping what the power competition means for separate ecosystems and which public and private investments in infrastructure and skills this will require. Setting up a national technology squad in combination with the latest insights from geoeconomics can make tech monitoring and road-mapping more effective and more valuable.

6 Chinese and US technology giants' acquisitions and technological advantage in Europe

6.1 Background[26]

This chapter focuses on the acquisitions and technological specialization of the major US- and Chinese-based technology companies shaping the global markets. The global technology giants' entry and behavior in European markets are of interest primarily for their potential longer-run influence on product market competition and consumer welfare. The ownership of intellectual property rights of key emerging technologies will further determine companies' success in global competition. Given their size and resources, technology giants' actions may have long-term effects also on European technological sovereignty and capabilities (see also Chapter 5).

We include the following companies in the group of US-based technology giants: Google, Amazon, Facebook, Apple, Microsoft, and IBM (i.e. the so-called GAFAMI). We selected the first five of the companies due to their apparent global market power that has given rise to both concerns in competition policy and initiatives to reign and regulate the companies (Koski and Pantzar 2019). We added IBM to the group of US-based tech giants, as Koski and Pantzar (2019) show in their study that IBM is among major global players in digital markets with vast health databases and a large number of acquisitions in data-intensive sectors. The sample of Chinese big tech companies include the four biggest technology companies in China: Baidu, Alibaba, Tencent, and Xiaomi (i.e. the so-called BATX).

The magnitude of research and development (R&D) investments of the technology giants provides one indicator of their size, innovation capabilities, and power in the global markets. The total R&D expenditures in Finland, covering all sectors (i.e. business and public sector and the universities), were about 6,7 billion USD in 2019. Amazon's R&D expenditures were more than 5-fold higher during the same time, and five of the US-based companies we analyzed had R&D expenditures exceeding Finland's total R&D investments.[27] The BATX companies' investments in R&D were lower than those of their

26 The analysis in this chapter uses data from the following sources: Crunchbase https://www.crunchbase.com/; Patentinspiration https://www.patentinspiration.com/; OECD https://stats.oecd.org/.

27 Only IBM's R&D expenditures were slightly lower than Finland's (i.e. about 6 billion USD in 2019).

US counterparts, but the total R&D investments of the four Chinese technology giants were more than double the Finland's total R&D investment in 2019. Furthermore, the US- and Chinese-based technology giants have constantly increased their R&D investments, becoming increasingly powerful global competitors.

Competition for and in the markets, and particularly concerning digital markets, often takes place via innovation. A large company may not acquire a smaller firm only due to the synergy and efficiency gains of technology transfer from the acquired company. The underlying intention may be to kill a competing firm's innovation or prevent future product market competition (see e.g. Cunningham et al. 2021; Kamepalli et al. 2020; Koski et al. 2020). Furthermore, the exceptional number of users of data giants' platforms generates massive data pools for their owners. The empirical findings of Koski et al. (2020) suggest that a dominant company in one market can exploit consumer data from that market to become dominant in other connected markets. The consequence may be reduced long-term innovation and competition in various digital and traditional markets and thus decreased consumer welfare.

Our data concerning acquisitions indicates that large US-based technology companies have, indeed, rather aggressively targeted and bought European companies, particularly in software and mobile business. On the other hand, Chinese big tech companies acquired only a few European firms during the 2010s. However, the number of applied patents in Europe and the United States[28] by the big Chinese technology companies has drastically increased during the second half of the 2010s.

It also seems that the global technology giants from the United States and China have a technological advantage over (their peers in) Europe and Finland in Information and Communication Technology (ICT) but not in other sample technology domains. They specialize in technologies essential for gathering, storing and analyzing personal data. Companies in Finland were more specialized in environment-related technologies compared to the US- and Chinese-based technology giants, except for climate change mitigation technologies in ICT, in which global technology giants had a clear technological advantage.

The rest of the chapter is organized as follows. Section 6.2 introduces the methodology and data. Then, we analyze Chinese and US-based technology companies' acquisitions in Europe (Section 6.3) and their technological specialization (Section 6.4). Section 6.5 concludes with the policy discussion.

28 In particular, we refer here to patent applications to the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO).

6.2 Methodology and data

We explored the annual total number of acquisitions of the US and Chinese-based technology giants and further the relative importance of acquired companies' product market areas. We calculated the relative importance of different product market areas as the number of acquisitions in the product market divided by the total number of acquisitions of the US and Chinese big tech company groups.

We extracted data concerning acquisitions during the years 2000-2018 from Crunchbase. In comparison to the datasets using traditional industrial classification (e.g. NACE codes), the Crunchbase database provides a notable advantage by its highly granular level classification of the companies' main product markets (see Koski et al. 2020 for a more detailed discussion on the Crunchbase data). The taxonomy within Crunchbase consists of 744 "industries", which further belong to 46 "industry groups." Any company can be classified into an arbitrary collection of industries based on its core business activities.

We used the revealed technological advantage (or RTA) index to measure the US- and Chinese-based technology companies' (innovation) specialization in different technology domains compared to (to their peers in) the European countries, Finland and the world. We calculate technology giants' revealed technological advantage over three geographical areas: i) Europe (i.e. EU-27 countries), ii) Finland, and iii) the world. The data concerning the Chinese and US-based technology giants' and Finland-originating patent applications to the European Patent Office and with the United States Patent and Trademark Office during 2005-2019 were extracted from the PatentInspiration, which is a commercial patent database based on the DOCDB database from the EPO. The DOCDB database contains bibliographic data from over 102 countries. We used OECD patent statistics, "Patents by technology", to extract the number of patent applications filed from Europe and the world total in different technology domains covered by the database and the total number of patent applications in all technology domains. The data OECD patent data cover the years 2005-2017.

The revealed technological advantage (RTA) index

The RTA index was calculated as the ratio of i) the number of data giants' patent applications in a particular technology domain divided by the total number of patent applications in the technology domain originating from a certain region and ii) the total number of data giants' patent applications divided by the total number of patent applications originating from a certain region as follows:

$$RTA_j = \frac{P_{cdj} / \sum P_{dj}}{\sum P_{cj} / \sum P_j}$$

where P_{cdj} denotes the number of patent applications filed by a company group c in technology domain d with the patent office of region j.

The index is equal to zero when the technology giant group has no patents in a given technology domain, and it is equal to 1 when the technology giant groups' share of patent applications in the technology domain equals its share of patent applications in all technology domains (i.e., there is no specialization). The RTA value above one indicates specialization in the given technology domain. The index is calculated on patent applications filed to the European Patent Office (EPO) and with the United States Patent and Trademark Office (USPTO).

We focus on high-technology sectors and related patenting activities. The OECD patent data were extracted from the following technology domains: ICT, environment-related technologies, medical technology, nanotechnology, and biotechnology.[29] We calculated the corresponding patent application counts in different technology domains for the Chinese and US-based sample companies in each technology domain.

29 Patents in each technology domain are identified using codes of the International Patent Classification (IPC) as described in the OECD Patent Statistics database: https://www.oecd-ilibrary.org/science-and-technology/data/oecd-patent-statistics_patent-data-en.

6.3 US tech giants acquire more aggressively European firms than China's big tech

Large global technology companies' increasing market power has raised competitive concerns, and suspicions of their abuse of market power have further resulted in various antitrust litigations in different continents. The competitive concerns expand to the technology giants' acquisitions as their buyouts of small, innovative companies may be targeted to terminate their innovation and ensure that they will not pose a future competitive threat to the acquirer (i.e. they are so-called killer acquisitions). Furthermore, the technology giants' buyouts may decrease available venture capital funding and generate lower business dynamism reducing market entry rates in their target product markets. This is the so-called "kill zone effect" for which Koski et al. (2020) find empirical evidence concerning the US-based technology giants' acquisitions in the US and European markets. In addition to competitive concerns, it has been argued that particularly Chinese acquisitions may concern critical technological capacities and lead to undesirable technology transfer (see e.g. Fuest et al. 2021), and further be used as weapons in geoeconomic competition.

