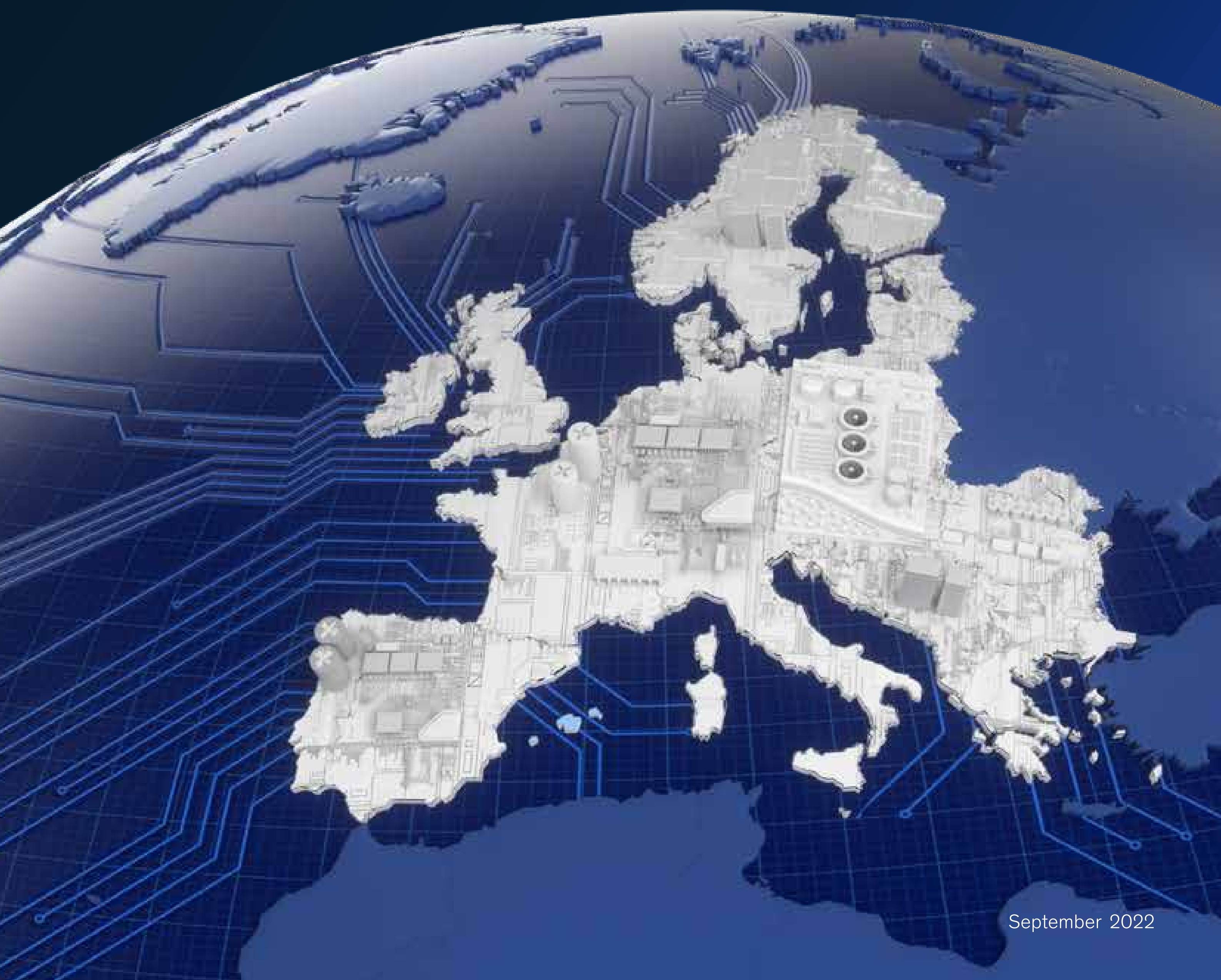
McKinsey Global Institute

Securing Europe's competitiveness

Addressing its technology gap



September 2022

McKinsey Global Institute

The McKinsey Global Institute (MGI), the business and economics research arm of McKinsey, was established in 1990 to develop a deeper understanding of the evolving global economy. MGI's mission is to provide leaders in the commercial, public, and social sectors with the facts and insights on which to base management and policy decisions.

MGI research combines the disciplines of economics and management, employing the analytical tools of economics with the insights of business leaders. Our “micro-to-macro” methodology examines microeconomic industry trends to better understand the broad macroeconomic forces affecting business strategy and public policy. MGI’s in-depth reports have covered more than 20 countries and 30 industries.

Current research focuses on seven themes: growth and competition; labor markets and work; financial markets and investment; consumers, behavior, and health; resources and sustainability; technology and innovation; and society and institutions.

Recent reports have assessed the impact of the COVID 19 crisis on the future of work, productivity and growth, and consumer demand; prioritizing health; the social contract; Black economic mobility; the impact of AI; the Bio Revolution; physical climate risk; impact of corporations on economy and households; and global value chains.

MGI is led by McKinsey & Company senior partners Sven Smit, who serves as chair, and Chris Bradley, Kweilin Ellingrud, Marco Piccitto, Olivia White, and Jonathan Woetzel, who serve as directors. Michael Chui, Mekala Krishnan, Anu Madgavkar, Jan Mischke, Jeongmin Seong, and Tilman Tacke are MGI partners. Project teams are led by the MGI partners and include consultants from McKinsey offices around the world. These teams draw on McKinsey’s global network of partners and industry and management experts.

The MGI Council is made up of McKinsey leaders and includes Hemant Ahlawat, Michael Birshan, Andrés Cadena, Sandrine Devillard, André Dua, Katy George, Rajat Gupta, Eric Hazan, Solveigh Hieronimus, Acha Leke, Clarisse Magnin, Jurica Novak, Gary Pinkus, Hamid Samandari, Sha Sha, Oliver Tonby, and Eckart Windhagen. The Council members help shape the research agenda, lead high-impact research, and share the findings with decision makers around the world. In addition, leading economists, including Nobel laureates, advise MGI research.

This report contributes to MGI’s mission to help business and policy leaders understand the forces transforming the global economy and prepare for the next wave of growth. As with all MGI research and reports, this work is independent and reflects our own views. This report was not commissioned or paid for by any business, government, or other institution, and it is not intended to promote the interests of McKinsey’s clients. For further information about MGI and to download reports, please visit www.mckinsey.com/mgi.

Securing Europe's competitiveness

Addressing its technology gap

September 2022

Authors
Sven Smit, Amsterdam
Magnus Tyreman, Stockholm
Jan Mischke, Zurich
Philipp Ernst, Hamburg
Eric Hazan, Paris
Jurica Novak, Warsaw
Solveigh Hieronimus, Munich
Guillaume Dagorret, Paris

Preface

In light of Russia's invasion of Ukraine in early 2022, political and business leaders around the globe are keenly focused on defense, energy supply, food security, and supply chain disruptions. The crisis has raised concerns about resilience, self-reliance, and strategic autonomy. In this context, it would be all too easy to forget the vital and growing role of technology—the focus of this research—in competitiveness, growth, and—yes—resilience and strategic autonomy in Europe.

Notwithstanding urgent challenges, Europe has been experiencing a slow-motion but increasingly apparent crisis centered on the region's technological capabilities and the competitiveness of its firms—one that requires attention if Europe is to boost growth, combat the specter of stagflation, finance investments in sustainability and inclusion, and maintain its strategic autonomy. Confronting Europe's corporate and technology gaps with other major regions will require European leaders to show the same resolve and collaboration they have displayed in their response to the pandemic as well as to their initial response to the invasion of Ukraine.

This report builds on an MGI article in May 2022, *Securing Europe's future beyond energy: Addressing its corporate and technology gap*. Our diagnostic presents Europe's erosion of corporate and technological competitiveness in depth, describes its root causes, and proposes actions that can turn a challenge into a high-stakes opportunity. The analysis is framed by the imperative of achieving sustainability, inclusion, and growth, and it gauges where Europe stands on all three dimensions. The research then focuses on the performance of European corporations, using McKinsey's Corporate Performance Analytics (CPAnalytics) to examine a sample of more than 2,000 companies in Europe and the United States with revenue of more than $1 billion. MGI found that European companies, in aggregate, are significantly underperforming their US counterparts, and that technology—namely information and communications technology (ICT) and pharmaceuticals—is responsible for much of the difference. The research details corporate performance both at the sector level and for individual economies. We also look at ten transversal technologies that are permeating virtually every sector and gauge where Europe stands in each of them to ascertain its competitive position in the years ahead. Finally, the report discusses some areas where European decision makers in the public and private sectors could better leverage Europe's scale and accelerate its response to disruption.

The research was led by Sven Smit, a McKinsey senior partner in Amsterdam and chairman of MGI; Magnus Tyreman, managing partner for McKinsey in Europe in Stockholm; Matthias Evers, a former McKinsey senior partner in Hamburg; Eric Hazan, a McKinsey senior partner in Paris; Jurica Novak, a McKinsey senior partner in Warsaw; Solveigh Hieronimus, a McKinsey senior partner in Munich; Jan Mischke, an MGI partner in Zurich; and Philipp Ernst, a McKinsey senior expert in Hamburg. Sahil Tesfu (alumnus) and Louis-Charles Mosseray (alumnus) kicked off the research. The project team was led by Guillaume Dagorret, a McKinsey consultant in Paris, and Valentin Liebhart (alumnus), a McKinsey consultant in Berlin. The team comprised Lucie Bertholon, Louis Blanluet, Laura Bogaert, Mehdi Bouajila, Tim Deelen, Beatriz Go, Jakob Graabak, Tomasz Mataczynski, Teuta Thaqi, and Carlijn Van Der Linden. We are grateful to MGI colleagues Jeongmin Seong and Tilman Tacke for their helpful guidance. We also thank Tera Allas, director of research and economics in McKinsey's London office.

We are deeply grateful to our academic adviser Hans-Helmut Kotz, resident fellow, Center for European Studies at Harvard University, and senior fellow, Leibniz Institute for Financial Research SAFE in Frankfurt, Germany.

Colleagues from around Europe offered valuable insights into various aspects of our research. We thank Paula Afonso, Hemant Ahlawat, Pontus Averstad, Sukriti Bansal, Kim Baroudy, Harald H. Bauer, Thomas Baumgartner, Christian Behrends, Alejandro Beltran, Arjita Bhan, Fabian Billing, Michael Birshan, David Bishop, Oscar Boldt-Christmas, Malte Bornemann, Duarte Braga, Laura Bremme, Peter Breuer, Raphael Buck, Ondrej Burkacky, Trevor Burns, James Chavin, Hannah Chen, Michael Chui, Fredrik Darlquist, Dago Diedrich, Jonathan Dimson, Sundiatu Dixon-Fyle, Maurizio Donato, Julian Dragendorf, Peter Dröll, Hauke Engel, Massimo Giordano, Andreas Gläfke, Nadine Grießmann, Ferry Grijpink, Christian Harbo Madsen, Stephanie Hauser, Kersten Heineke, Kimberly Henderson, Caroline Henricson, Teun Hermsen, Dorothee Herring, Samira Herzog, Matt Higginson, Klemens Hjartar, Marcus Hohmann, Daniel Holland-Letz, Tania Holt, Dieuwert Inia, Mena Issler, Christian Jansen, Paul Jenkins, Claudia Kampel, Axel Karlsson, Martin Kellner, Patrick Klinkoff, Benedikt Kloss, Daniel Läubli, Sebastien Lacroix, Karsten von Laufenberg, Rachel Lee, Henry Legge, Charlie Lewis, Chris Llewellyn, Johannes Lüneborg, Clarisse Magnin, Jukka Maksimainen, Dana Maor, Manuela Martin, Maria Martinez, Muireann McCarthy, Niko Mohr, Manuel Möller, Timo Möller, Jörg Mußhoff, Tomas Naucler, Marc Niederkorn, Florian Niedermann, Sophie Neumann, Even Polymeneas, Fabian Queder, Jaana Remes, Julien Revellat, Felix Rölkens, Karin Saken, Sam Samdani, Aditi Sanghvi, Christian Schaette, Thorsten Schleyer, Namit Sharma, Stuart Shilson, Marcus Sieberer, Tobias Silberzahn, Virginia Simmons, Ron Sobol, Freddie Sodergren, Christoph Sohns, Henning Soller, Axel Spamann, Dennis Spillecke, Bhargs Srivathsan, Erika Stanzl, Tilman Tacke, Gregor Theisen, Jonathan Tilley, Dmitry Tolstiney, Andreas Tschiesner, Thomas Vahlenkamp, Lieven Van Der Veken, Frederic Vandenberghe, Godart van Gendt, Matthew Veves, Jasper von Ouwerkerk, Frank von Willert, Ulrich Weihe, Alexander Weiss, Felix Wenger, Thomas Weskamp, Eric Wiebes, Eckart Windhagen, Martin Wrulich, Weige Wu, Alexandra Zemp, Matija Zesko, and Przemyslaw Zima.

This report was edited by MGI executive editor Janet Bush. We thank MGI executive editor Lisa Renaud for her thoughtful input, as well as key members of MGI's operations team for their support, namely Nienke Beuwer, director of EMEA communications; editorial production manager Vasudha Gupta; MGI data visual editor Chuck Burke; graphic designers Marisa Carder and Patrick White; and research specialist Tim Beacom. We are grateful to McKinsey's Europe communications director Ian Gleeson, and director of media relations Graham Ackerman.

This research contributes to our mission to help business and policy leaders understand the forces transforming the global economy. As with all MGI research, it is independent and has not been commissioned or sponsored in any way by any business, government, or other institution.

Sven Smit
Director and Chair, McKinsey Global Institute
Senior Partner, McKinsey & Company
Amsterdam

Marco Piccitto
Director, McKinsey Global Institute
Senior Partner, McKinsey & Company
Milan

Chris Bradley
Director, McKinsey Global Institute
Senior Partner, McKinsey & Company
Sydney

Olivia White
Director, McKinsey Global Institute
Senior Partner, McKinsey & Company
San Francisco

Kweilin Ellingrud
Director, McKinsey Global Institute
Senior Partner, McKinsey & Company
Minneapolis

Jonathan Woetzel
Director, McKinsey Global Institute
Senior Partner, McKinsey & Company
Shanghai

September 2022

Contents

In brief

Addressing Europe's corporate and technology gap

Russia's invasion of Ukraine not only has been a humanitarian catastrophe but also has shone a harsh light on a range of strategic challenges, from defense to food and energy security, and made resilience an even higher priority. Technology is pivotal, too, for Europe's strategic autonomy and resilience, as well as its growth and competitiveness. While the war in Ukraine and its impact are at the forefront of our minds, Europe also needs to address a slow-motion crisis centered on a corporate and technological gap that predated the invasion in February 2022. For the sake of long-term resilience and prosperity, the region needs to act decisively to develop and scale competitive firms and technologies more quickly. The following are the key findings:

When Europe works, it works well. Europe has a strong record on sustainability and inclusion. Europe has 2.4 times lower CO_2 emissions per capita and 1.8 times lower CO_2 emissions per unit of GDP than the United States, and emissions are declining 30 and 50 percent faster than in China and the United States, respectively. Income inequality as measured by the Gini index is 30, compared with 41 in the United States and 39 in China. All top ten countries in the Social Mobility Index published by the World Economic Forum are European. Starting from the bottom quintile, it takes two to three generations in Scandinavia to attain mean income; in the United States, it takes five generations. Europe tracked other advanced economies' sluggish growth in per capita GDP between 2000 and 2019, but Europe's per capita GDP is about 30 percent lower than that of the United States, mostly because of labor market choices and the fact that economies in Central and Eastern Europe have not yet caught up with their Western European counterparts.

Europe's corporations on average lag behind their international peers on metrics of profitability, growth, and innovation. Europe has many high-performing companies, but, in aggregate, between 2014 and 2019, large European companies (with more than $1 billion in revenue) had three percentage points lower return on invested capital, grew 40 percent more slowly, and spent 40 percent less on R&D—all in comparison with US counterparts sampled. ICT and pharmaceuticals account for 60 percent of the growth gap and 75 percent of the R&D gap.

As technology permeates all sectors, Europe is falling behind on eight of ten transversal technologies. Ten transversal technologies are permeating virtually all industries. Seven link to digitization with strong winner-take-most dynamics and network effects, putting Europe at a disadvantage. For instance, the top ten major companies investing in quantum computing are in the United States or China, not in Europe. In artificial intelligence (AI), investment by US corporations is six times that of their European counterparts. In 5G, Europe has strong suppliers but lags behind on deployment. In cleantech, a European stronghold, the region remains ahead on patents, venture capital funding, and world-class installed capacity in mature technologies. But even there, China intervened to take the lead in cleantech production in nearly all areas, and the United States leads on most breakthrough technologies including nuclear fusion. Technological disruption challenges Europe's stronghold industries. For instance, US manufacturers account for close to 70 percent of all kilometers traveled by L4 fully-autonomous vehicles.