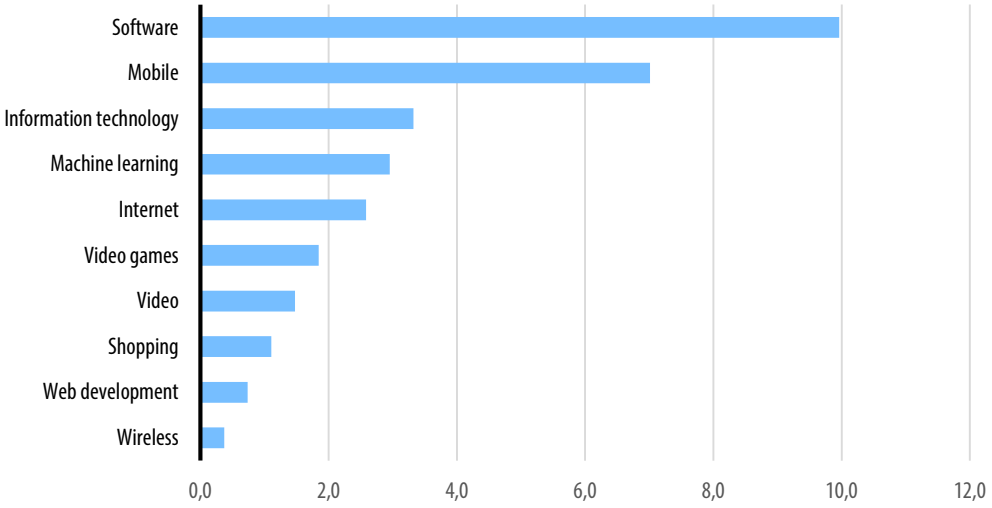
Data indicate that Chinese big tech companies have not been as aggressive acquirers in Europe as the US-based large technology companies. The BATX group made, in total, six acquisitions in Europe during the sample years that took place between 2015 and 2020. Four of the acquired companies were digital or video game developers bought by Tencent, including the Finnish-based Supercell. Alibaba bought other two companies that were active in e-commerce and software.

However, a closer look reveals that Tencent and Alibaba have made more acquisitions via their subsidiaries. Tencent has acquired eight European companies via its subsidiaries Supercell and Miniclip. All these companies were active in gaming, further enhancing Tencent's market position and consolidation in the gaming sector. Interestingly, Alibaba's subsidiaries have not made any acquisitions in Europe. All in all, however, the total number of acquisitions made by Chinese companiesin Europe has increased significantly in the 2010s, according to the Crunchbase database. Chinese-based companies bought 30 European companies in 2010-2014, compared to their 115 acquisitions of European companies in 2015-2019. These numbers do not include acquisitions made by the subsidiaries of Chinese companies.

The six US-based technology giants bought over 270 European companies from 2002-2018. Figure 36 shows the product market share index of the top ten product markets in which the US-based technology giants acquired companies between 2002 and 2018. About 10 percent of all GAFAMI acquired companies in Europe were active in software markets and about 7 percent in mobile technology. The top ten product markets

in which US-based large technology companies bought European companies further involved information technology, machine learning, internet, video and video games, shopping, web development and wireless markets.

Figure 36. The US-based technology giants' acquisitions: top 10 product markets 2002-2018



Source: Crunchbase.

The US technology giants have not acquired companies as actively in China as in Europe. According to Crunchbase data, they did not buy any Chinese companies during the 2010s, and Google's and Amazon's buyouts of two Internet companies during the 2000s were exceptions. Chinese big tech bought in total eight US-based companies, all during the 2010s. The acquired US companies comprised primarily application, software and online game developers.

6.4 Chinese and US-based big tech specialize in ICT

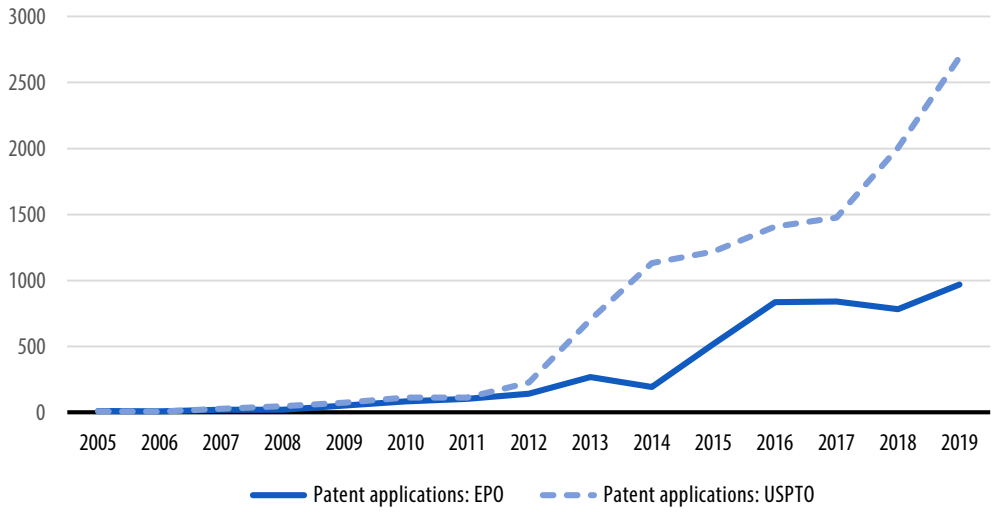
6.4.1 China's technology giants have increased patenting in the US and Europe

The patent system was initially designed to provide a temporally limited monopoly for the inventor of new technological knowledge. Firms also use patent protection for strategic purposes, for example to raise their competitors' costs to gain an advantage in the product markets and to foreclose or lessen competition. Means to raise rivals' costs via patenting include, for instance, costly patent litigations, refusing to license patents,

or offering to license the patent only in the costly package comprising a large number of patents of which most are useless to the buyer. Accumulation of a large number of patent applications claiming minor variations on competitors' key technologies is another strategic means generating uncertainty for rivals of whether their new products infringe these patents. Furthermore, in the context of geoeconomic rivalry, the ownership of intellectual property rights of key enabling technologies determines, by and large, who takes the lead in innovation and high technology.

Figure 37 shows the total number of patent applications filed by the four Chinese big tech companies to the EPO and USPTO in 2005-2019. The total number of their patent applications filed to the EPO and the USPTO during the sample years is, respectively, close to 4900 and over 11000. In the 2010s, there was a strong, upward trend in the EPO and USPTO patent applications of the Chinese big tech. The number of patent applications filed to the EPO was over 10-fold, and those filed to the USPTO over 20-fold in 2019 compared to the counts of patents filed in 2010.

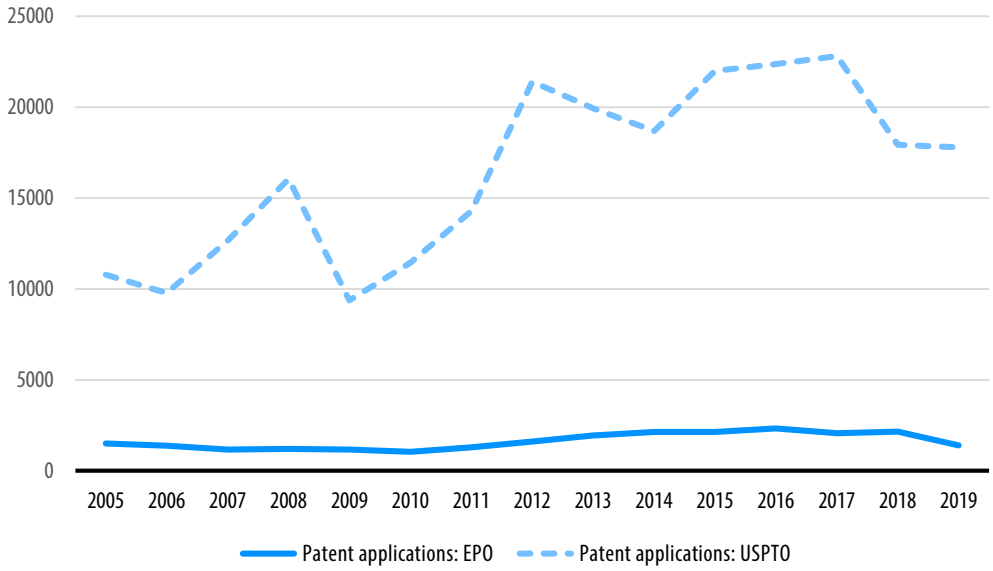
Figure 37. The total number of patent applications filed by Chinese big tech companies to the EPO and the USPTO: 2005-2019



Source: Patentinspiration.

The six US-based large technology companies filed over 23,000 patent applications to EPO and over 180,000 patent applications to the USPTO from 2005 to 2019. The total number of applied patents was considerably higher, but the growth in the number of filed patent applications during the 2010s was more moderate than among the Chinese big tech companies. As a comparison, the total number of patent applications from 2005-2019 with the USPTO (EPO) originating from Finland was over 33,700 (27,100). These numbers reflect how technology giants position as large as (small) individual countries as developers of emerging technologies in the global technology race and play an influential role in the geoeconomic competition.

Figure 38. The total number of patent applications filed by US big tech companies to the EPO and the USPTO: 2005-2019



Source: Patentinspiration.

6.4.2 Technology giants have technological advantage in ICT compared to EU and Finland

We calculated the revealed technological advantage or RTA index concerning the EPO patent applications originating from EU-27 countries, Finland, and the world. Table 15 reflects the relative specialization of the US and Chinese big tech companies in the selected major technology domains based on their patent applications filed to the EPO. The Chinese and US big tech appear both to have a substantial technological advantage in ICT in Europe. A higher technological advantage of big tech in the ICT over (their peers in) the EU-27 countries than the world total reflects that the EU countries are less specialized in the ICT technologies as the countries in the world in total. Notably, the tech giants' revealed technological advantage in ICT in Europe is much lower when compared to Finland than to the EU-27/world in the total. This descriptive finding reflects Finland's revealed technological advantage in ICT in Europe compared to the other EU-27 and world countries.

Table 15. The revealed technological advantage (RTA) indices in the selected technology domains: EPO patent applications 2005-2017

Technology field	US big tech vs. EU-27 (Finland)	Chinese big tech vs. EU-27 (Finland)	US big tech vs. world	Chinese big tech vs. world
ICT	5,50 (1,89)	5,65 (1,94)	3,75	3,84
Nanotechnology	0,34 (0,81)	0,00 (0,00)	0,25	0,00
Biotechnology	0,03 (0,05)	0,00 (0,00)	0,02	0,00
Medical technology	0,07 (0,10)	0,01 (0,01)	0,06	0,01
Environment-related technologies	0,40 (0,50)	0,13 (0,21)	0,44	0,15

Data sources: Patentinspiration, OECD.stat.

The US-based technology giants' patent applications cover a broader spectrum of technology fields: they have filed patents to the EPO, unlike their Chinese counterparts, also in the fields of nanotechnology and biotechnology. Also, the US-based companies' relative shares of patent applications involving environment-related technologies and medical technology are substantially higher than those of the Chinese companies. Nevertheless, the data reflects that European companies hold a technological advantage in environment-related innovation in Europe. Compared to the global technology giants, Finland's specialization in selected technology domains does not seem to deviate much from other European countries. The EU-27 countries as total seem to be more specialized in nanotechnology than Finland.

Table 16 shows the RTA indices for the patent applications filed at the USPTO. The RTA values for ICT indicate that the technological advantage of global technology giants in the ICT domain is notable also in the United States. The RTA indices get lower values in the ICT technology domains than the patented technologies in Europe though. These descriptive findings hint that the global technology giants face more competition in the ICT technology areas in the United States than in Europe.

Table 16. The revealed technological advantage (RTA) indices in the selected technology domains: USPTO patent applications 2005-2017

Technology field	US big tech vs. EU27 (Finland)	Chinese big tech vs. EU27 (Finland)	US big tech vs. world	Chinese big tech vs. world
ICT	3,28 (1,60)	3,50 (1,70)	2,28	2,44
Nanotechnology	0,17 (0,89)	0,00 (0,00)	0,12	0,00
Biotechnology	0,03 (0,06)	0,05 (0,09)	0,03	0,05
Medical technology	0,05 (0,09)	0,08 (0,13)	0,05	0,07
Environment-related technologies	0,33 (0,45)	0,13 (0,17)	0,42	0,16

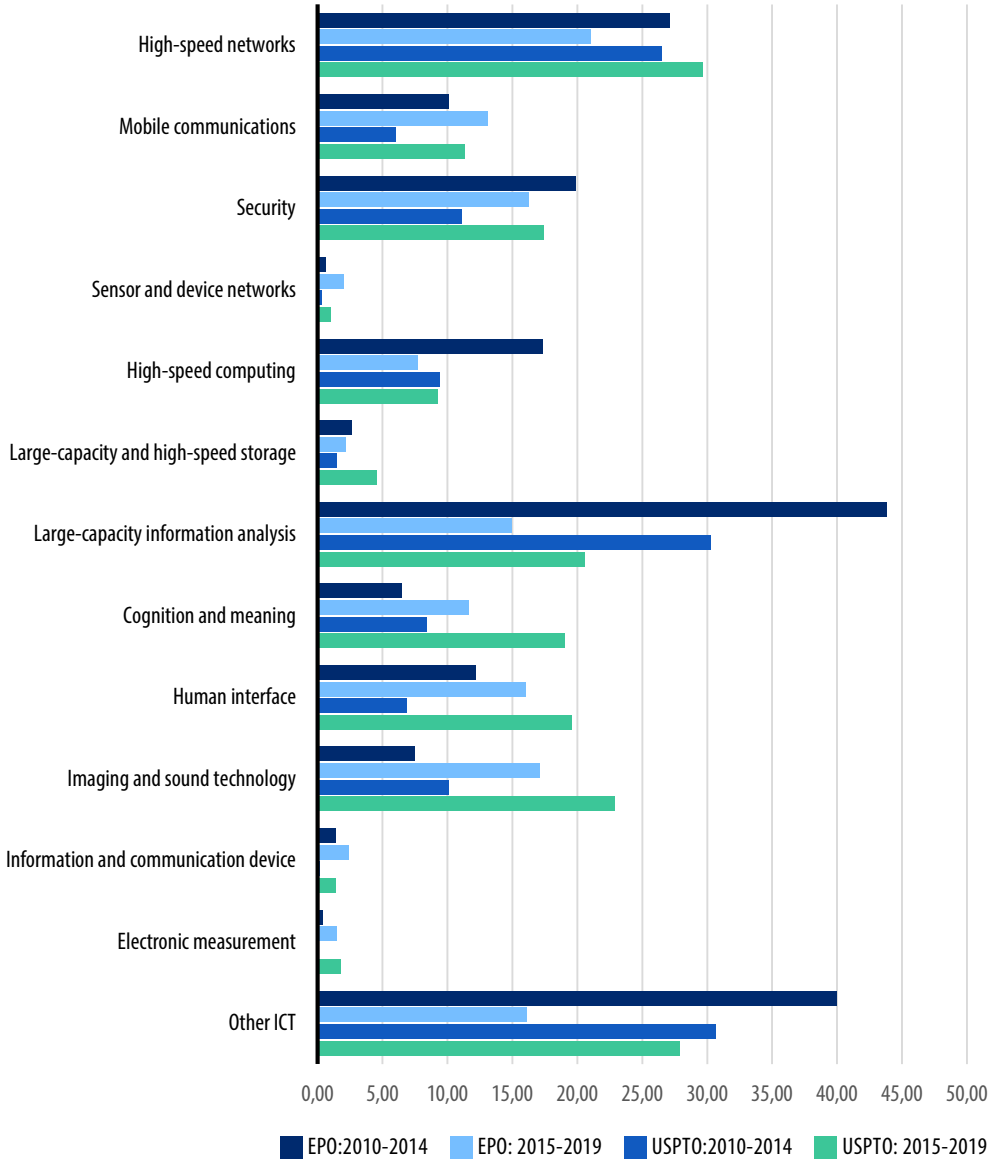
Data sources: patentinspiration, OECD.stat.

6.4.3 Global technology giants specialize in technologies essential for analyzing personal data

Global technology giants have been specialized in ICT, but also Finland is profiled as a high-tech and ICT country (see Section 5.4). To better understand specialization patterns of Chinese and US-based technology giants versus the Finnish market players in ICT, we next explore in more detail the patent applications among ICT sub-domains during the 2010s.

From 2010 to 2014, about 44% (30%) of the patents filed by the Chinese big tech companies to the EPO (USPTO) comprised large-capacity information analysis technologies that enable dealing with large amounts of data for analysis. Approximately 40% (31%) of the filed EPO (USPTO) patent applications involved other ICT technologies, about 27% (26%) were related to high-speed networks and 20% (11%) to security.

Figure 39. Shares of ICT patent applications filed by the Chinese big tech companies to the EPO and USPTO: 2010-2014 vs. 2015-2019