The stakes are high. We estimate that corporate value added of €2 trillion to €4 trillion a year could be at stake by 2040. This is equivalent to one percentage point of growth a year; six times the amount needed in Europe to achieve net-zero emissions by 2050; or about 90 percent of all current European social expenditure. Moreover, in a shifting geopolitical environment that appears increasingly polarized, Europe's strategic autonomy and voice in the world could be at risk.

In a winner-takes-most world, European decision makers and companies need to be proactive in favor of speed and scale. For its firms to compete, Europe needs to level the playing field and play at greater scale and speed. Eleven initiatives could help turn the tide. For instance, moving to joint procurement in innovation-related areas, from defense to healthcare, could promote cross-border competition and scale; today Europe pools only 0.2 percent of its total public procurement at the European level, compared with 45 percent at the US federal level. Further, could Europe create a common 28th regime for regulating high-growth firms as they scale? Could it consider developing fast-track regulatory approval and decision-making processes, as happened in the case of COVID-19 vaccine approval? Whether or not the competitive arena improves, corporate leaders and owners need to take more risks and raise competitiveness by, for instance, setting stretch long-term targets, adjusting incentives, and leveraging programmatic M&A and alliances to build scale and capabilities.

There are reasons to be optimistic. Europe has many strengths, including high-quality education systems and one of the most open and connected economies in the world. In 2021, Europe experienced the largest increase in unicorns since 2014 and attracted a record $110 billion of venture capital funding, exceeding China's tally. And the European Union has launched a number of initiatives aimed at addressing the technology gap, including the Digital Markets Act, Horizon Europe, and the Important Projects of Common European Interest.

Europe's corporate and technology gap

Europe's corporations underperformed US counterparts in 2014–19. The gaps were largely due to tech.

Corporate performance metrics, 2014–19

Metric	Europe vs US	Tech sector's share of the gap
Return on invested capital	20% less profitable than US	90%
Revenue growth	40% lower than US	60%
Capital expenditure	8% less than US	80%
R&D spending, 2019	40% less than US	70%

How technological disruption is putting pressure on Europe's stronghold sectors

Tech was largely a vertical industry on its own but is now challenging all sectors.

Ten transversal technologies	Measure of Europe's position relative to that of other global leaders
Next-level automation	0.8
Future of connectivity	0.6
Distributed infrastructure	0.3
Next-generation computing	0.5
Applied AI	0.4
Future of programming	0.2
Trust architecture	0.4
Bio Revolution	0.6
Next-gen materials	1.3
Future of cleantech	1.0

← Lag | Lead →

Three example sectors

	Automotive	Pharma, biotech, and life sciences	Defense
Europe holds strong positions …	2 out of 3 of the world's top automotive manufacturers	Combined size of top ten players roughly the same as in United States	The second-largest military budget globally
… but is being technologically outpaced	Less than 1% of kilometers traveled by autonomous vehicles	Half the US number of new biotech drug approvals in 2018–20	2.5 times less spending than US on cybersecurity

The value at stake: €2 trillion to €4 trillion annually to 2040

Equivalent to ▸

- **30–70%** of forecast European GDP growth, 2019–40
- **6×** the cost of the net-zero transition
- **~90%** of Europe's social spending

A strategy for Europe

In order to compete as winner-takes-most dynamics spread, Europe needs to:

- ✔ **Play at its full scale**
- ✔ **Increase its speed**
- ✔ **Level the playing field for its firms**

McKinsey Global Institute

© Caia Image/Getty Images

1. When Europe works, it works well

Continuing to better the lives of all Europeans over the long haul requires sustainability, inclusion, and growth. The three reinforce—or can undermine—one another; it is not a question of or, but and.[1] Growth is needed to achieve prosperity and well-being, and to pay for the transitions required to make Europe's economies more sustainable and inclusive. Not only is sustainability critical for our planet, but without it, there can be no long-term prosperity. Inclusivity is a goal in its own right and is needed to strengthen aggregate demand and propel growth as well as to secure sufficiently broad support to sustain necessary sustainability investments.[2]

Where does Europe stand on sustainable and inclusive growth? The region is further ahead than others in the battle against climate change—although progress, as elsewhere, is not rapid or extensive enough to secure net-zero emissions by 2050. Europe also leads on equality, social progress, and life satisfaction—aspects of inclusiveness—albeit with significant variations within regions. When Europe works, it works well (Exhibit 1).

Sustainability: Europe is a world leader on holding down the level of carbon emissions and the pace of reducing them

30–50%

faster decline in carbon emissions in Europe than in the United States and China

Europe remains one of the largest emitters of carbon globally, with 6.4 metric tons of CO_2 per capita on average, but this is less than China's 7.3 metric tons and well below 16.0 metric tons in the United States.[3] Emissions have also been declining at a rate between 30 and 50 percent faster than in the United States and China. Europe has been a front-runner globally on action to mitigate climate change, putting in place targets for the reduction of pollution in the early 2000s. It has pledged to achieve net-zero greenhouse gas emissions before other regions (Exhibit 2).[4] European countries are global leaders on the use of renewable energy. Between 2000 and 2018, the region increased its share of renewable energy by between 3.7 percent and 5.3 percent per annum, depending on the economy. In the same period, the United States increased its share by 3.1 percent a year, while China reduced its share by 4.1 percent per annum.[5]

1 Bob Sternfels, Tracy Francis, Anu Madgavkar, and Sven Smit, "Our future lives and livelihoods: Sustainable *and* inclusive *and* growing," McKinsey & Company, October 26, 2021. Countries that have experienced faster growth over the past four decades had lower market inequality in the 2010s. See Philippe Aghion, Reda Cherif, and Fuad Hasanov, "Fair and inclusive markets: Why fostering dynamism matters," VoxEU, January 20, 2022.

2 Unless specified otherwise, in our analysis, Europe comprises the 27 member states of the European Union (EU) plus Norway, Switzerland, and the United Kingdom. We group these economies as Europe 30. This report discusses them as a region. However, we acknowledge that this group includes independent countries, often with very different economic profiles. Moreover, these countries have a number of neighbors to the east, including Ukraine, that are part of the European continent and may in the future forge closer economic ties with the group of 30 countries analyzed in this research. In the final section, on potential actions that Europe can take, many of the measures described would need to happen at the level of the EU, ideally in collaboration and coordination with the other nations in the geographic region.

3 Continental Europe includes Austria, Belgium, France, Germany, Luxembourg, Netherlands, and Switzerland. Northern Europe comprises Denmark, Finland, Ireland (the Republic of), Norway, Sweden, and the United Kingdom. Southern Europe comprises Cyprus, Greece, Italy, Malta, Portugal, and Spain. Eastern Europe comprises Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Poland, Slovak Republic, and Slovenia.

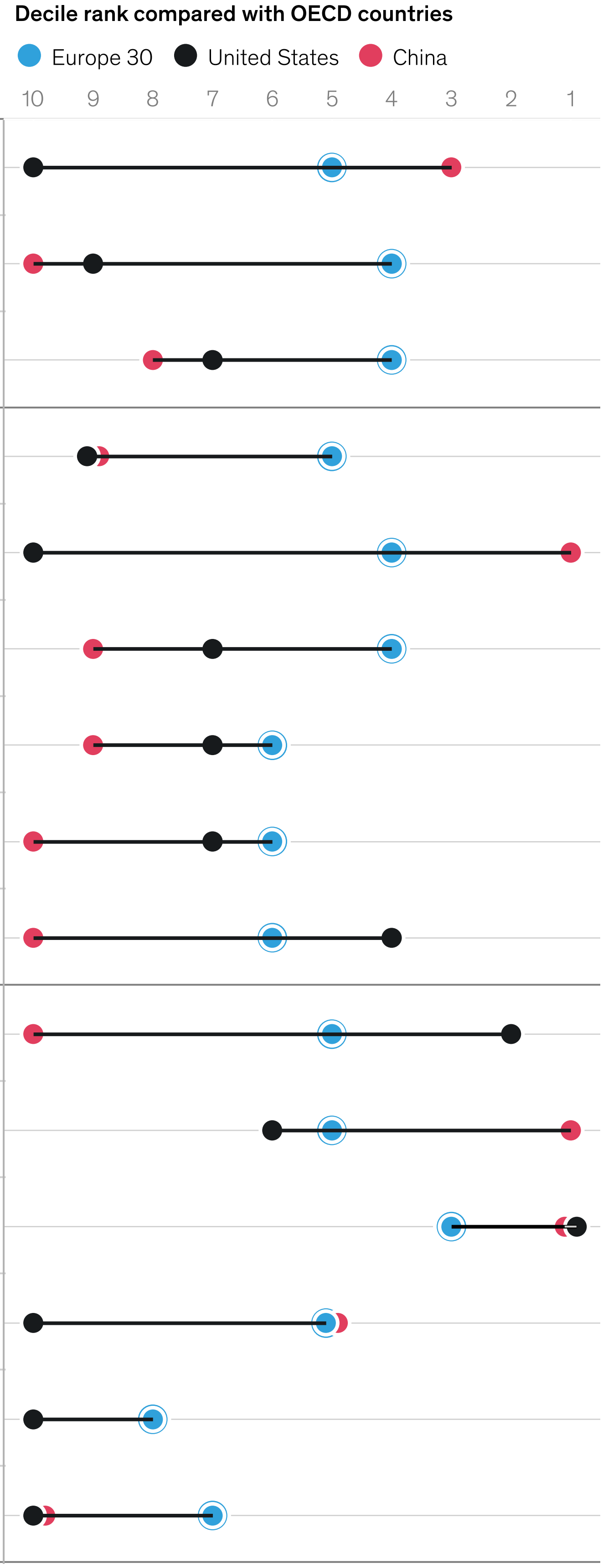
4 Scope 2 (production-based) emissions. Data come from Our World in Data.

5 Organisation for Economic Co-operation and Development (OECD).

Exhibit 1

Europe has been a leader on sustainability and inclusion, but the trajectory of macroeconomic growth is a concern.

Category	Metric	Europe 30 average[1]
Sustainability	CO_2 emissions per capita (consumption), 2019 (metric ton)	7.8
	CO_2 emissions per unit of GDP, 2018 (kg per 2017 $ of GDP at purchasing power parity)	0.13
	Fossil fuel consumption, 2019 (% of primary energy)	74
Inclusion and well-being	Income inequality, Gini index, 2018 or latest	0.30
	Poverty rate at national poverty lines, 2018 (% of population)	13.4
	Social Mobility Index, 2020	75.7
	Life expectancy, 2019 (years)	81.1
	Social Progress Index, 2020	87.9
	Life satisfaction index, 2020	6.5
Growth and prosperity	Per capita GDP, 2019 (purchasing power parity, constant international 2017 $)	45,300
	Per capita GDP growth, 2000–19 (purchasing power parity, compound annual growth rate, %)	1.4%
	Inward foreign direct investment flows, 2019 ($ billion)	321
	Current account balance, 2020 (% of GDP)	2.0
	Public debt, 2020 (% of GDP)[2]	113
	Private debt, 2020 (% of nominal GDP)[3]	102



1. Europe 30 includes the European Union plus Norway, Switzerland, and the United Kingdom.
2. Comparable data are not available for China.
3. Private debt is calculated as the sum of loans to nonfinancial sector and households.

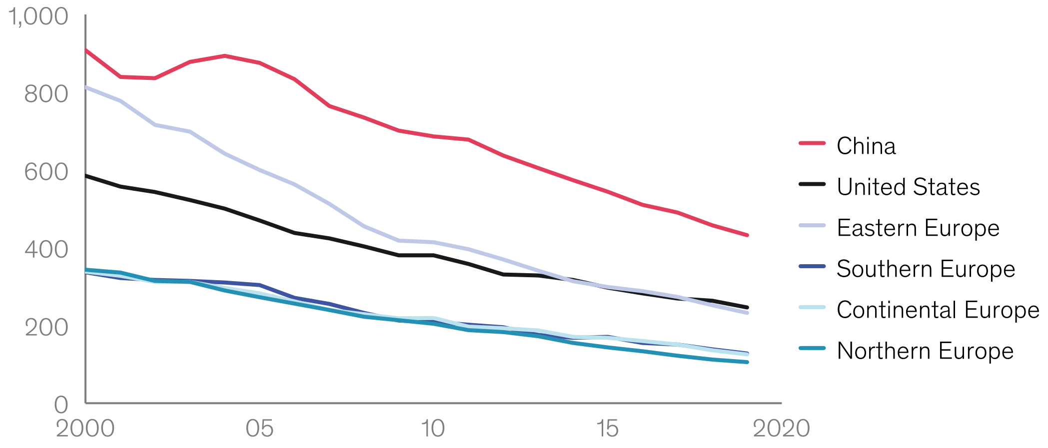
Source: OECD; World Bank; McKinsey Global Institute analysis

Exhibit 2

European CO_2 emissions are lower than in other major regions and declining faster.

CO_2 emissions, 2000–19

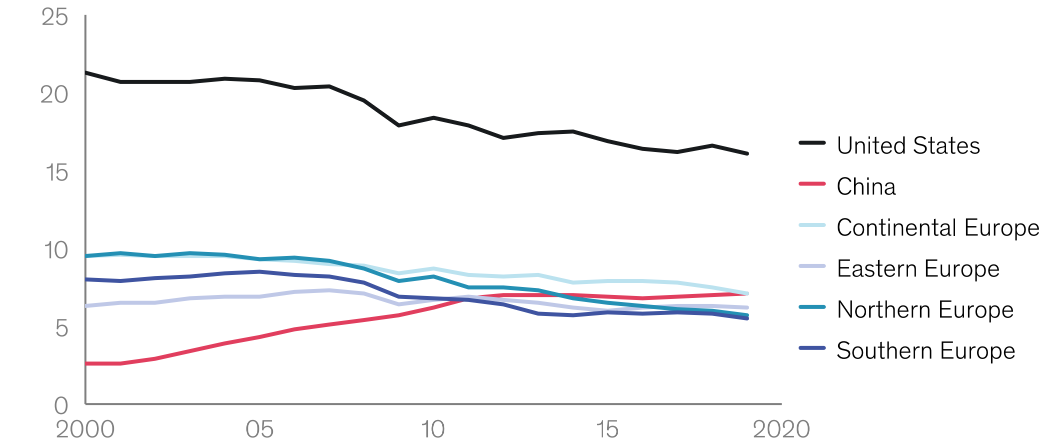
CO_2 emissions per $ million of GDP, purchasing power parity, million metric tons carbon



Compound annual growth rate (CAGR), %

	2000–19	2010–19
China	-3.8	-5.0
United States	-4.4	-4.7
Eastern Europe	-6.4	-6.2
Southern Europe	-5.0	-5.3
Continental Europe	-5.1	-6.0
Northern Europe	-6.0	-7.0

CO_2 emissions per capita, metric tons



CAGR, %

	2000–19	2010–19
United States	-1.5	-1.5
China	+5.4	+1.5
Continental Europe	-1.5	-2.2
Eastern Europe	-0.1	-0.9
Northern Europe	-2.6	-4.0
Southern Europe	-1.9	-2.3

Source: Our World in Data; World Bank; McKinsey Global Institute analysis

Its collective scale has worked in Europe’s favor.

Inclusion and social progress: Northern and Continental Europe lead on most dimensions

Europe leads on most dimensions of inclusion and social progress. However, there is significant divergence on these measures within the region with high rankings generally due to a strong showing by countries in Northern and Continental Europe.

Income inequality as measured by the Gini index is only 30.[6] The figure in the United States is 41, and in China, 39.[7] The Europe 30's gap between the top 10 percent in household disposable income and the bottom 10 percent was 67 percent smaller than the equivalent gap in the United States in 2019.[8] Europe is also well placed on elements of inclusiveness such as gender equality. In 2019, 28 of the Europe 30 had an average score of about 10 percent on the Gender Inequality Index published by the United Nations Development Programme, compared with 20 percent for the United States.[9] All the countries ranked in the top ten of the 2020 World Economic Forum's Social Mobility Index are European.[10] Europe overall has the highest life expectancy in the world: the EU-27 average in 2019 was 81 years, versus 79 in the United States and 77 in China.[11]

We used the Social Progress Index to gauge Europe's performance on well-being.[12] According to the index, the highest-ranked countries in 2020 were in Continental and Northern Europe. Norway, Denmark, and Finland took the first three places, and Sweden and Switzerland ranked fifth and sixth (after New Zealand). The average score for the five top-ranked European countries on the index was 92 (the figure for the five largest European countries by population was similar at 89). The United States scored 86 and China 66.[13] On social progress overall, Europe and China are continuing to make headway, while the United States is holding its position or declining.

Looking in more detail at the elements that contribute to well-being, a combination of a sense of personal safety, health, and the quality of the environment accounts for the leading position of so many European countries (Exhibit 3). Looking more closely at health, Europe has the highest life expectancy, five to six years on average higher than in the other major regions we considered. However, Eastern Europe's average life expectancy is six years lower than the European average and three years lower than the US average, and on a par with China in 2019. Eastern Europe is also improving life expectancy more slowly than either Europe as a whole or China and the United States. Taking the top ten countries globally for nutrition and basic care, all ten are European. The United States ranks 29th and China 46th. Europe is continuing to improve on health, the United States is stable, and China is catching up quickly.