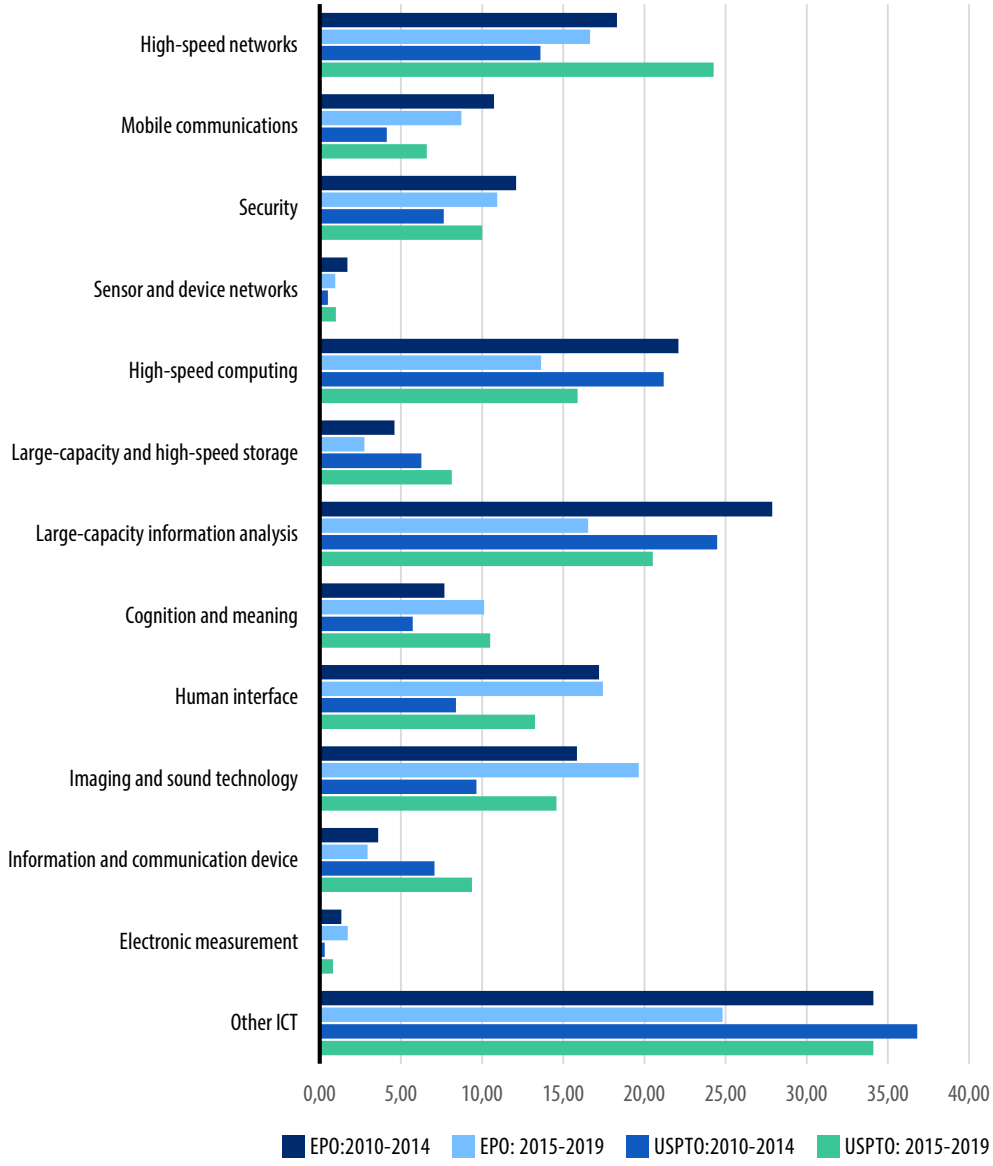
Source: Patentinspiration.

The Chinese big tech companies' patent applications filed with the EPO between 2015 and 2019 were more evenly distributed across different technology categories than during the first half of the 2010s. High-speed networks and large capacity information analysis technologies were still among the most common technology groups. However, the relative importance of mobile communications, cognition and meaning, human interface

and imaging, and sound technology increased in the filed EPO patent applications of Chinese big tech during the second half of the 2010s.

During the first half of the 2010s, the list of the most important technologies among the filed patent applications of the US technology companies resembled that of the Chinese tech giants. The list includes large-capacity information analysis technologies, high-speed networks, and other ICT technologies. Also, high-speed computing technologies are covered in over 20% of the patent applications of the US-based technology giants and human interface and imaging and sound technology in over 15 percent of filed EPO patent applications during 2010-2014.

Figure 40. Shares of ICT patent applications filed by the US big tech companies to the EPO and USPTO: 2010-2014 vs. 2015-2019



Source: Patentinspiration.

During the second half of 2010, the order of importance of technologies among the patent applications filed by the US-based technology giants remained relatively similar to the first half of 2010. The relative importance of patented ideas concerning large-capacity information analysis has decreased, though, and the importance of the patent applications involving cognition and meaning technology and imaging and sound technology had slightly increased.

Table 17. The revealed technological advantage (RTA) indices in the ICT domains: EPO patent applications 2005-2019

Technology field	US big tech vs. Finland	Chinese big tech vs. Finland
High-speed networks	1,00	1,46
Mobile communications	0,49	0,58
Security	2,47	3,53
Sensor and device networks	0,96	1,34
High-speed computing	11,28	8,82
Large-capacity and high-speed storage	4,10	1,61
Large-capacity information analysis	5,98	7,33
Cognition and meaning	5,58	5,17
Human interface	2,69	2,03
Imaging and sound technology	2,29	1,64
Information and communication device	1,08	0,43
Electronic measurement	0,81	0,36
Other ICT	6,48	5,55

Data sources: patentinspiration, OECD.stat.

Table 17 indicates that the US- and Chinese-based technology giants have, by and large, similar revealed technological advantages in the ICT domains compared to Finland. The sample technology companies are specialized in most of the ICT domains. Finland has a technological advantage in the mobile communications, sensor and electronic measurement domains, and sensor and device network compared to the US-based big tech and information and communication devices compared to the Chinese technology giants.

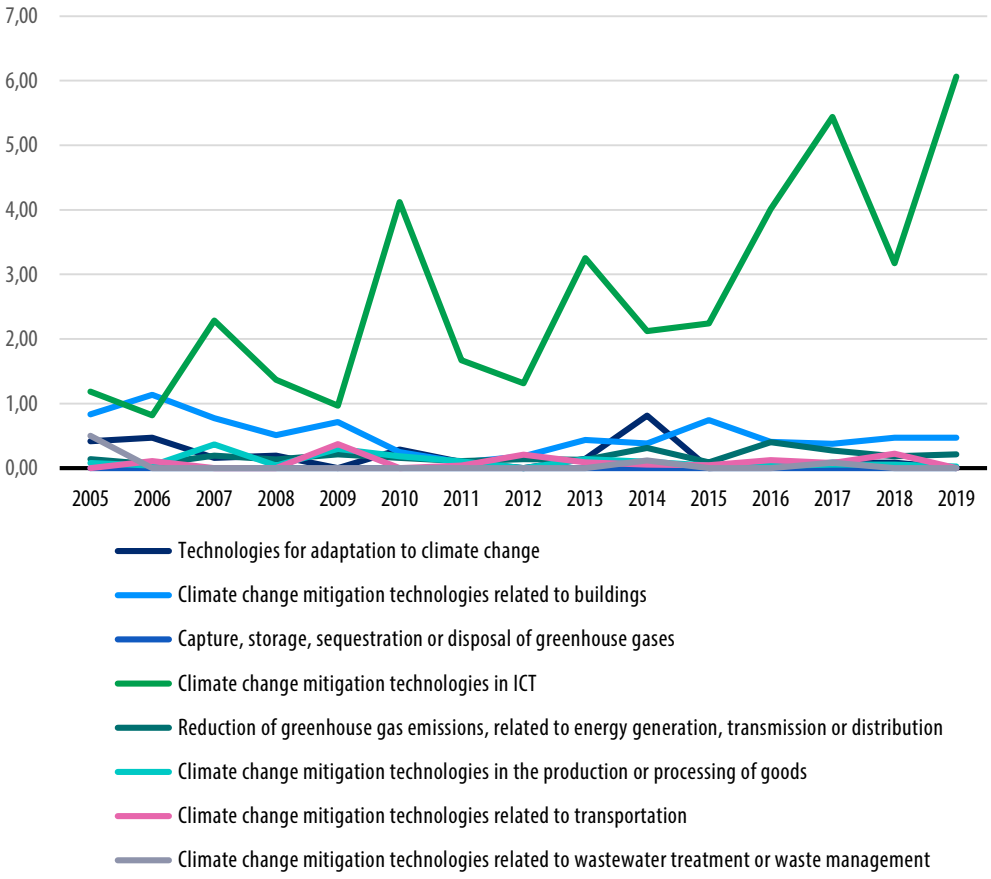
It is also notable that both US and Chinese technology giants are intensely specialized, compared to Finland, in ICT technologies that are important in gathering, storing, and analyzing data. Such ICT sub-domains comprise high-speed computing, large-capacity and high-speed storage, and large-capacity information analysis. Furthermore, their patent applications reveal specialization, particularly in technologies essential for analyzing personal data such as cognition and meaning, human interface and imaging, and sound technology.

6.4.4 Technology giants specialize in climate change mitigation technologies in ICT

We next take a more detailed look into environment-related technologies in which Finland was more specialized than the global technology giants. It is apparent that also global technology companies are paying increasing attention to sustainability. Microsoft, for instance, announced in January 2020 a "new environmental sustainability strategy focused on carbon, water, waste, and ecosystems" and told that it would invest $1 billion over the next four years in new technologies and innovative climate solutions to reduce and ultimately remove Microsoft's carbon footprint (Microsoft 2020).

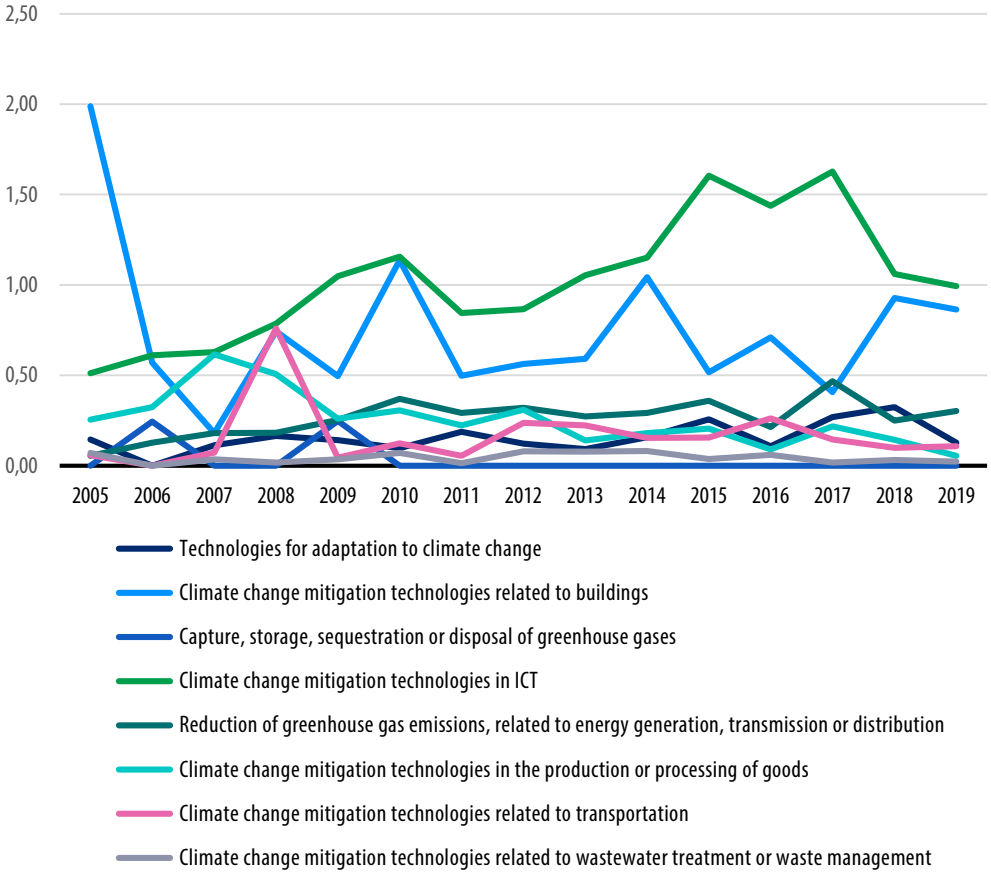
Figures 41 and 42 indicate that GAFAMI companies invest in research and development, producing patented ideas, particularly in climate change mitigation technologies in ICT (i.e. information and communications technologies aiming to reduce their own energy use), and had a clear technological advantage in this domain compared to Finland. The data further show that the specialization of the US-based technology giants has increased in this environmental technology domain, and that Finland was, instead, specialized in other environment-related technology domains.

Figure 41. The revealed technological advantage (RTA) indices of the US-based technology giants vs. Finland in the environment-related technology domains: EPO patent applications 2005-2019



Data sources: patentinspiration, OECD.stat.

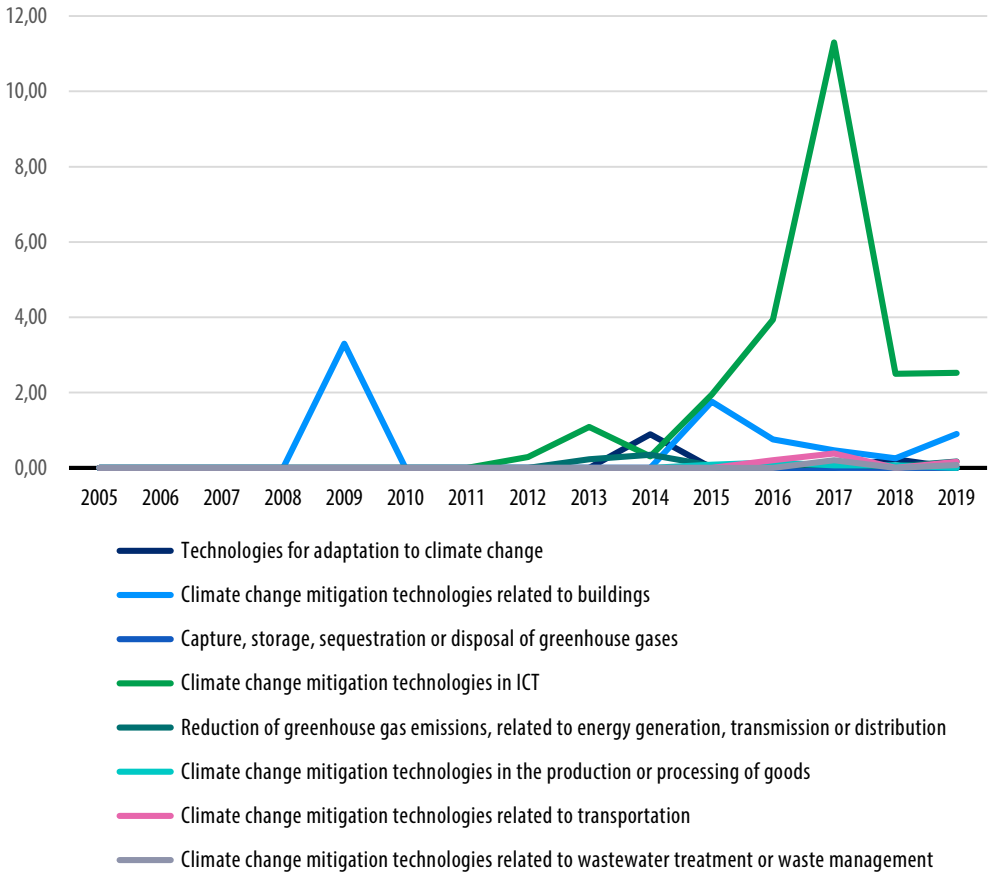
Figure 42. The revealed technological advantage (RTA) indices of the US-based technology giants vs. Finland in the environment-related technology domains: USPTO patent applications 2005-2019



Data sources: patentinspiration, OECD.stat.

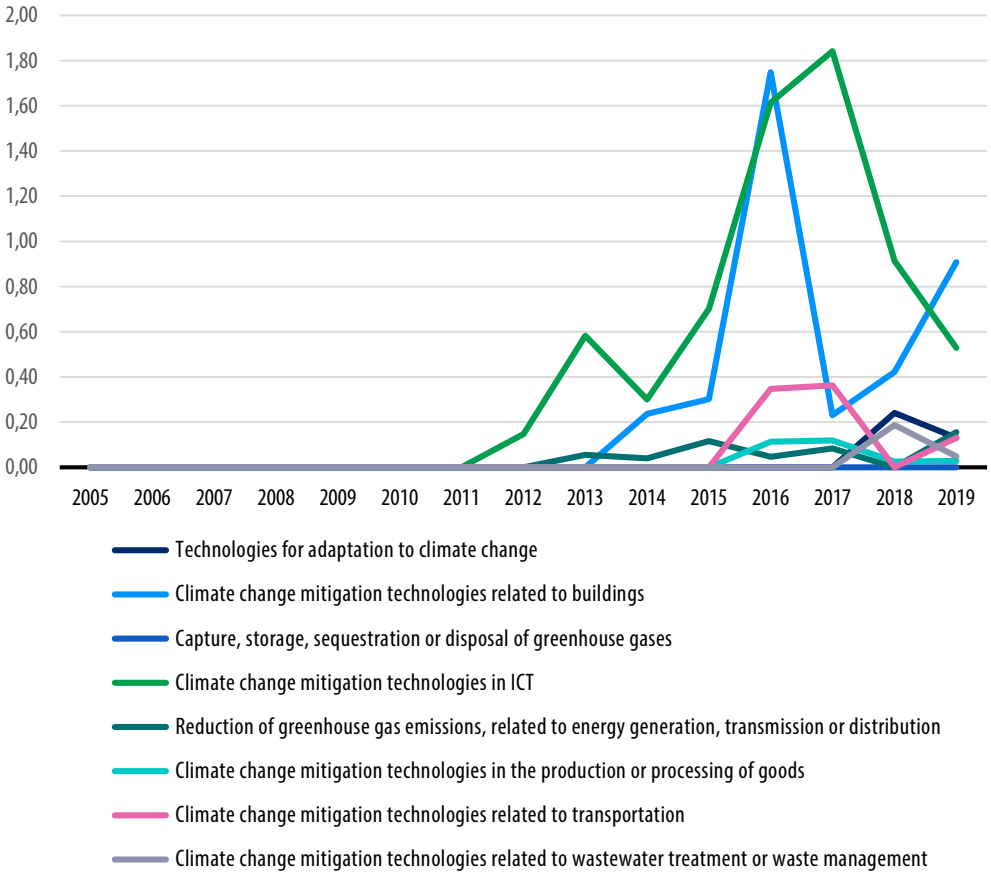
The revealed technological advantage in Figures 43 and 44 show that the Chinese-based technology giants did not file any patent applications either to the EPO or with the USPTO in most environment-related technology domains until the 2010s. However, they have also expanded patenting in various environment-related technology domains during the second half of the 2010s. During 2015-2019, they had a technological advantage compared to Finland in climate change mitigation technologies in ICT in the European markets and 2016-2017 in the US markets. Finland was specialized in other environment-related technology sub-domains compared to the BATX companies.