9 of top 10

countries for life satisfaction were European in 2020

Northern and Continental European countries top life satisfaction rankings and score higher on average than the United States (Exhibit 4).[14] In 2020, nine of the top ten countries for life satisfaction were European. However, when including all European countries, Europe's ranking is lower than that of the United States. On the World Happiness Index, Europe scores 6.4, the United States 6.9, and China 5.1. The World Happiness Report also ranks life satisfaction by city, and on this measure Europe and the United States are closer; 37 percent of cities ranked in the global top 30 are in Europe, and 30 percent in the United States.

Several European economies lead on social mobility. Looking at the number of generations it takes for those born in low-income families to approach the level of the mean income in their country, we find that in the United States it is five generations, but only, for instance, two or three in Scandinavia and four in some Continental European countries (Exhibit 5).

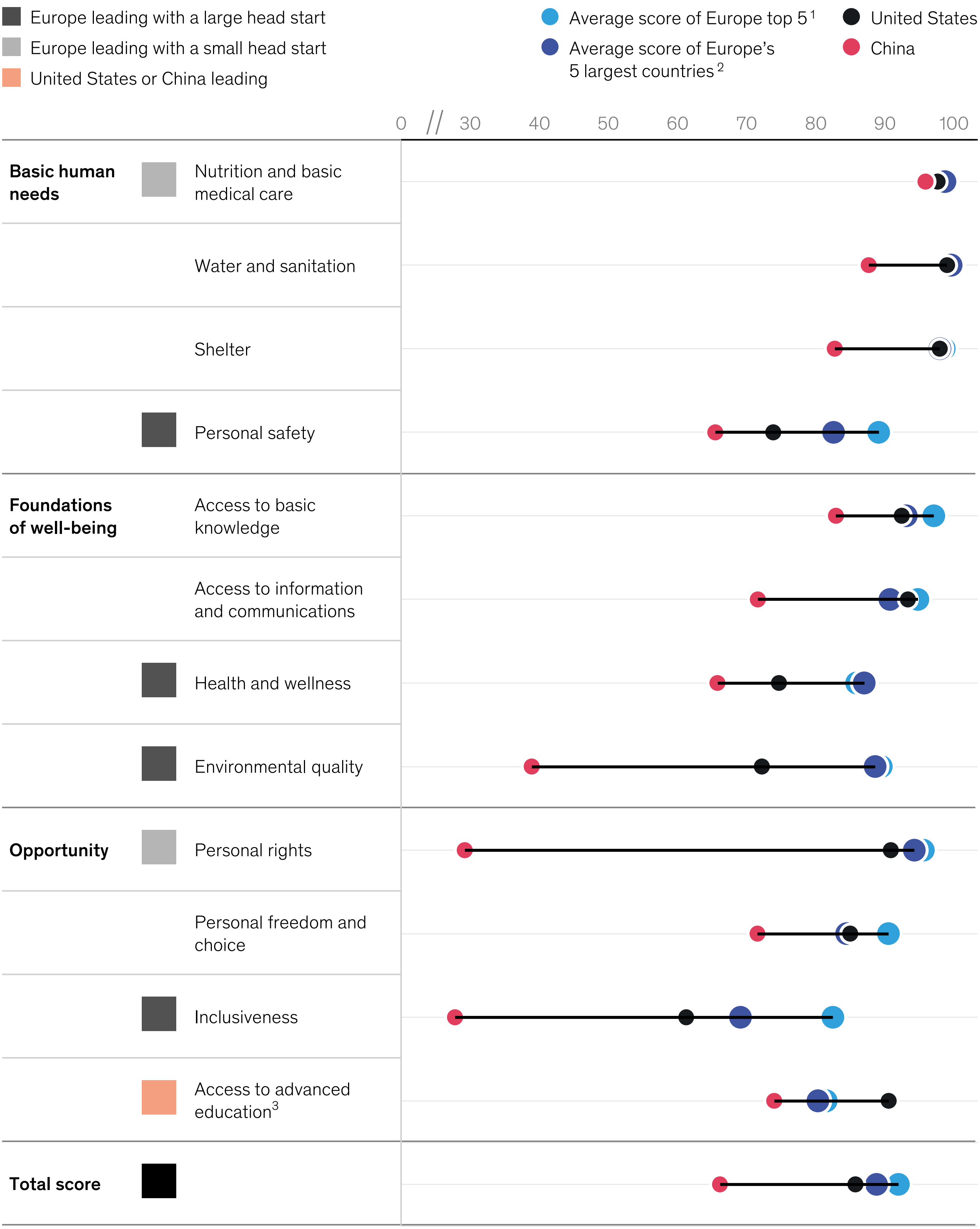
---

6 Europe 30 average weighted by GDP; data from Eurostat.
7 Europe 30 weighted average with GDP, 2019 or latest figure available (2018 for China); Eurostat, World Bank. Scope to compare with China's Gini is limited, as China's measure is based on consumption while measures in Europe and the United States are based on income distribution.
8 Euromonitor data.
9 Gender Inequality Index, United Nations Development Programme.
10 Social Mobility Index 2020, World Economic Forum.
11 Life expectancy at birth in the United States decreased between 2014 and 2017, returning to the 2014 level in 2019.
12 Social Progress Index, Social Progress Imperative, 2020.
13 The five top-ranked European countries on the index are Norway, Denmark, Finland, Sweden, and Switzerland. The five largest European countries are Germany, France, the United Kingdom, Italy, and Spain.
14 John F. Helliwell et al., *World happiness report 2020,* Sustainable Development Solutions Network, 2020. The ranking by country is based on the results of Gallup World Poll Surveys, which ask respondents to rate their lives on six dimensions: levels of GDP, life expectancy, generosity, social support, freedom, and corruption.

Exhibit 3

Europe is a global leader on social progress, reflecting personal safety, health, and quality of the environment.

Underlying dimensions driving Europe's leading position



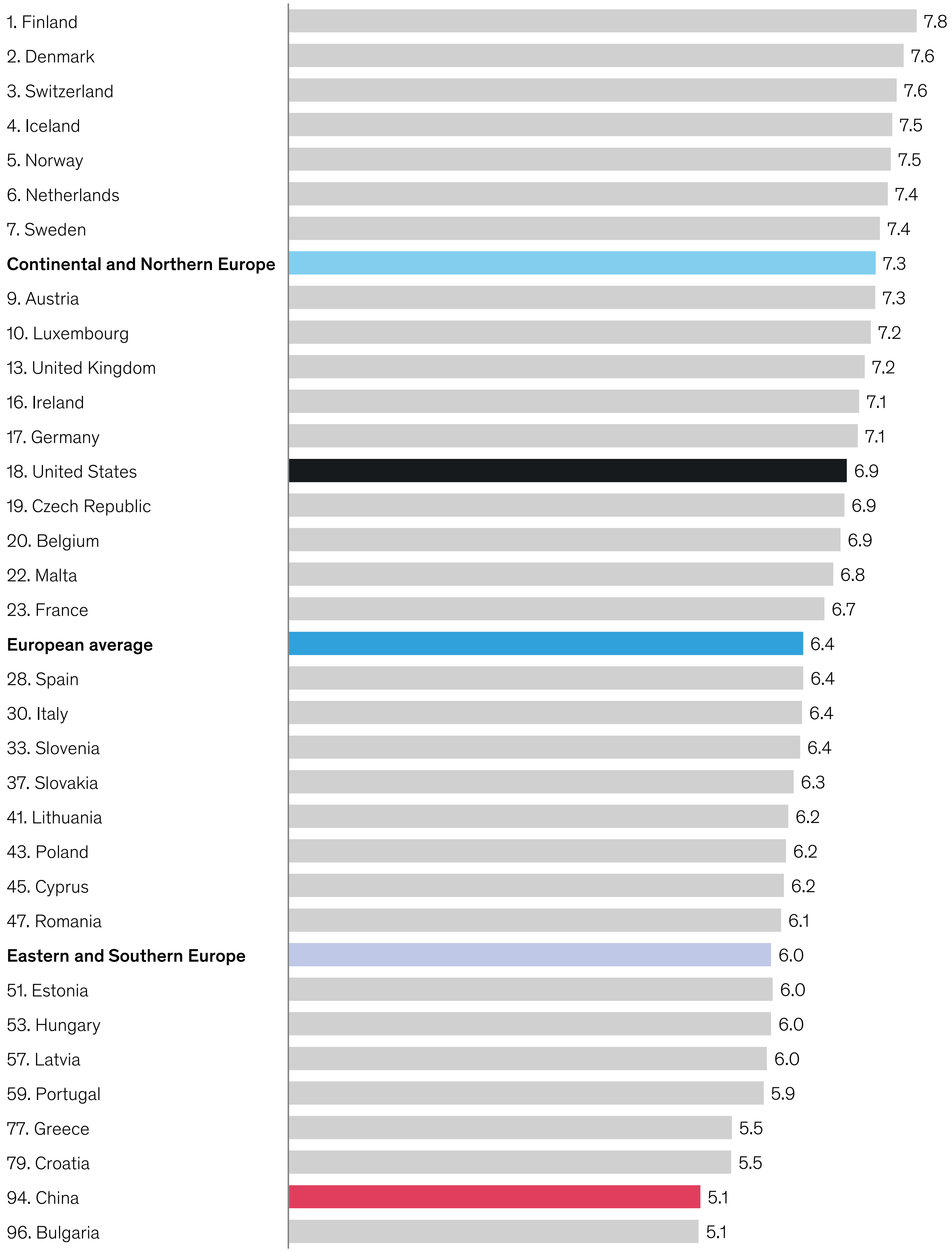
1. Top 5 ranked European countries: Norway, Denmark, Finland, Sweden, and Switzerland.
2. Top 5 largest European countries by population: Germany, France, United Kingdom, Spain, and Italy.
3. Quality weighted universities, citable documents, women with advanced education, expected years of tertiary schooling.

Source: Social Progress Index; McKinsey Global Institute analysis

Exhibit 4

Life satisfaction is the highest in Northern and Continental Europe.

Continental and Northern European countries are leading the World Happiness Report[1]



1. The World Happiness Report measures life satisfaction, ie, a global, evaluative judgment about one's life.

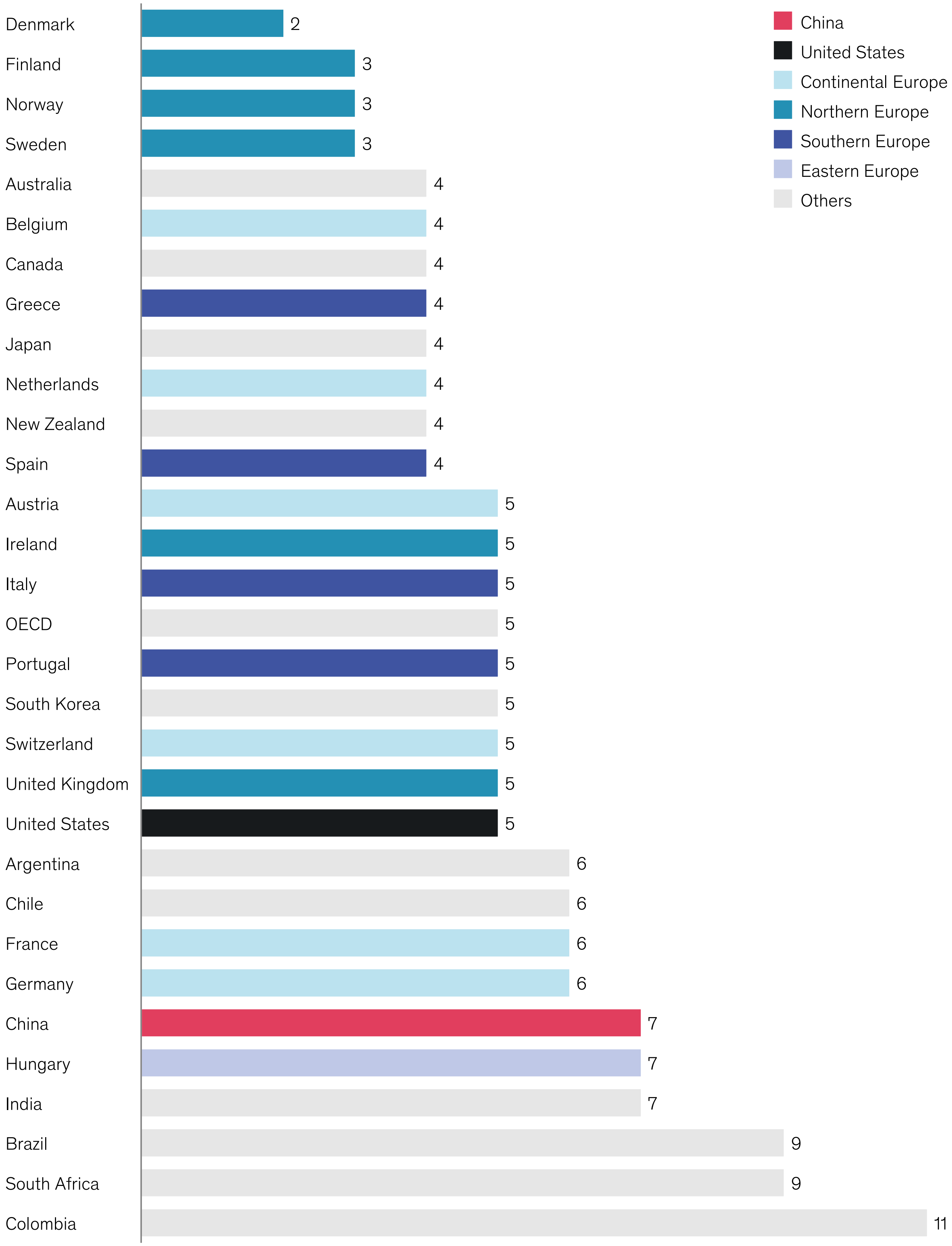
Note: Included are cities with at least 300 observations recorded from 2014 to 2018. The ten largest American cities are included. Several European cities are missing.

Source: McKinsey Global Institute analysis

Exhibit 5

Differences within regions persist, but Northern European countries have the highest income mobility across generations.

Number of generations away from attaining mean income for low-income families



Source: *A broken social elevator? How to promote social mobility*, OECD, 2018

Europe has tracked major advanced economies on growth and prosperity

Looking back over a longer period, between 1970 and 2010, Europe's GDP growth was more dynamic than that of the United States on a per capita basis. Europe's per capita GDP grew at 2.3 percent versus 1.9 percent in the United States, partially because of catch-up effects. Driven by faster population growth, in total GDP terms the US economy grew faster than the Europe 30 economy in aggregate.[15] Between 1970 and 2010, Europe's total GDP grew by 2.6 percent versus 2.9 percent in the United States. While GDP per capita matters for living standards, total GDP matters for market scale and firm growth opportunities.

One notable contributing factor was the convergence of the economies of Central and Eastern Europe once they joined the European Union (EU) in 2004 in the biggest single enlargement of the bloc. Eastern European economies started closing the gap with their western counterparts both in the run-up to 2004 and subsequently.[16] The pace, extent, and timing of this convergence varied among these economies. Another contributory factor has been the impact of the Single Market, which is estimated to have added 9 percent to long-term European GDP. In short, its collective scale was working in Europe's favor over this period.[17]

However, between 2010 and 2020, European GDP growth lost steam, falling to 0.8 percent, compared with 1.7 percent in the United States, in the aftermath of the euro crisis in 2010 (Exhibit 6).[18] The United States ran a more expansionary macroeconomic policy than Europe and was more aggressive in bailing out banks—notably, bank bailouts in Europe were handled at the national rather than regional level.

Additionally, Europe's per capita GDP (in purchasing power parity terms and constant 2017 international dollars) was $45,100 in 2019, 30 percent lower than $63,900, the figure for the United States.

Most US states have higher per capita GDP than most European countries (Exhibit 7). Moreover, only the bottom decile earns higher income, on average, than in the United States.[19]

---

15 World Bank data.

16 *Including institutions: Boosting resilience in Europe, World Bank report on the European Union*, World Bank, 2019.

17 Jan In't Veld, "The economic benefits of the EU Single Market in goods and services," *Journal of Policy Modeling*, volume 41, number 5, September–October 2019.

18 Per capita GDP weighted average with population. GDP is the cumulative GDP of the Europe 30 groups. Data points are missing for some countries before 1995. Data come from the World Bank.

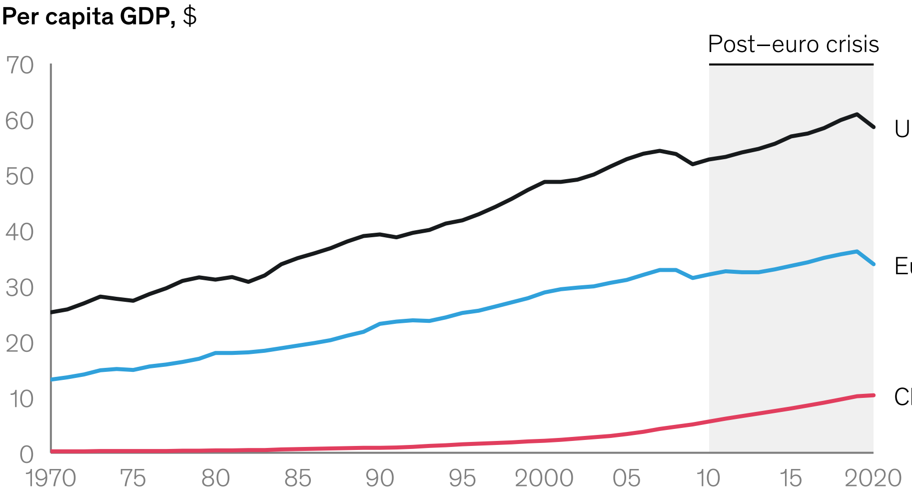
19 Emily A. Shrider et al., *Income and poverty in the United States: 2020*, US Census Bureau, September 2021.