Figure 43. The revealed technological advantage (RTA) indices of the Chinese-based technology giants vs. Finland in the environment-related technology domains: EPO patent applications 2005-2019



Data sources: patentinspiration, OECD.stat.

Figure 44. The revealed technological advantage (RTA) indices of the Chinese-based technology giants vs. Finland in the environment-related technology domains: USPTO patent applications 2005-2019



Data sources: patentinspiration, OECD.stat.

6.5 Conclusion

The chapter has analyzed large US and Chinese-based tech companies' acquisitions on the European markets and further their specialization in different technology domains. We find that the large US-based technology companies have rather aggressively targeted and bought European companies, particularly in software and mobile business. Instead, the Chinese big tech companies have acquired only a few European firms. The data, however, indicate that the large Chinese technology companies' buyouts have rapidly increased during the past years, while part of them was undertaken via the subsidiaries of the Chinese-based companies. Furthermore, heavily government-subsidized, particularly Chinese-based, companies may gain an unfair advantage due to the public subsidies from their home countries and distort competition when acquiring companies in the EU area.

These trends are alarming as the global technology giants' acquisitions may terminate innovation and further kill their potential competitors, with detrimental long-term consequences on competition and consumer welfare. Technology giants continue to expand their business to and acquire companies from various sectors, including, for instance, the energy sector, manufacturing, health care, and financial services. Consequently, their actions can be harmful to competition in numerous sectors comprising those in which European or Finnish companies tend to have a competitive advantage.

Competitive concerns on the actions of the global technology giants in Europe are justified and already addressed and discussed in the EU. The proposed *Digital Markets Act* (DMA) by the European Commission is designed to ensure that the large platform companies that act as "gatekeepers" do not abuse their dominant position. However, it does not enable the Commission to prevent gatekeepers' acquisitions. The *EC Merger Regulation* (see Council of the European Union 2004) gives the Commission the power to intervene and prevent a merger or require changes to the merger arrangements, but only if the concentration exceeds certain turnover thresholds.

The proposed regulation of the European Parliament and the Council on foreign subsidies distorting the internal market (European Commission 2021i) would oblige the buyer to notify the Commission in advance of its acquisition if it is established in the EU and has a turnover in the EU of at least EUR 500 million and non-EU financial support of at least EUR 50 million in the previous three calendar years. For such acquisitions, the Commission would assess whether foreign aid distorts the internal market by improving the company's competitive position in the internal market. In addition, the Commission would have mandate, on its own initiative, examine existing acquisitions or smaller acquisitions below the turnover threshold, and require their termination if found that they distort competition in the internal market as a result of non-EU aid received during the previous three years.

The EU-wide regulation is needed to address the so called killer acquisitions of technology giants (and those generating the kill zone) and such acquisitions and concentrations that give an unfair competitive advantage and distort competition due to the acquirer's public subsidies outside the EU area. However, it is vital to ensure that regulations do not lead to protectionism, sheltering European companies from fair international competition. The proposed regulation concerning foreign subsidies distorting the internal market is not sufficient as the regulation does not concern large technology giants' acquisitions distorting competition in case a non-EU country does not financially subsidize the acquirer. A possible way to tackle the problem EU-wide is to amend the proposed DMA or existing merger regulation.

Our data further show that the number of applied EPO and USPTO patents of the big Chinese technology companies has drastically increased during the second half of 2010. The US- and Chinese-based technology giants had a technological advantage over Europe and Finland in ICT. The most common ICT technologies in the patents filed by the Chinese and US technology giants included large capacity information analysis and high-speed network technologies. Finland was specialized in environment-related technologies compared to the US- and Chinese-based technology giants, except for climate change mitigation technologies in ICT, in which global technology giants had a clear technological advantage.

The importance of technologies used for gathering, transmitting and analyzing personal data, such as images and sound data, increased among the filed EPO patent applications of both the US and Chinese technology giants during the 2010s. This reflects technology giants' investments in new technologies needed to exploit their continuously developing data-based business models. These developments further relate to the need for regulatory actions to reduce the technology giants' exclusive control over the massive datasets they collect.The proposed *Digital Markets Act* obligates gatekeepers to provide business users, or their authorized third parties, free of charge with effective, high-quality, continuous and real-time access and use of aggregated and non-aggregated data provided for or generated in the context of the relevant core platform services.

Policymakers should aim to ensure that the DMA regulation will be approved in the proposed format regarding the technology giant's data sharing obligations. This would mean that plenty of data exclusively in possession of technology giants would also become available to European companies in digital markets. Access to gatekeepers' data would provide new possibilities to compete and innovate in the digital markets for European and Finnish companies. Start-ups with data-based business models have the potential to scale up quickly, and the productivity growth potential of the data-based business is enormous. Finnish companies should now heavily invest in know-how, technologies and business models exploiting digitalization and data. At the same time, technology giants' continuous development and specialization in new technologies targeted to gather, store and analyze personal data further emphasize the importance of regulations protecting consumer privacy.

PART III

7 Conclusion: Implications for Finland

This report has investigated the risks and opportunities for the European Union in general, and Finland in particular, of the ongoing geoeconomic competition between the United States and China. It discusses Europe's exposure to geoeconomics, and particularly Finland's preparedness to adapt to the era of geoeconomic rivalry. To this end, the report points to some worrying dynamics for both Finland and Europe more broadly, but also avenues for dealing with risks, and even some opportunities.

Global interdependence, and the global trade system embodying it, have traditionally been seen as sources of peace and stability. However, the currently intensifying great-power competition between the United States and China is threatening to challenge this view. In this new environment of growing power politics and national security, economy and security are increasingly intertwined. What was previously seen as positive interdependence is now viewed as potentially dangerous dependence. This, in turn, makes nation states vulnerable to the influence that others can exert due to complex connectivity. This entails strategic competition where geoeconomics – the leveraging of economic interdependencies for power political ends – is increasingly important.

As indicated by the well-known discussion related to 5G technology, the new era of geoeconomic competition has also expanded to the technological domain, where the importance of strategic autonomy and state control seems to be continuously growing. While the competition over the strategic control of technology takes place mostly between the United States and China, other states cannot escape its impacts and implications. Europe, Finland and their technology companies are susceptible to geoeconomic risks, which can influence market entry and market operations. Hence, this report has sought to improve the existing understanding of the interdependencies and risks related to contemporary technological competition, as well as come up with better ways to recognize and evaluate geoeconomic risks.

Chapter 2 showed how an effective defence against malign economic relations starts with a more resilient and competitive economy at home, reinforced by security of supply and resilience. Finland should always assess risks that have the potential to impact its strategic and national security interests in a strategic frame. For instance, national policies on emerging and disruptive technologies (EDT) are increasingly not only economic or science policy issues but also foreign, security and defence policy issues. In addition, the Finnish economy and businesses are increasingly vulnerable to geoeconomic risks. Consequently, Finland requires a set of holistic and novel measures for identifying, assessing, monitoring and mitigating them. To this end, Finland should establish a joint situation picture of geoeconomic risks between the public and private sectors, which would be shareable with its international partners when appropriate. This should incorporate geoeconomic risk indicators, coupled with a living situation picture of critical dependencies in trade, finance, supply chain, critical technology, and data. Finland should also adopt a more strategic approach to technical standards in critical technologies. This would entail utilizing the Finnish Standards Association's (SFS) existing competencies and programmes, as well as incentivizing companies to invest in standards. Such an approach should be synchronized with the emerging EU approaches to technical standards and leverage the shared values and interests with the US. Finally, companies that experience geoeconomic risks must be able to seek advice and support from the government and ideally peers in a safe and supportive environment. The government could consider setting up a trusted information-sharing network supported by government officials and suitable experts, for example under the auspices of the appropriate business associations.

Chapter 3 argued that, as a trade-dependent and open economy, it is in Finland's strategic interests to promote multilateral rules-based frameworks in order to maintain as open a global economy as possible, but also to seek the means to hedge against the potential balkanization resulting from the negative aspects of China's rise and the ongoing decoupling between China and the United States. Due to the increasing interdependency between various policy areas, Finland should consider following the EU's emerging approach to integrating various policy areas concerning the strategic environment. Such a holistic approach would integrate the requirements of external and internal, as well as "hard" and "soft" security. The *UK Integrated Review* (GOV.UK 2021) provides a pertinent example of such an approach. The *CER Directive* offers an opportunity for Finland to leverage its strong tradition in security of supply and modernize it towards a more coherent strategic framework covering all relevant resilience policy contexts, including risks imposed by geoeconomics. It also provides Finland with an opportunity to influence the emerging European resilience policy framework towards interoperability with and support for the national policy framework. Moreover, the intra-European differences are also broad, as can be interpreted from the Digital Economy and Society Index (DESI) scores within Europe. Still, much is already being done as can be seen from the discussions around the European Digital Single Market, security integration and continuously evolving

regulation. Nonetheless, Europe has strong institutions, venture capital ecosystems and economic power in general, as well as a long history of collaboration, which all play their own part in protecting Europe from geoeconomic risks, and ensuring that the required resources are available for improving Europe's position in the global race.