Exhibit 6

The pace of Europe's GDP growth dropped after the euro crisis in per capita and total terms.

GDP, 1970–2020 (2015 $)[1]

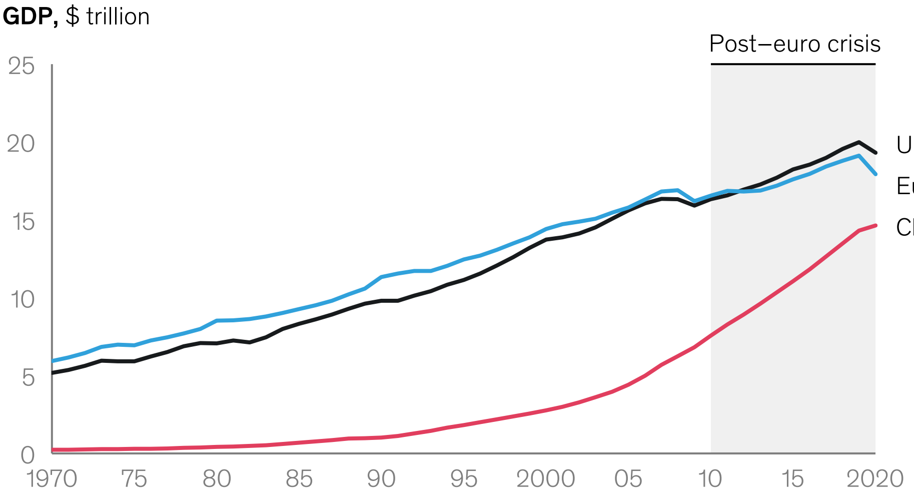
Per capita GDP, $



Compound annual growth rate (CAGR), %

	1970–2010	2010–20
United States	1.9	1.0
Europe 30	2.3	0.6
China	7.8	6.3

GDP, $ trillion



CAGR, %

	1970–2010	2010–20
United States	2.9	1.7
Europe 30	2.6	0.8
China	9.1	6.8

1. Per capita GDP: weighted average with population. GDP: cumulated GDP of Europe 30.

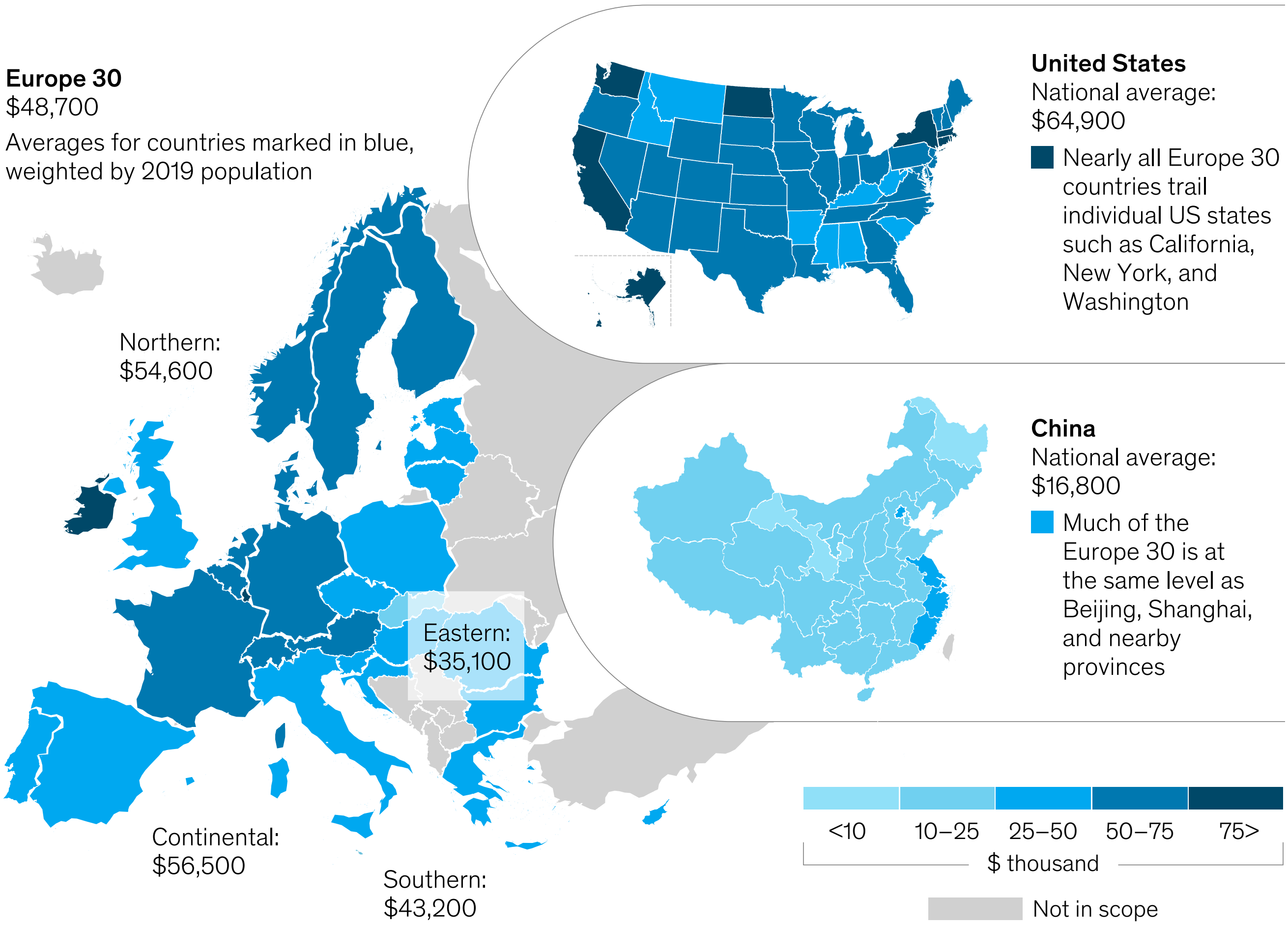
Source: World Bank; McKinsey Global Institute analysis

Forty percent of Europe's persistent per capita GDP gap with the United States is based on settled—and widely supported—societal and lifestyle choices in Europe.

Exhibit 7

Most US states have higher per capita GDP than most European countries.

Per capita GDP, purchasing power parity, current $



Source: World Bank Database; US Bureau of the Census; US Bureau of Economic Analysis; McKinsey Global Institute analysis

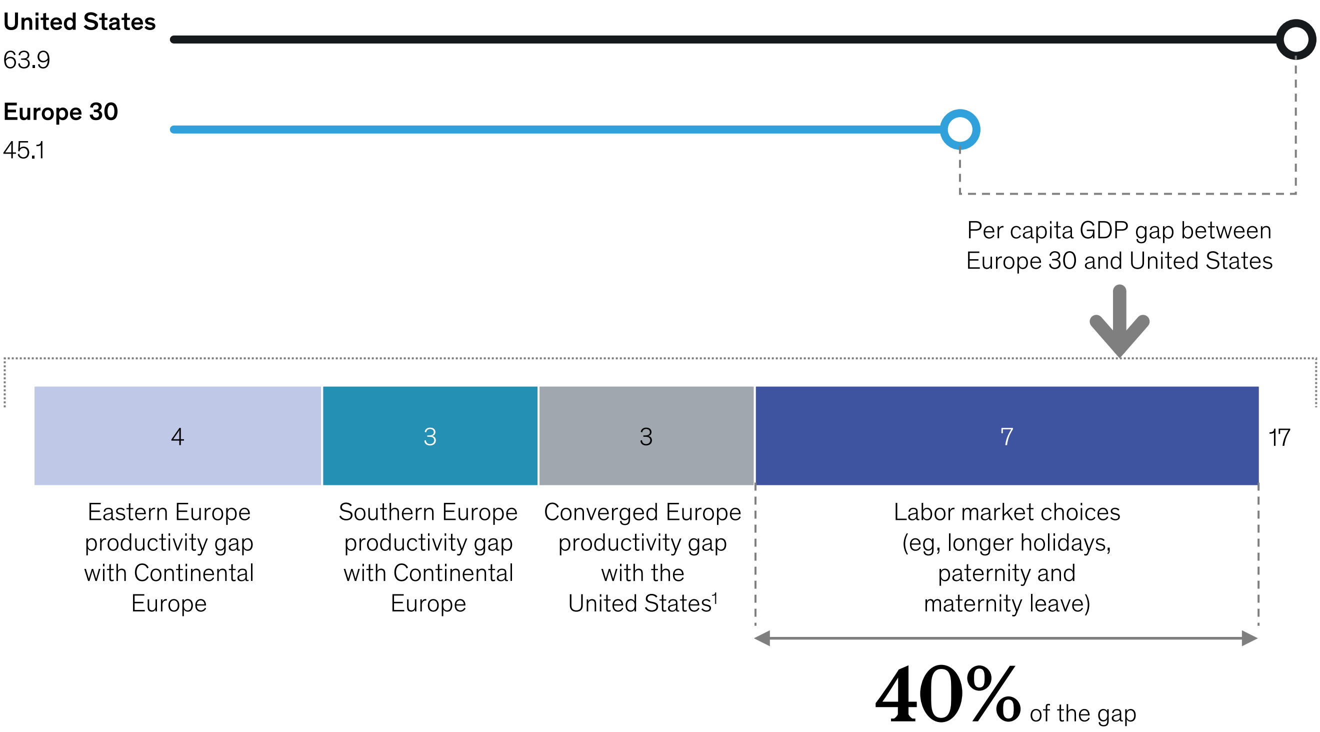
Not all of Europe's persistent per capita GDP gap with the United States translates into lower welfare for European citizens. Forty percent of the gap is based on settled—and widely supported—societal and lifestyle choices in Europe. They include opting for earlier retirement ages and more vacation and parental leave in Europe. There is a great deal of heterogeneity in the provision of public goods within Europe, which is not accounted for in GDP, but, overall, these choices account for 40 percent of the gap. An additional 30 percent is driven by persistently large divides between different regions of Europe, even if those are diminishing (Exhibit 8).[20]

[20] Olivier Blanchard, "The economic future of Europe," *Journal of Economic Perspectives*, volume 18, number 4, fall 2004; and *Removing barriers to growth and employment in France and Germany*, McKinsey Global Institute, March 1997.

Exhibit 8

40 percent of the per capita GDP gap with the United States reflects labor market choices.

Per capita GDP, purchasing power parity, 2019, $ thousand



1. Assumes that all of Europe has caught up with continental European productivity.
Note: Figures may not sum to 100% because of rounding.
Source: McKinsey Global Institute analysis

Collaboration across countries has supported Europe's strong showing on sustainability and inclusion, and some aspects of growth

Europe's strong showing on sustainability, inclusion, and aspects of growth reflects what the region can achieve when it collaborates most effectively, playing to its strengths and scale.

— On sustainability, the European Green Deal strategy and the Fit for 55 package both included major funds that will contribute to Europe's response to the climate crisis and support its aim to become the first climate-neutral continent by 2050.[21] The €72 billion Social Climate Fund, for instance, will provide support and investments to vulnerable households and entrepreneurs affected by the climate action plans of member states. In addition, the EU's research and innovation program for 2021 to 2027—Horizon Europe—will allocate about 35 percent of its €95 billion budget to innovation supporting sustainability.[22]

— On inclusion, European direct investment and labor mobility have contributed to rapid growth in its less prosperous regions. Membership in the EU has enabled just short of 22 million people in Eastern Europe to leave poverty.[23]

— On growth, Europe has created world-competitive companies in sectors from steel to aerospace on the back of one of the largest markets in the world. Airbus is one example. Amadeus is another; the global airline reservations system, formed in 1987 in a collaboration among Air France, Iberia, Lufthansa, and SAS, is becoming one of Europe's largest and most valuable software companies. More recently, European institutional

[21] *Horizon 2020 European Green Deal call: Results and ambitions for the future*, European Commission, October 2021.
[22] *Research and innovation for the European Green Deal*, European Commission.
[23] Eurostat.

innovations such as the European Stability Mechanism created in 2012, the SURE program, and the NextGen EU (including the Resilience and Recovery Fund) have helped absorb some of the largest economic shocks in a century.

11

European countries in the top 20 on PISA scores

Europe has many fundamental strengths, including high-quality education systems, openness to trade, and relatively lower national debt. Eleven European countries rank in the top 20 in Program for International Student Assessment (PISA) scores compiled by the Organisation for Economic Co-operation and Development (OECD). Europe is home to 43 percent of the world's top 100 universities for life sciences, according to The Times Higher Education World University Rankings 2021, compared with 34 percent in the United States. In the case of trade, Europe is more open than the United States, although this traditional strength may also turn into a vulnerability in a changing geopolitical environment. For the Europe 30, exports accounted for 10.9 percent of GDP. In the United States, the share was 6.8 percent. Note that these are apples-to-apples comparisons that strip out intraregional trade.[24] Europe has the most sophisticated industrial supply chains.[25] Finally, it has a lower level of public and private debt as a share of GDP than the United States; for 2020, the figure was 218 percent of GDP in aggregate, compared with 326 percent in the United States.[26]

In aggregate, Europe is a leader on sustainability and inclusion, and tracks other regions on growth. But Europe's future growth trajectory could be in doubt because of an underwhelming performance by its companies in comparison with those in the United States. In the next chapter, we look at corporate performance and its root causes, finding that today's gaps are largely due to lagging technology in Europe.

[24] Data are for trade in goods and come from the United Nations Conference on Trade and Development (UNCTAD) and the World Bank.

[25] Seven of the top ten countries on MGI's Global Connectedness Index are European. See *The Atlas of Economic Complexity*, Growth Lab at Harvard University, 2020.

[26] Cumulative public and private debt-to-GDP ratios in 2020; Europe 30 average weighted by GDP. Data come from the OECD and the World Bank.


© Stanislaw Pytel /Getty images

2. Europe's tech-driven corporate gap

Europe has many high-performing companies, but in aggregate, its firms are growing more slowly, creating lower returns, and investing less in R&D than their US counterparts. This largely reflects long-standing weakness on ICT and other forms of disruptive innovation. As technology and disruption continue to spread across sectors and exert deepening influence on competitiveness, Europe is vulnerable almost everywhere.

Corporate Europe's technology gap has long been considered a result of specialization and competitive advantage, with the justification that Europe is strong on other sectors such as industry, chemicals, materials, and fashion, for instance, and therefore the disparity is not something to worry about. This is no longer true. Technology is now permeating all sectors via transversal technologies such as artificial intelligence (AI), quantum computing, and cloud. If Europe is not successful in competing in these technologies, it could lose all its strongholds in traditional industries. To give just one example, Europe has been a leader in automotive but could become a laggard in autonomous driving.

$2t–$4t

of corporate value added could be at stake annually by 2040

Corporate value added of €2 trillion to €4 trillion a year could be at stake by 2040. To put this into perspective, that would be equivalent to about half of total forecast European GDP growth to 2040, six times the amount needed to transition to net zero by 2050, and about 90 percent of all current European social expenditure.

Unless Europe confronts its corporate and technology gap, its strong performance on sustainability and inclusion could become more difficult to maintain. Although some Europeans argue that lower growth is needed to achieve net zero, growth strengthens confidence and creates a healthy investment climate and new income streams that are needed to pay for the energy transition. Lagging growth could, moreover, undermine inclusion by limiting the pool of funds available to spend on social programs.[27] Finally, it could also compromise Europe's strategic autonomy in economics and geopolitics in an increasingly polarized world.[28] While strategic autonomy is fully compatible with strong global trade and collaboration, it does require multiple supplier options as well as leading capabilities in some areas as a strong bargaining chip.

Europe's clear and well-known weakness in tech is a primary source of a large and growing corporate performance challenge

Data show that Europe's corporate performance is underwhelming in aggregate. To understand this phenomenon, we used McKinsey's Corporate Performance Analytics (CPAnalytics) to examine a sample of about 2,200 companies around the world with revenue of more than $1 billion (see Box 1, "Corporate analysis"). Between 2014 and 2019, large European companies with more than $1 billion in revenue were 20 percent less profitable (measured by return on invested capital) than their US counterparts, grew revenue about 40 percent more slowly, invested 8 percent less (capital expenditures relative to the stock of invested capital), and spent about 40 percent less on R&D (Exhibit 9).[29]

27 Benjamin M. Friedman, *The moral consequences of economic growth*, Knopf Doubleday Publishing Group, 2010.
28 The EU defines strategic autonomy in a way that is different from the concept of sovereignty. Rooted initially in defense and security, it has, over time, broadened to include economics and technology. The broad concept is that Europe should not do everything within Europe but should never rely on a single source. See *Why European strategic autonomy matters*, European External Action Service, December 3, 2020.
29 MGI research has found that in OECD economies, the business sector has provided 72 percent of GDP; that contribution has tripled in per capita GDP terms since the 1960s. See *A new look at how corporations impact the economy and households*, McKinsey Global Institute, May 2021.