Chapter 4 showed how direct economic relations (trade, foreign affiliates) with the United States are more important for the Finnish economy than those with China. Indirect economic relations via the EU underline this conclusion. Finnish strengths appear to be in the areas of telecommunications, computer, and information services, with Finland's exports to the United States jumping by 89% in 2020. While likely an anomalous year, it shows Finland's competitiveness in these sectors of growing global importance and offers avenues for increased collaboration with the US. China's importance for Finland grew during the first decade of this century, but during the last ten years the US has grown in relative importance in comparison. At the same time, the share of high-tech electronic manufactures in Finnish exports to China has diminished markedly and been replaced by agro-based manufactures, mainly pulp. Chapter 4 also indicates how the United States is also a more important market area for Finnish multinational enterprises (MNEs) than China, and that the gap has been increasing in recent years. Despite the vast business opportunities available in China, Finnish companies prioritize the US market. However, in the case of foreign MNEs in Finland, the reverse applies, with Chinese enterprises becoming relatively more important. Policies that support R&D investment, including from the public sector's perspective investments in education, basic research, and research infrastructure, are needed to improve Finland's ability to position itself in the geoeconomic competition. Further liberalization of international trade and an emphasis on level playing fields are likewise needed to ensure future competitiveness.

Chapter 5 assessed Finland's technological capabilities and cooperation in research and development with the United States and China. It highlights the growing importance of science and technology in the context of geoeconomic competition, particularly how China has overtaken the United States in the number of publications and patent applications. In the technological sphere, developments thus indicate movement towards a multipolar system in which the US and China in particular compete for leadership. At the same time, the analysis shows how the European Research Area and European partners are most important when it comes to Finnish science, research and development cooperation. A key observation made in this chapter is that, compared to its European peers, Finland's high co-owned patent share with China is exceptional and mainly driven by Nokia and Huawei. On the one hand, Nokia's solutions offer an alternative to countries that sanctioned Huawei – not least the USA – while on the other hand, Nokia has invested heavily in China-based activities. Current joint Finland-China activities should be interpreted against the signing of a Joint Declaration in 2017 and a Joint Action Plan for 2019–2023. To understand the cooperation dynamics between Finland and the USA and

between Finland and China, the strategic capability and critical technology development of Finland's heavyweight Nokia has been and is expected to continue to be of crucial importance. The patent data analysis in Chapter 5 highlights that the bulk of China-Finland activities relate to Nokia operations in China. The main great-power interest in Finnish capabilities relates to Nokia. The Finnish policy mix therefore needs to continue to pay close attention to Nokia's activities. At the same time, Huawei's activities in Finland need to be closely monitored. A key observation made in the analysis is that co-owned patent dynamics signal a decoupling trend between Finland and the USA. This decoupling trend is also indicated for Finland's European peers. While the share of co-owned patents between Finland and the USA used to reach almost 20% in 2007, co-owned patent shares have recently dropped below 3%. This overall USA-EU trend picked up after 2011 and is interpreted as a strategic change towards centralized patent portfolios owned by US companies.

To maintain and develop technological competences, Finland needs to safeguard its access to critical talent and infrastructure. This implies that there is an even stronger need for policy coordination across ministries to ensure that crucial information is shared more effectively and constrained resources are invested in a coherent way (Deschryvere et al. 2021). To illustrate the importance and complexity of policy coordination, one can think of celebrated FDI attraction policies that may unintentionally lead new foreign subsidiaries to limit the access that Finnish companies have to critical talent. There is a clear risk that even in the case of a significant national ambition and budget for technology sovereignty, Finnish companies will no longer be able to attract sufficient talent as the war for talent has never been so intense and multi-faceted. More specialization in niches and more strategic international cooperation may offer a way forward. As mapping technology competences becomes increasingly important, paradoxically it also becomes increasingly difficult. To tackle this challenge, we recommend setting up the Finnish Observatory of Critical Technologies (cloud version), which can cooperate closely with its EU counterpart(s) and inform the government on its strategy and policy mix. However, rolling out the ambition to develop or acquire competences to identify, understand, assess, develop, advance, produce, use, and incorporate critical technologies (March & Schieferdecker 2021) will require a stable and long-term political and budgetary commitment. Such a renewed strategy would be a good fit for the Finnish government's target of 4% by 2030 (see also Ali-Yrkkö et al. 2021). Given their strategic importance, quantum technologies can serve as a first case in raising Finland's technological competences game.

Chapter 6 focused on analyzing the acquisitions by and technological advantage of Chinese and US technology giants in Europe. The analysis showed how Chinese and US-based global technology giants, by specializing in technologies essential for gathering, storing and analyzing personal data, have gained a technological advantage over Europe

and Finland in some crucial sectors such as ICT, where Finland has previously profiled itself with success. The number of EPO and USPTO patents applied for by the big Chinese technology companies has been growing expeditiously in recent years, and neither Europe nor Finland appear to be at the global technological forefront. Part of the problem in Europe seems to be a lack of so called "knowledge valorization". The European Union, including Finland, has struggled to effectively bring knowledge and technologies to market, and the economic benefits of European innovation often seem to be realized outside Europe. Policymakers should aim to ensure that the *Digital Markets Act* will be approved in the proposed format regarding the technology giants' data-sharing obligations. This would mean that a great deal of data exclusively in the possession of technology giants would also become available to European companies in digital markets, and provide them with new opportunities to compete and innovate in these markets. The EU-wide regulation is needed to address (a) the killer acquisitions of technology giants, as well as those generating the kill zone by creating market entry barriers, and (b) the acquisitions and concentrations that give an unfair competitive advantage and distort competition due to the acquirer's public subsidies outside the EU area. It is vital, however, to ensure that regulations do not lead to protectionism, shielding European companies against fair international competition. The proposed regulation concerning foreign subsidies distorting the internal market is not sufficient as the regulation does not concern large technology giants' acquisitions distorting competition in case a non-EU country does not financially subsidize the acquirer. A possible way to tackle the problem EU-wide is to amend the proposed *Digital Markets Act* or existing merger regulation.

Appendices

Productive capacities

UNCTAD has calculated indices for productive capacities, shown in the following graphs for China, the USA, Finland, and Germany in 2000–2018. The overall Productive Capacities Index (PCI) is the geometric average of the values of eight PCI categories: natural capital, human capital, energy, transport, ICT, institutions, structural change, and private sector. These are explained in the accompanying Infobox.

It is not surprising that China's PCI rose the most in 2000–2018 as its economic development has been quite strong. Its advances have been strongest in transport, human capital, and ICT, but also importantly in structural change. These are signs of significant steps in fields that support a modern economy and technological development.

The more developed economies – the USA, Finland, and Germany – have also seen their overall PCIs rise, but much more modestly as their starting levels were higher. Finland is the laggard among these countries. All three countries have undergone the strongest development in ICT and human capital. Between 2000 and 2018, institutions weakened in Finland and the USA, and the private sector in Germany.

The overall PCI is highest in the USA (50.5 points), closely followed by Germany (47.4) and more distantly by Finland (41.8) and China (40.0). The Western democracies have their strongest lead over China in institutions, followed by human capital and ICT. China has the lead in natural capital. While catching up will become more difficult, China will undoubtedly continue to make advances towards the global frontier in terms of the overall index.

Note, for example, that ICT in this index estimates the accessibility and integration of communication systems within the population. It does not refer to any specific industry that produces ICT equipment or software. However, widespread access to communication systems enables the use of ICT technologies and thereby a more developed digital economy and services.

Productive capacities index (PCI) by UNCTAD

The overall Productive Capacities Index (PCI) by UNCTAD is the geometric average of the values of the following eight PCI categories.

Human capital captures the education, skills and health conditions possessed by the population, and the overall research and development integration in the texture of society through the number of researchers and expenditure on research activities. The gender dimension is reflected by the fertility rate which at each increase reduces the human capital score.

Natural capital estimates the availability of extractive and agricultural resources, including rents generated from the extraction of the given natural resource, minus the cost of extracting the resource. To capture commodity dependence, natural capital decreases as the material intensity increases. Some of the indicators in natural capital are measured in relation to the size of the economy. Therefore, to ensure the correct interpretation of changes in the natural capital component, it is useful to review the data for individual indicators included in the component.

Energy measures the availability, sustainability and efficiency of power sources. For this reason, it is composed of the use of and access to energy, losses in distribution and renewability of energy components and sources, and includes the GDP generated by each unit of oil to further highlight the importance of optimal energy systems.