Box 1

Corporate analysis

McKinsey & Company's CPAnalytics database has about 12,000 companies worldwide with revenue of more than $1 billion. For this analysis, we took 7,428 companies with headquarters in Europe and the United States and filtered out around 5,000 companies for data and scope reasons. This left us a sample of 2,222 companies for which we undertook detailed analysis. Specifically, we excluded:

- 4,381 companies that do not report invested capital
- 767 subsidiary companies as well as financial companies for which return on invested capital (ROIC) is not an appropriate metric
- 301 private and state-owned companies, as many had a mostly public service provision rather than a profit and growth objective; examples include public railway companies and hospitals.

We then added back 243 separately listed subsidiary, private, or state-owned companies following a company-by-company check that subsidiaries are separately listed and not consolidated with their parent companies, or state-owned firms that have a commercial remit.

In terms of sample mix by geography of the CPAnalytics sample, the United States represents 55 percent of number of companies and 58 percent of revenue in 2014–19 while European countries represent, respectively, 45 and 42 percent. The three largest European countries—Germany, the United Kingdom, and France—represent, respectively, 44 percent in terms of numbers of companies, and 55 percent in terms of revenue.

R&D intensity analysis was calculated from the 2020 EU Industrial R&D Investment Scoreboard (2019 figures) with the world's top 25,000 R&D spenders, excluding financial and real estate companies.

Looking at the sample mix by geography of the 2020 EU industrial R&D scoreboard, the United States represents 54 percent of number of companies, 43 percent of revenue, and 58 percent of R&D spending, all in 2019, while European countries represent 46, 57, and 42 percent, respectively. The three largest European countries—Germany, the United Kingdom, and France—represent more than half of Europe's sample, with 51, 61, and 64 percent of Europe's total, respectively.

A (possibly substantial) portion of this may reflect rising concentration and superstar dynamics in US firms, as well as their higher share of investment in intangible assets.[30] In 2019, intangibles such as innovation, brands, and human, digital, and analytical capital accounted for 42 percent of US investment; in ten European economies, the share was 36 percent.

Nevertheless, the numbers are startling.[31] Most of the differences are observable in technology-creating industries, specifically tech, ICT (including large technology firms), and pharmaceuticals. Together, these sectors account for more than 90 percent of the return on invested capital (ROIC) gap, over 80 percent of the gap on capital expenditure relative to the stock of invested capital, more than 60 percent of the revenue growth gap, and over 70 percent of the R&D intensity gap (Exhibit 10). While the difference in ROIC is a double-edged sword, and there is a legitimate argument that high ROIC reflects entrenched market positions and pricing power, the growth and R&D gaps are clearly not sustainable for Europe.

The ICT difference is also seen in the enterprise value (debt plus equity) of large, listed firms. The value of large European firms was on a par with that of US-based firms in 2000 ($7 trillion versus $8 trillion). However, by November 2021, those in the United States were worth more than double their European counterparts ($46 trillion versus $21 trillion). The six largest US technology firms contributed almost half to that value difference (Exhibit 11). We note that geopolitical turbulence in the first half of 2022, a period in which stock markets were highly volatile, had a greater impact on US growth stocks than on European ones; the market valuation gap between US and European corporations narrowed but did not close.

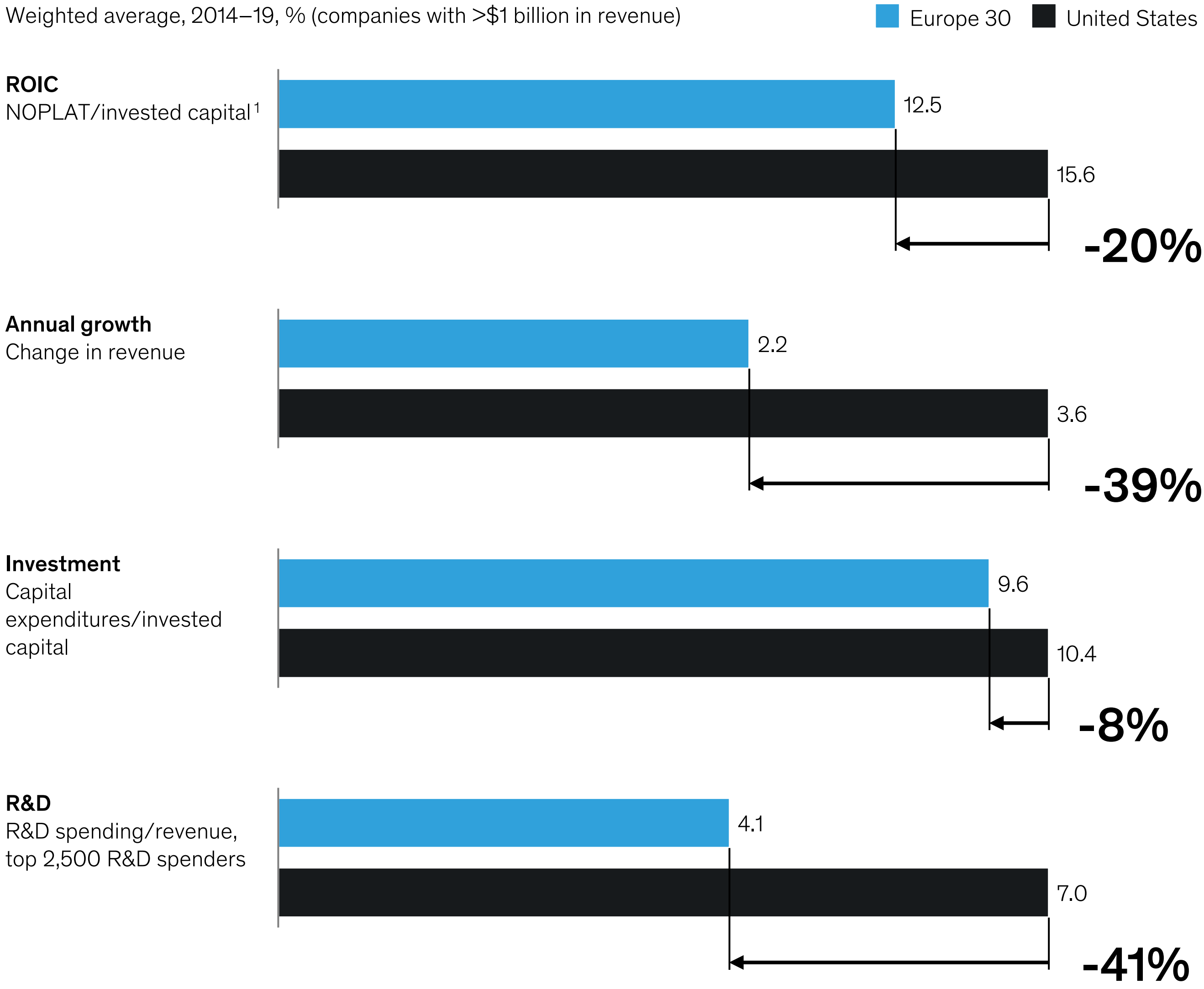
[30] MGI defines a superstar as a firm, sector, or city that has a substantially greater share of income than peers and is pulling away from those peers over time. For firms, our metric is economic profit, a measure of a firm's invested capital multiplied by its return above the cost of capital. We focus on economic profit rather than revenue size, market share, or productivity growth because these other metrics have a risk of including firms that are simply large and might not create economic value. MGI's research finds that superstar firms' earnings represent 13 to 15 percent of the entire global pool of economic surplus and 22 to 25 percent of all corporate earnings worldwide. See Thomas Philippon, *The Great Reversal: How America gave up on free markets*, Belknap Press, 2019; and *Superstars: The dynamics of firms, sectors, and cities leading the global economy*, McKinsey Global Institute, October 2018.

[31] Thomas Philippon, *The Great Reversal: How America gave up on free markets*, Belknap Press, 2019.

Exhibit 9

Corporate Europe lags behind US counterparts in aggregate on profitability, growth, investment, and R&D.

Weighted average, 2014–19, % (companies with >$1 billion in revenue)



1. Return on invested capital; net operating profit less adjusted taxes.
Note: Financial companies excluded.
Source: McKinsey Corporate Performance Analytics; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

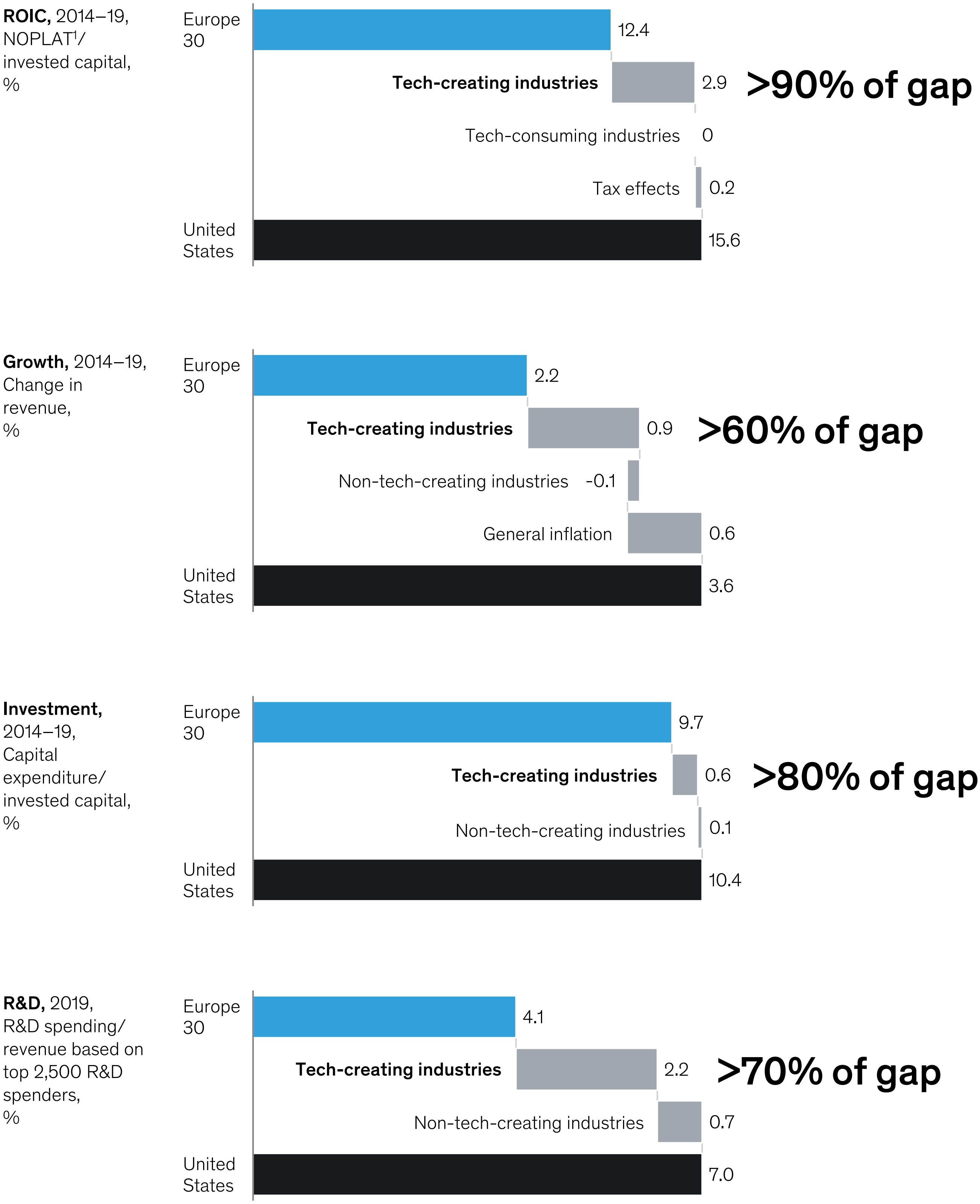
Recent signs indicate that Europe's tech industries have picked up. According to Atomico, in 2021 Europe experienced the largest increase in unicorns (startups valued at more than $1 billion) since 2014, with 98 new unicorns.[32] In 2021, Europe attracted a record $110 billion of venture capital funding, exceeding other markets. Nevertheless, Europe's capital investment is still nearly three times lower than that of the United States, and the uptick in capital investment has not yet translated into companies with sufficiently large scale to move the needle on aggregate corporate performance. A March 2022 note from Morgan Stanley highlighted Europe's rising share of small-scale funding rounds of up to $10 million, an early sign of generating future leading companies, and noted that talent spinning out of Europe's unicorns is increasingly staying in Europe rather than going to the United States or Asia. Morgan Stanley said that US skeptics have started to warm to Europe. In the past three years, typically US-focused venture capital funds have begun to participate more in Europe deals.[33]

32 *State of European Tech 21*, Atomico, December 2021.
33 *Europe's private promise*, Morgan Stanley, March 2020.

Exhibit 10

Corporate Europe's performance is not on a par with that of US counterparts, largely because of tech-creating industries.

US/Europe 30 delta in return on invested capital (ROIC), growth, investment, and R&D
Sample of ~2,200 companies with revenue of more than $1 billion; financial companies excluded

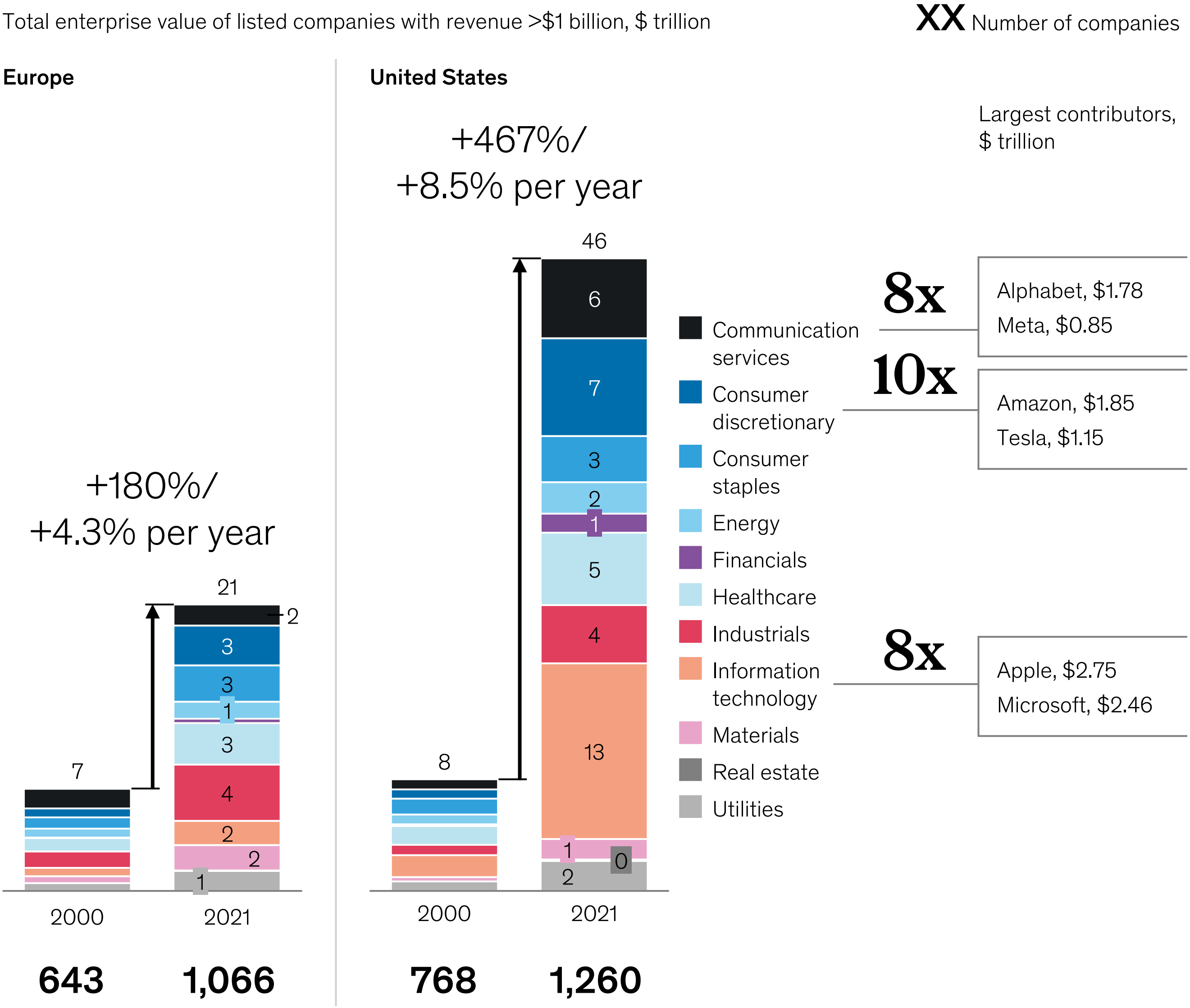


1. Net operating profit less adjusted taxes.
Note: Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Exhibit 11

US corporate values are rising strongly, while European company valuations are falling behind.

Total enterprise value of listed companies with revenue >$1 billion, $ trillion



Note: Data labels <5 not shown. Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; McKinsey Global Institute analysis

Relative corporate performance varies by sector

The relative performance of European companies against their US counterparts varies. We looked at the same four metrics of corporate performance: ROIC, revenue growth, capital expenditure relative to stock of invested capital, and R&D intensity (Exhibit 12). As may be expected, Europe has a strong record, particularly on automotive and industrials, and a pronounced gap in ICT and, increasingly due to the higher weight of biotech, in pharmaceuticals. The picture is more nuanced in other sectors. For instance, in aerospace and defense, large European firms tend to be smaller and less profitable, but they have been growing more strongly and invested a higher share of revenue in R&D than their US competitors; while this could be a good sign, it is as much a reflection of national fragmentation and a lack of European scale. In materials, European firms tend to be larger and growing more quickly, but they invest a lower share of their revenue in R&D.

Exhibit 12

Sector deep dive (1/2).

Weighted average, 2014–19, %

Europe 30 | United States

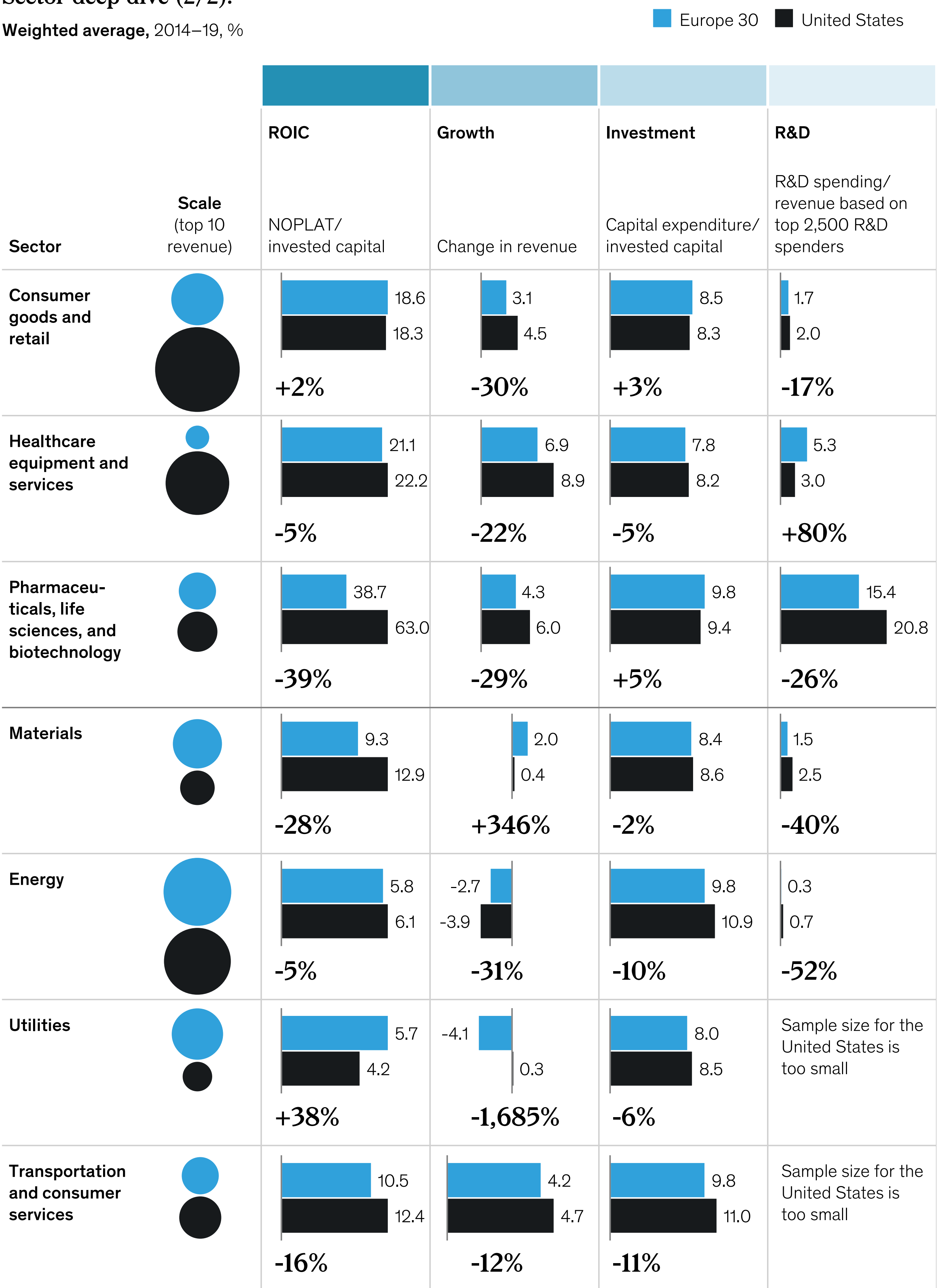
Sector	Scale (top 10 revenue)	ROIC NOPLAT/ invested capital	Growth Change in revenue	Investment Capital expenditure/ invested capital	R&D R&D spending/ revenue based on top 2,500 R&D spenders
Aerospace and defense		16.4 26.0 -37%	4.1 3.3 +25%	10.1 8.3 +23%	5.0 3.1 +61%
Automobile and components		14.4 11.2 +28%	6.3 1.7 +279%	14.8 11.8 +26%	5.8 4.5 +30%
Industrials		15.0 20.9 -28%	4.5 2.2 +102%	8.0 8.3 -4%	4.1 3.3 +24%
Telecommu-nications and media		18.1 20.5 -12%	1.9 9.9 -81%	16.9 14.7 +15%	1.9 1.7 +12%
Information technology		37.0 62.1 -40%	3.3 4.2 -23%	11.5 19.1 -40%	14.6 12.9 +13%
Commercial and professional services		34.5 22.1 +56%	8.0 3.2 +153%	10.9 9.6 +14%	3.1 4.4 -30%

Note: Financial companies excluded. Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Exhibit 12

Sector deep dive (2/2).

Weighted average, 2014–19, %



Note: Financial companies excluded. Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

As technology permeates sectors and scale advantages and winner-takes-most dynamics rise, Europe's approach may not be sustainable

Technology used to be a sector; now it is everywhere. It has spawned a range of transversal technologies relevant to all sectors, such as AI, quantum computing, and cloud; the core of competitive dynamics is now horizontal rather than vertical. Value creation is shifting to these horizontal areas with strong corporate winner-takes-most dynamics and network effects. The World Economic Forum estimates that 70 percent of the new value created in the whole economy over the next ten years will be digitally enabled, and the COVID-19 pandemic only accelerated this momentum.[34] In July 2020, executives surveyed by McKinsey estimated that they had accelerated adoption of digitization, in the case of supply chains by 35 percent.[35]

70%

of new value created globally will be digitally enabled, according to the World Economic Forum

Digitization and the spread of a broad range of transformational technologies is, if anything, speeding up, and the potential penalty for lagging on innovation and key technologies is rising. In 2019, MGI analyzed nearly 6,000 of the world's largest public and private companies with revenue of more than $1 billion—so-called superstars—and found that the top 10 percent of firms capture 80 percent of positive economic profit. The middle 60 percent of companies record near-zero economic profit on average, showing how hard it can be to defy market forces. The bottom 10 percent destroy as much value as superstars create. The gap between leaders and laggards is widening, suggesting that winner-takes-most dynamics are playing out. After adjusting for inflation, superstar companies have 1.6 times more economic profit, on average, than superstars 20 years earlier, and bottom-decile companies on average have 1.5 times more economic loss.[36]

Where economies and companies stand on key technologies is therefore pivotal. But what are the technologies that matter? McKinsey researched a wide range of tech trends and homed in on the ten that are most relevant.[37] We look at ten transversal technologies on which Europe's future performance and prosperity hinge (Exhibit 13). We compared Europe's relative position to that of the leader or second-best region on the innovation, production, and adoption stages for the ten transversal technologies. For each metric in each of these three stages, we first calculated the size ratio of Europe against the leader or second-best region; for instance, in the case of number of patents, which is one metric in the innovation stage, if Europe issued 18 percent of world-class patents versus 56 percent in the United States, the ratio is 0.3 (Exhibit 14).[38] The factor of each stage is the average of the ratios of respective metrics. Finally, we estimate that from a ratio of 0.1 to 0.7, Europe is considered lagging behind; from 0.8 to 1.2, Europe is on a par; and from 1.3 up, Europe is leading.

Europe leads on only two of the ten (Exhibit 15). For some illustrative examples, see Exhibit 16.

---

34 *Shaping the future of digital economy and new value creation*, World Economic Forum.

35 *What 800 executives envision for the postpandemic workforce,* McKinsey Global Institute, July 2020.

36 Sree Ramaswamy, Michael Birshan, James Manyika, Jacques Bughin, and Jonathan Woetzel, "What every CEO needs to know about 'superstar' companies," McKinsey Global Institute, April 2019; and Chris Bradley, Martin Hirt, and Sven Smit, *Strategy beyond the hockey stick: People, probabilities, and big moves to beat the odds*, Wiley, 2018.

37 For every trend, McKinsey calculated a momentum score based on the growth rate of the technologies underlying the trends, which we derived from an in-depth analysis of six proxy metrics: patent filings, publications, news mentions, online search trends, amount of private investment, and the number of companies making investments. Scores for the underlying technologies were then rolled into a single composite score for the trend itself. See *The top trends in tech*, McKinsey Digital, 2021.

38 World-class patents are identified through the number of countries in which a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s). See Jan C. Breitenger, Benjamin Dierks, and Thomas Rausch, *World-class patents in cutting-edge technologies: The innovation power of East Asia, North America, and Europe*, Bertelsmann Stiftung, June 2020.

Exhibit 13

There are over 60 future arenas of competition at the intersection of transversal technologies and sectors.

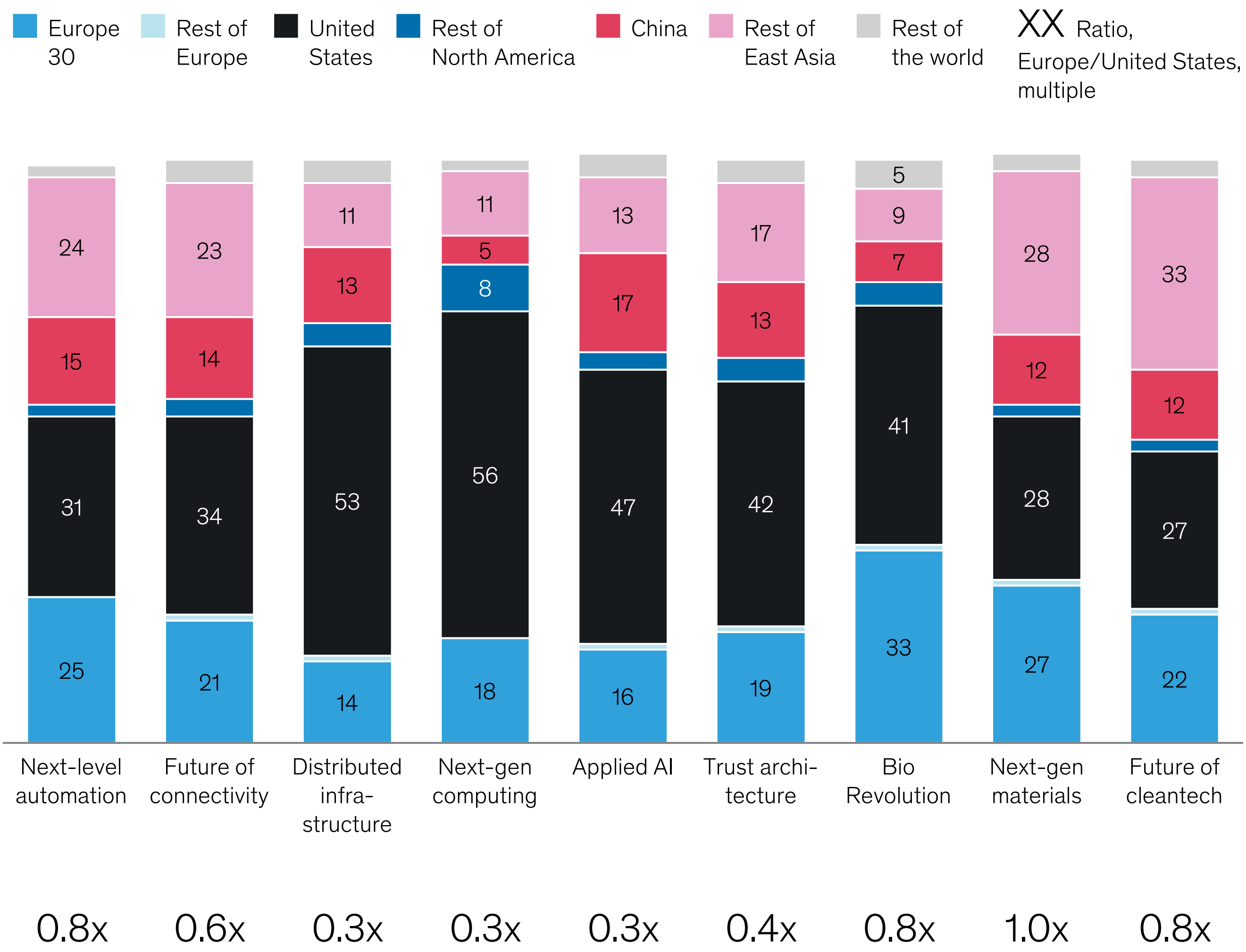
	Industrials (incl auto and defense)	**Chemicals and materials** (incl agriculture)	**Transportation, energy, and infrastructure**	**Pharmaceuticals and healthcare**	**Consumer and retail**	**Financials and professional services**
Next-level process automation	Robotics, additive manufacturing, drones, digital twins	Virtual development modelling, testing, agriculture next-generation	Modular construction, prefab, additive manufacturing, robotics	Virtual clinical trials, surgery robot, additive manufacturing	Domestic service robot, warehouse automation	—
Future of connectivity	Industry 4.0, connected cars, connected soldiers	Smart farming	Smart cities, smart power plants/grids, embedded sensors	Remote health monitoring, wearables	Wearables, smart home	—
Distributed infrastructure	Cloud and edge computing					
Next-generation computing	Quantum computing					
Applied AI	Autonomous vehicles	Precision agriculture	Last-mile drone usage, smart power plants/grids	AI imaging and diagnostics, drug discovery	Marketing analytics, speech recognition	Pricing risk analytics, automated operations, tech-augmented advisory
Future of programming	Software 2.0					
Trust architecture	Cyberwar	Traceability	Smart contracts	Blockchain in supply chain and records	Smart sourcing	Blockchain, smart contracting
Bio Revolution	Industrial enzymes, exoskeleton	Next-generation crops, bioroutes for chemicals	Biopolymers, biofuels, engineered produce transportation	Gene and stem cell therapy, tissue engineering, brain-device interaction, neurogenomics, biomolecules	Alternative proteins, microbiome-based products	—
Next-generation materials	Nanomaterials, new materials, new-generation weapons	Nanosensors, next-generation composites, synthetic materials/ chemical design	New materials, new construction materials	Tissue engineering	Personalization, new materials	—
Future of cleantech	Decarbonization, electric vehicle	Wireless irrigation systems, green cement/steel, recycling	Modular, virtual twins, renewables, CCS, green energy	—	—	—

Source: PitchBook; McKinsey Corporate Performance Analytics Tool; McKinsey Global Institute analysis

Exhibit 14

The United States generates more world-class patents than Europe in transversal technologies.

Share of world-class patents in frontier technologies by technology,[1] 2019, %



1. World-class patents are identified through the number of countries in which a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s).

Note: Data for future of programming not available. Data labels <5 not shown. Figures may not sum to 100% because of rounding.
Source: Bertelsmann Stiftung; McKinsey Global Institute analysis

Lack of scale in transversal technologies risks Europe's position across sectors, including strongholds like automotive and luxury goods

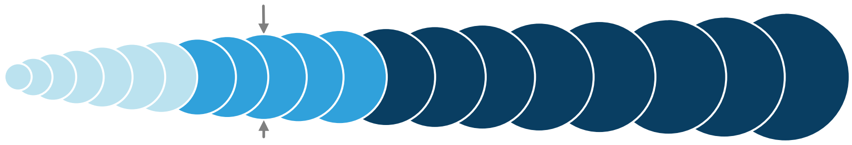
Europe is being eclipsed on industrial-scale adoption of technology. Take automotive as an example. There are still two European automotive companies in the world's top three auto manufacturers. As of 2018, five of the top ten premium cars sold in the United States were European. However, as of 2021, only three of the top ten electric vehicles sold in the United States were European.[39] Additionally, US manufacturers account for close to 70 percent of all kilometers traveled by L4 full-autonomous vehicles, mostly because of Europe's lag in AI, late regulation, and lack of funding. Similarly, European companies account for 95 percent of the value of luxury brands globally, but Europe is lagging on wearable devices; Apple, Huawei, Samsung, and Xiaomi have a combined market share of almost 65 percent. Europe has some of the most productive retailers but has no online retail platform to match the size of leading US and Chinese online retailers. Europe has strength in software, too, but is not leveraging its position to establish a world-leading business-to-business software company such as

[39] *Electrified light-vehicle sales report Q4 2021*, Kelley Blue Book, 2022.