Transport measures the capability of a system to take people or goods from one place to another. It is defined as the capillarity of the road and rail network, and air connectivity.

ICT (Information and Communication Technology) estimates the accessibility and integration of communication systems within the population. It includes fixed line and mobile phone users, internet accessibility and server security.

Institutions aim at measuring political stability and efficiency through regulatory quality, effectiveness, success in fighting criminality, corruption and terrorism, and safeguarding citizens' freedom of expression and association.

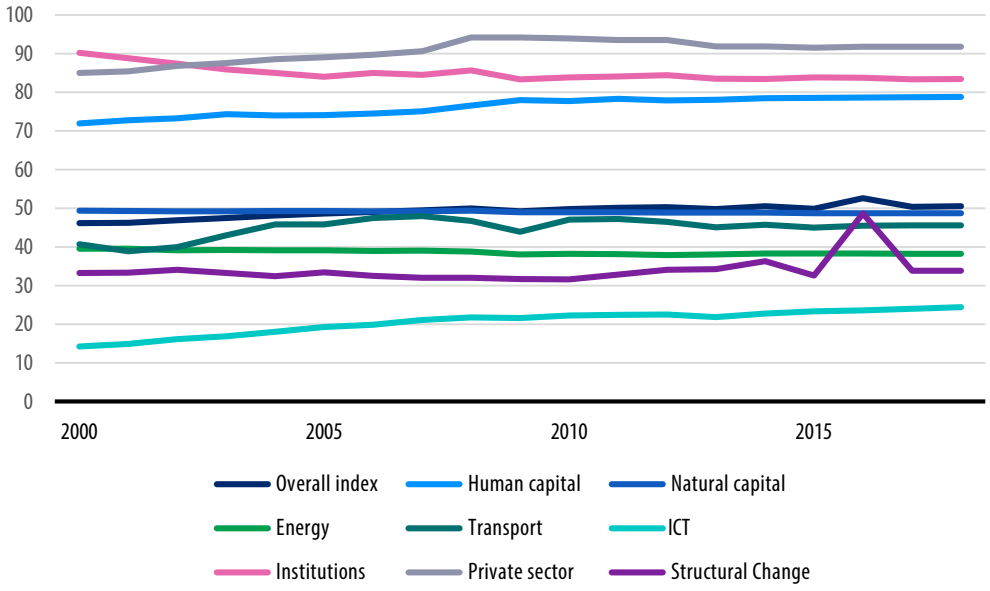
The private sector is defined by the ease of cross-border trade, which includes time and monetary costs for export and import, and support for business in terms of domestic credit, velocity of contract enforcement and time required to start a business.

Structural change refers to the movement of labour and other productive resources from low-productivity to high-productivity economic activities. This shift is currently captured by the sophistication and variety of exports, the intensity of fixed capital and the share of industry and services in total GDP. Structural change can also happen within a given sector provided that binding constraints in the sector are identified and effectively addressed.

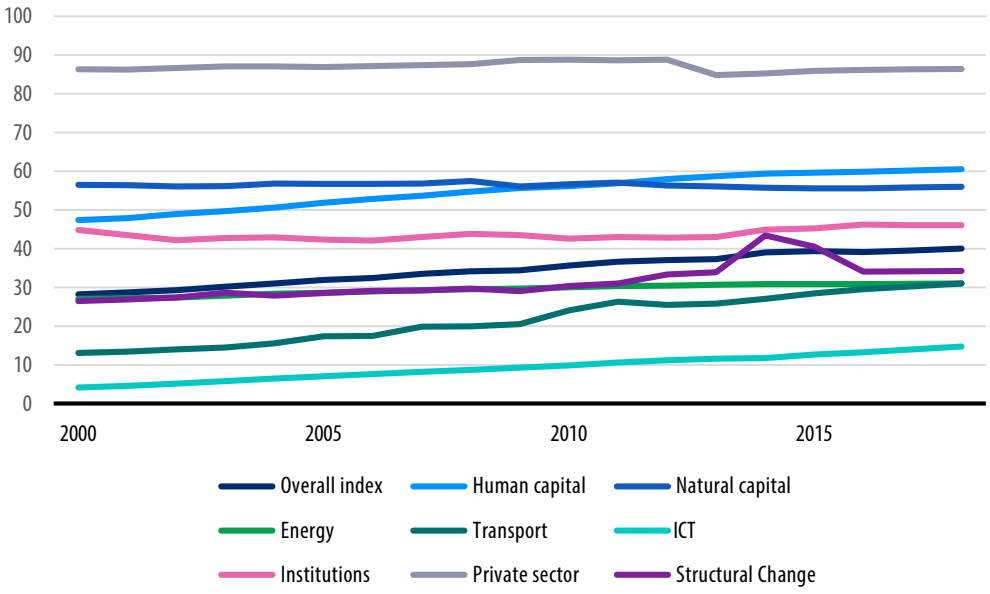
Source: UNCTAD.

Table 18. Productive capacities indices (see Infobox above for further information)

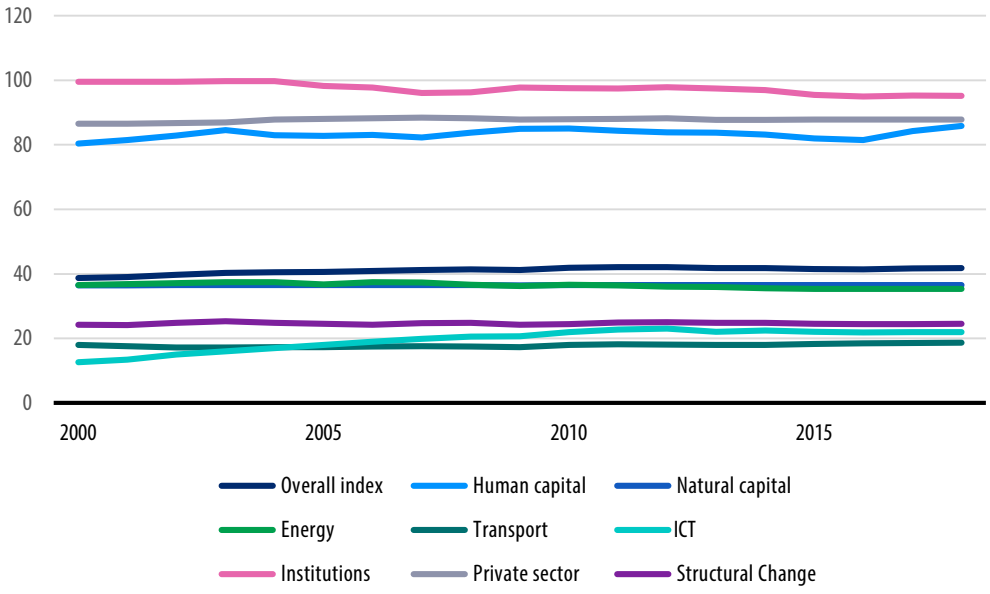
United States



China



Finland



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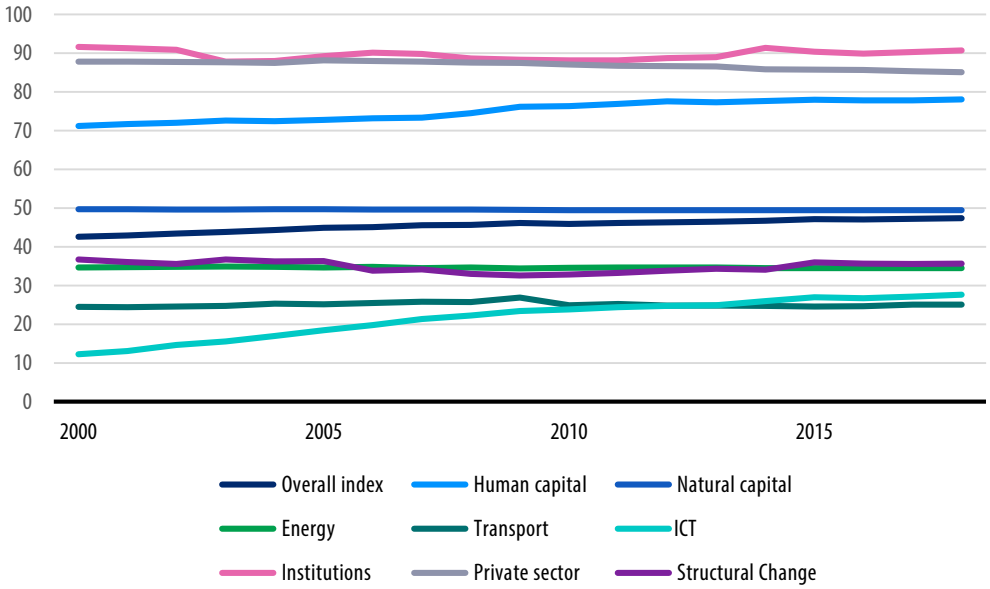

Source: UNCTAD.

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