Exhibit 15

Out of ten transversal technologies, such as AI, quantum computing, and cloud, Europe leads on two.

Relative European position vs leading or second-best region on a range of metrics, multiple[1]



Transversal technologies	Keywords	Innovation[2]	Production[3]	Adoption[4]	Average
Next-level automation	Industrial, collaborative, and professional robots; additive manufacturing; virtualization	0.6	1.0	0.7	0.8
Future of connectivity	5G, Internet of Things	0.7	0.7	0.3	0.6
Distributed infrastructure	Cloud, edge computing	0.2	0.1	0.7	0.3
Next-generation computing	Quantum computing, neuromorphic software	0.5	n/a	n/a	0.5
Applied AI	Robotic process automation, optimized decision making, natural language processing, computer vision, speech technology	0.5	<0.1	0.8	0.4
Future of programming	Software 2.0, no-code and low-code programming	0.3	<0.1	n/a	0.2
Trust architecture	Blockchain, zero-trust security/cybersecurity	0.3	0.3	0.6	0.4
Bio Revolution	Biomolecules, biosystems, bio-machine interface, biocomputing	0.8	0.4	0.5	0.6
Next-gen materials	Nanomaterials, composite materials	0.7	2.0	1.2	1.3
Future of cleantech	Solar power, wind energy, hydropower, nuclear, electric vehicles, hydrogen	1.3	0.4	1.2	1.0
Average		**0.6**	**0.6**	**0.7**	

1. For instance, if Europe issues 200,000 patents per year related to automation vs 400,000 a year in the United States, the multiple is 0.5 times.
2. Average number of the ratios based on number of publications, number of patents, and venture capital funding ($ billion).
3. Average number of the ratios for top ten companies on market share (%), market capitalization ($ billion), and corporate or private equity funding ($ billion).
4. Average number of the ratios based on public investment ($ billion), penetration (count per capita), and end-market share (%).

Source: *The top trends in tech*, McKinsey Digital, 2021; McKinsey Global Institute analysis

Exhibit 16

A snapshot of Europe's position relative to other major regions in ten transversal technologies largely reveals lags.

Next-level automation
$1B venture capital funding on robotics in Europe vs $5B in the United States, 2015–20

Future of connectivity
35% forecast 5G penetration in Europe vs 67% in China by 2024

Distributed infrastructure
2% revenue of European companies from cloud, vs 73% in United States, 2021

Next-generation computing
$8B announced public funding in Europe vs $15B in China, 2021

Applied AI
42% of European enterprises adopting at least one AI technology, vs 70% in China, 2021

Future of programming
10% top low-code/no-code platforms from Europe vs 75% from United States, 2020

Trust architecture
30% European companies in the top 100 that had implemented blockchain, vs 60% of US companies, 2021

Bio Revolution
United States has 2x approved biotech drugs vs Europe, 2018–20

Next-gen materials
55% additive manufacturing composites in Europe vs 29% in United States, 2019

Future of cleantech
7 companies in Europe working on nuclear fusion vs 13 in the United States, 2021

Source: McKinsey Global Institute analysis

Salesforce.[40] In short, Europe's lagging position on most transversal technologies jeopardizes its performance even in traditional sectors where it has led the world.

Markets have already internalized this shift. Taking market capitalization shifts as an imperfect proxy for investor expectations of leadership (such shifts are essentially a bet on future profitability and reflect increased productivity and other factors such as market power), European firms improved their ranking on only three of 20-plus sectors from 2000 to 2019: household and personal products, pharmaceuticals, and retail (Exhibit 17).

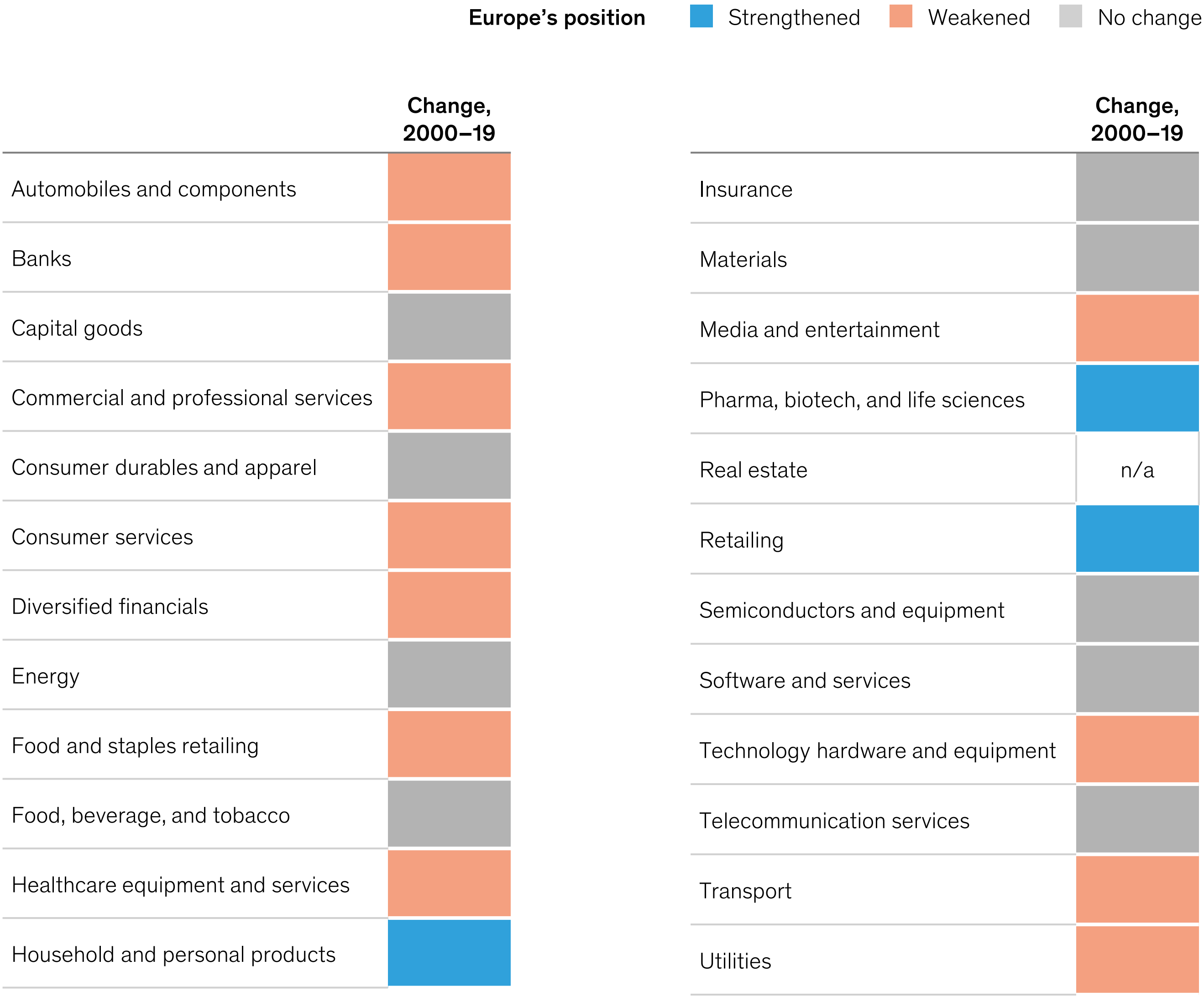
Europe's large companies lack scale and strategic control in comparison with their US counterparts. US companies have almost double the market-to-book ratios of their European counterparts, and nearly 30 percent higher levels of book equity (Exhibit 18).

40 Christian Behrends, Daniele Di Mattia, Jonathan Shulman, and Alberto Torres, "Reversal of fortune: How European software can play to its strengths," McKinsey & Company, February 2022.

Exhibit 17

Markets have already embedded the gap across sectors.

Change in market capitalization of top European and US firms

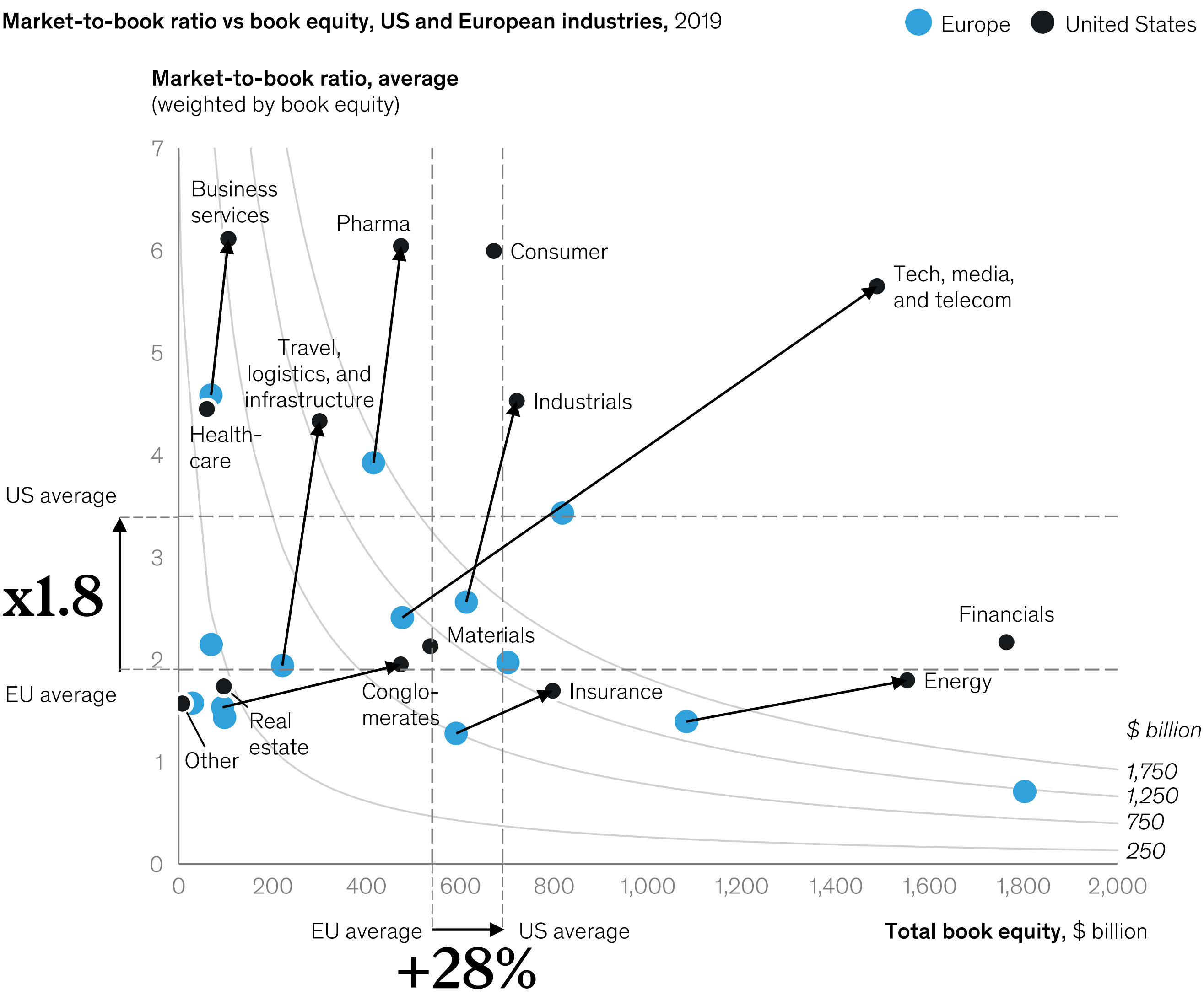


Source: McKinsey Corporate Performance Analytics Tool; McKinsey Global Institute analysis

Exhibit 18

US companies' market-to-book ratios are almost double and equity is nearly 30 percent higher than those of European counterparts.

Market-to-book ratio vs book equity, US and European industries, 2019



Note: Included are companies with revenue above $1 billion, 2000–20 thresholds; excluded are companies that are not listed or do not report asset values or market capitalization.
Source: McKinsey Corporate Performance Analytics Tool; McKinsey Global Institute analysis

In 2018, five of the top ten premium cars sold in the United States were European. However, as of 2021, only three of the top ten electric vehicles sold in the United States were European.

The value at stake is high, not only for growth but also for sustainability, inclusion, and Europe's strategic autonomy

At stake is not only the performance of Europe's companies, its tech prowess, and its economic growth and prosperity, but also its progress thus far on sustainability and inclusion. There are arguments that lower growth is needed to achieve net zero, but growth, properly measured, creates new income streams that are needed to pay for the energy transition and for inclusion measures, preventing zero-sum dynamics.[41]

Growth strengthens confidence and creates a healthy investment climate and new income streams that are needed to pay for the energy transition. Lagging growth could, moreover, undermine inclusion by limiting the pool of funds available to spend on social programs.

Our analysis suggests that if Europe fails to improve on transversal technologies, European firms could miss out on a value-added opportunity of €2 trillion to €4 trillion a year by 2040. Two approaches independently lead to this result (see Box 2, "Value at stake—methodology").

Value at stake of €2 trillion to €4 trillion equates to 30 to 70 percent of Europe's forecast GDP growth between 2019 and 2040, or one percentage point of growth a year.[42] To put this into further context, the lost value would be equivalent to six times the annual amount needed to transition to net zero.[43] And it would amount to about 90 percent of all current social expenditure in Europe (Exhibit 19).[44]

[41] Benjamin M. Friedman, *The moral consequences of economic growth*, Knopf Doubleday Publishing Group, 2010.
[42] IHS Markit.
[43] *The net-zero transition: What it would cost, what it could bring*, McKinsey & Company and McKinsey Global Institute, January 2022.
[44] European Commission statistical database.

Exhibit 19

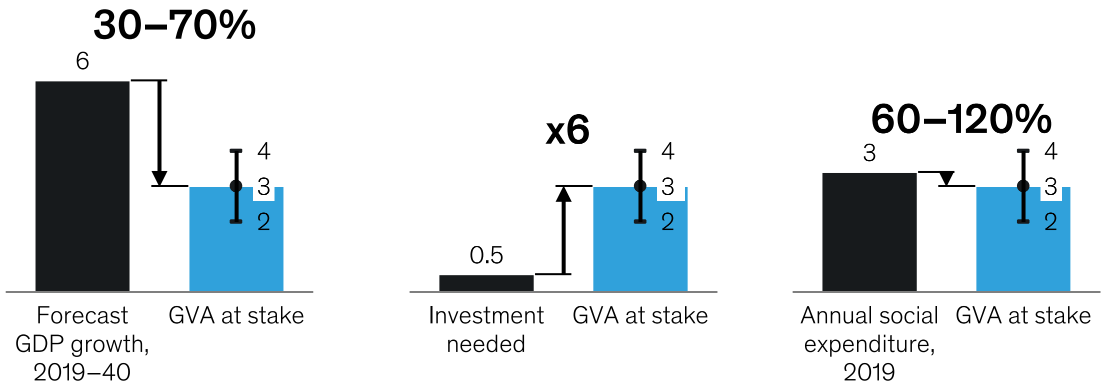
Value at stake is equivalent to half of GDP growth to 2040, six times the annual expected cost of the net-zero transition, and close to annual social expenditure.

$ trillion

Growth
GVA[1] at stake represents ~50% of GDP growth 2019–40

Sustainability
GVA at stake represents 6x annual gross investment needed to reach net-zero GHG by 2050

Inclusion
GVA at stake represents ~90% of European yearly social expenditure



Equivalent to

1%
GDP compound annual growth rate lost over the entire period

x6
annual gross investment needed to reach net-zero greenhouse gas emissions by 2050

€500
monthly universal income for the entire European population

1. Gross value added.
Note: Figures may not sum to 100% because of rounding.
Source: Oxford Economics Base Scenario; European Commission; McKinsey Sustainability; McKinsey Global Institute analysis

Box 2

Value at stake—methodology

Three approaches independently lead to the estimated value at stake (Exhibit 20).

— First, we looked at the market valuations of the top 5,000 global companies and translated this into revenue growth expectations, assuming constant ROIC. This analysis generated a figure of €3 trillion to €4 trillion less revenue a year for European companies than for US companies by 2040, or €1 trillion to €2 trillion lower corporate value added.

— Second, we used a bottom-up analysis of the ten transversal technologies' forecast market sizes and their equivalent in gross value added (estimated at 40 percent). The total forecast market size sums up to €11 trillion to €20 trillion by 2040. Given Europe's current share of global GDP (23 percent), this equates to €2 trillion to €5 trillion at stake. Then, its gross value-added equivalent (estimated at 40 percent of revenues) equals €4 trillion to €8 trillion. Again, given Europe's current share of global GDP, this equates to €1 trillion to €2 trillion at stake for the region.

— Finally, we used a bottom-up analysis of the economic impact of the adoption of the ten transversal technologies. There could be €16 trillion to €30 trillion of value at stake and, given Europe's current share, this equates to €4 trillion to €7 trillion at stake.

We estimated the lower bound of the share of gross value added of revenue at 0.4 for Europe, assuming that the remaining value added will be captured outside Europe.

We have not modeled the complex relationship between corporate value-added growth and economic growth. This would require understanding, for instance, the value generated in Europe by foreign subsidiaries, maintaining jobs and income in Europe; the alternative activities European firms and workers would pursue; the split of large corporate versus smaller firm value added; and second-order effects, nonlinear effects, or feedback loops that would be inherent to a general equilibrium modeling. As an illustration, if we assume that only profits shift abroad, the gross value added at stake would lie in the range of €1 trillion to €2 trillion (assuming a weighted average of 43 percent of gross operating surplus).[1]

[1] Forecast data for 2020–40 from IHS Markit.

Exhibit 20

€2 trillion to €4 trillion of corporate value added is at stake for Europe.

We have triangulated three methodologies to estimate the value at stake

Corporate valuation perspective	• Capital markets anticipate €3 trillion–€4 trillion revenue growth gap for listed companies by 2040 in Europe • Typical GVA-to-revenue[1] ratio of 0.4	**€1 trillion–€2 trillion** corporate value at stake
Production perspective of transversal technologies	• Market sizing of transversal technologies of €11 trillion–€20 trillion by 2040 with Europe 30's 23% share at stake	**€2 trillion–€5 trillion** corporate value at stake
	• Gross value-added equivalent of transversal technologies estimated between €4 trillion and €8 trillion by 2040 with Europe 30's 23% share at stake	**€1 trillion–€2 trillion** corporate value at stake
Adoption perspective of transversal technologies	• Global value added from adoption in transversal technologies of €16 trillion–€30 trillion by 2040 • Europe 30's 23% share at stake	**€4 trillion–€7 trillion** corporate value at stake

1. GVA = gross value added. If we were to consider growth operating surplus, value at stake would lie in the range of €1 trillion to €2 trillion (assuming a weighted average of 43 percent of gross operating surplus vs GVA).
Source: "The corporation in the 21st century," McKinsey & Company, November 2021; McKinsey Global Institute analysis

A shifting geopolitical environment that is increasingly polarized accentuates the need for strategic autonomy on critical technologies. Such autonomy is compatible with open economies and global collaboration: it can be achieved via multiple independent and various global sourcing options as well as a strong footprint of globally leading firms in Europe. But it will also require capability buildup by, and scaling of, European firms. Today, for instance, only 9 percent of semiconductors to meet European demand are produced in Europe, and European companies have only about 10 percent of the market across the semiconductor value chain. In infrastructure as a service (IaaS), Europe has no player with a market share of more than 1 percent.

Lagging tech-creating industries are the main reason for Europe's corporate gap. This leaves the region vulnerable competitively in ten transversal technologies that are increasingly influencing the dynamics of virtually every sector. In Chapter 3, we look at the performance of individual European countries on sustainable and inclusive growth.

A shifting geopolitical environment that is increasingly polarized accentuates the need for strategic autonomy on critical technologies.

©Christopher Hope-Fitch/Getty images

3. A country-level view

In this chapter, we provide the standing of nine European countries (which are very different in terms of size, industry structure, and institutional approaches) on sustainable and inclusive growth, and a summary of the relative position of corporations. We highlight the following countries:

France

Germany

Italy

The Netherlands

Poland

Spain

Sweden

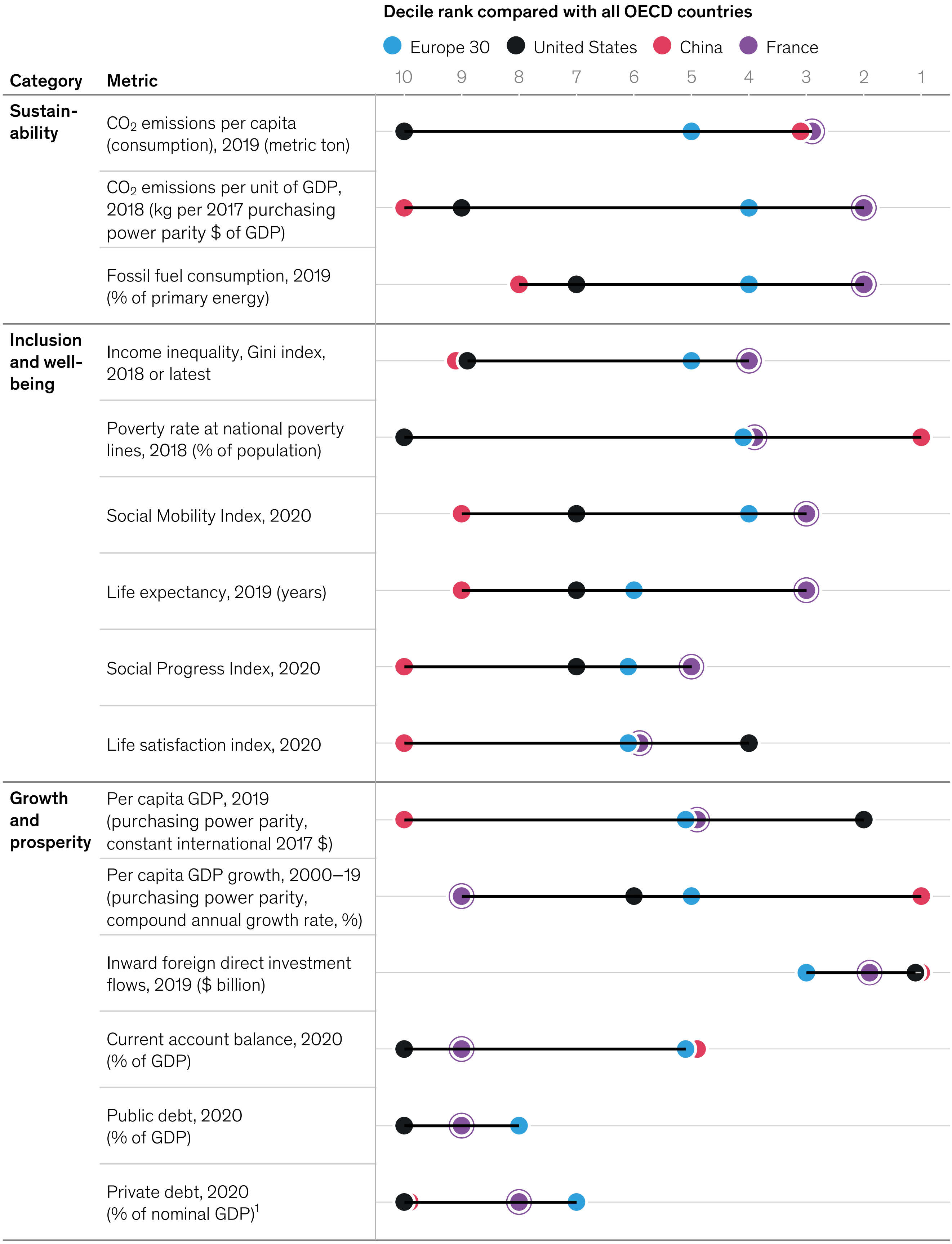
Switzerland

United Kingdom

France

Exhibit 21

France scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

70%

of France's electricity can be generated with low carbon emissions due to nuclear

Over the past decade, France has emerged as a world leader on promoting sustainability (Exhibit 21). France's per capita CO_2 emissions are much lower than the Europe 30 average and the US level, and on a par with those of China. A major contributor to this strong showing is France's extensive nuclear capacity, which ensures that about 70 percent of its electricity can be generated with low carbon emissions. France is the second-largest producer of nuclear energy in the world, with 56 operating reactors and capacity of more than 61,000 megawatts in 2021. France is performing above the Europe 30 average on inclusion. France has higher social mobility, life expectancy, and social progress readings than the Europe 30 average, the United States, and China. On growth and prosperity, however, France lags behind. Although its per capita GDP was on a par with the Europe 30 average in 2019, growth in per capita GDP between 2000 and 2019 was behind not only the Europe 30 average but also per capita GDP growth in China and the United States.

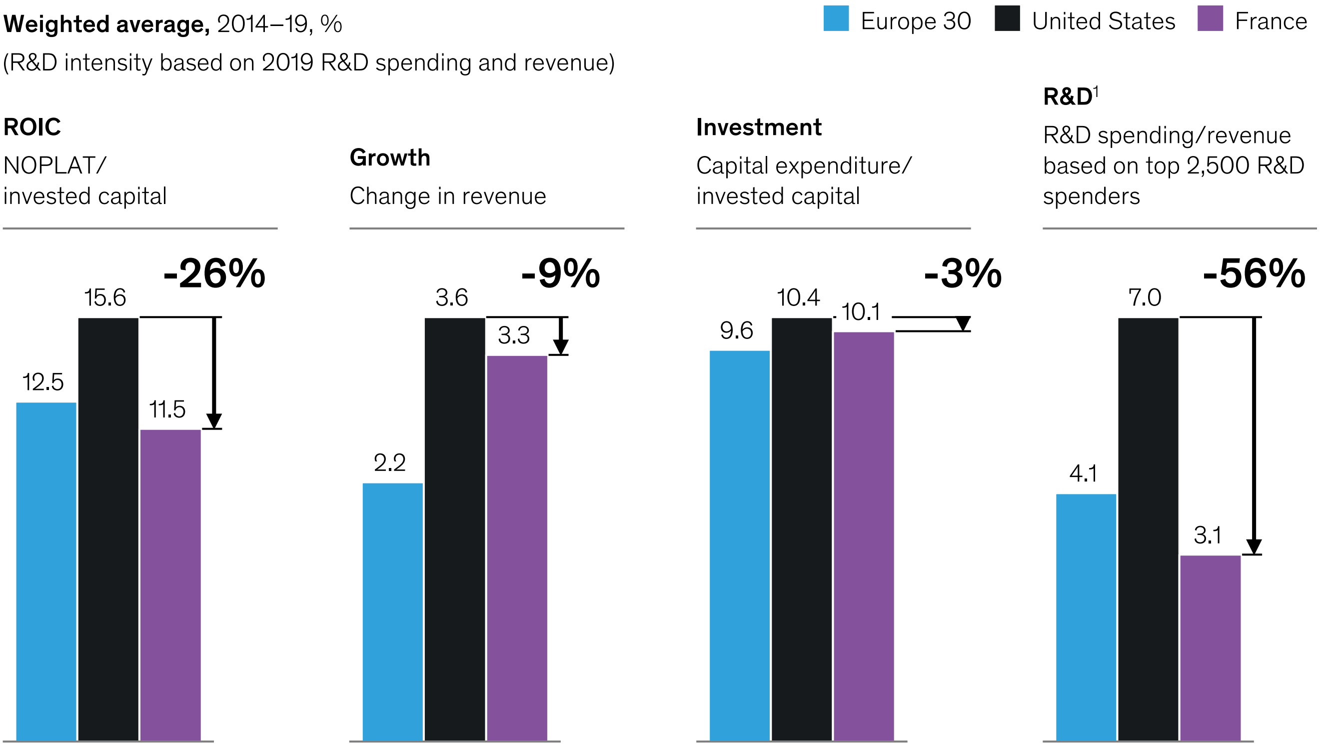
France's large companies outperform the economy but lag behind US counterparts on key metrics of corporate performance (Exhibit 22). Although they are only slightly behind their US counterparts—and match the Europe 30 average—on capital expenditure relative to invested capital stock, they lag significantly on return on invested capital and R&D intensity. Revenue growth is higher than the Europe 30 average, but it lags behind that of US large corporations by about 9 percent.

Exhibit 22

France corporate analysis

Weighted average, 2014–19, %

(R&D intensity based on 2019 R&D spending and revenue)



1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.

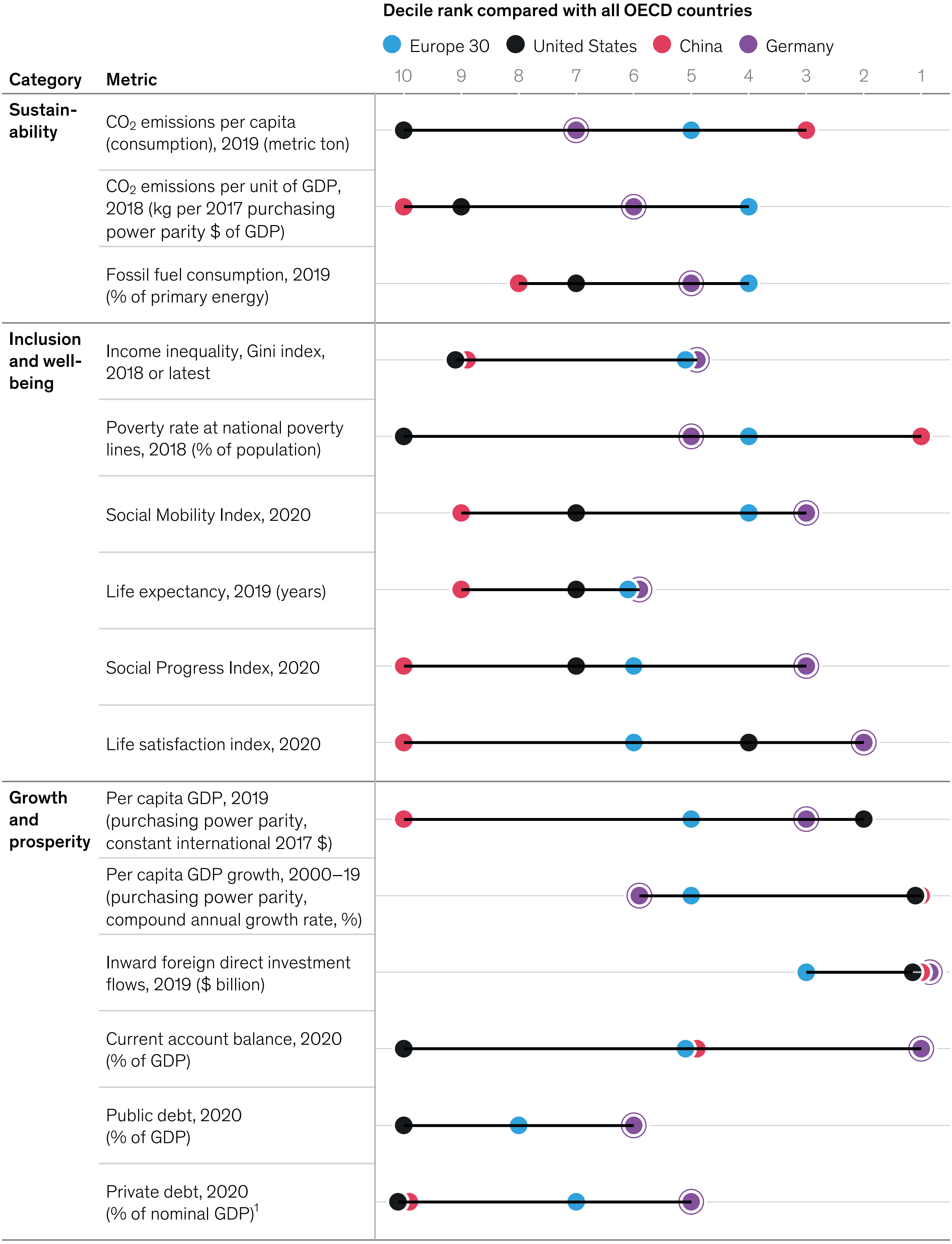
Note: Financial companies excluded. Sample sizes: ROIC (n = 113), growth (n = 123), investment (n = 113), R&D (n = 64). Figures may not sum to 100% because of rounding.

Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Germany

Exhibit 23

Germany scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

German large company growth lags behind that of US counterparts by

54%

Germany performs well on inclusion and on growth and prosperity, but less well on sustainability, where it lags behind the Europe 30 average (Exhibit 23). Germany's per capita (consumption-based) CO_2 emissions are significantly higher than those of China or the average of the Europe 30. The picture looks better relative to GDP. Germany has one of the strongest build-outs of renewables in Europe, having nearly doubled the installed capacity of renewables between 2011 and 2020.[45] However, the country's decision to end its use of nuclear power and its continued reliance on coal for power generation means that the country's emissions reduction targets are at risk.[46] On inclusion, Germany ranks relatively high on most metrics. Income inequality is on a par with the Europe 30 average, but social mobility is higher than the average. Life satisfaction is considerably higher than the Europe 30 average or in China or the United States. On growth and prosperity, Germany's per capita GDP in 2019 was just shy of that of the United States, and markedly higher than the Europe 30 average. Interestingly, however, growth in per capita GDP between 2000 and 2019 was lower than the Europe 30 average and China, albeit on a par with the United States.

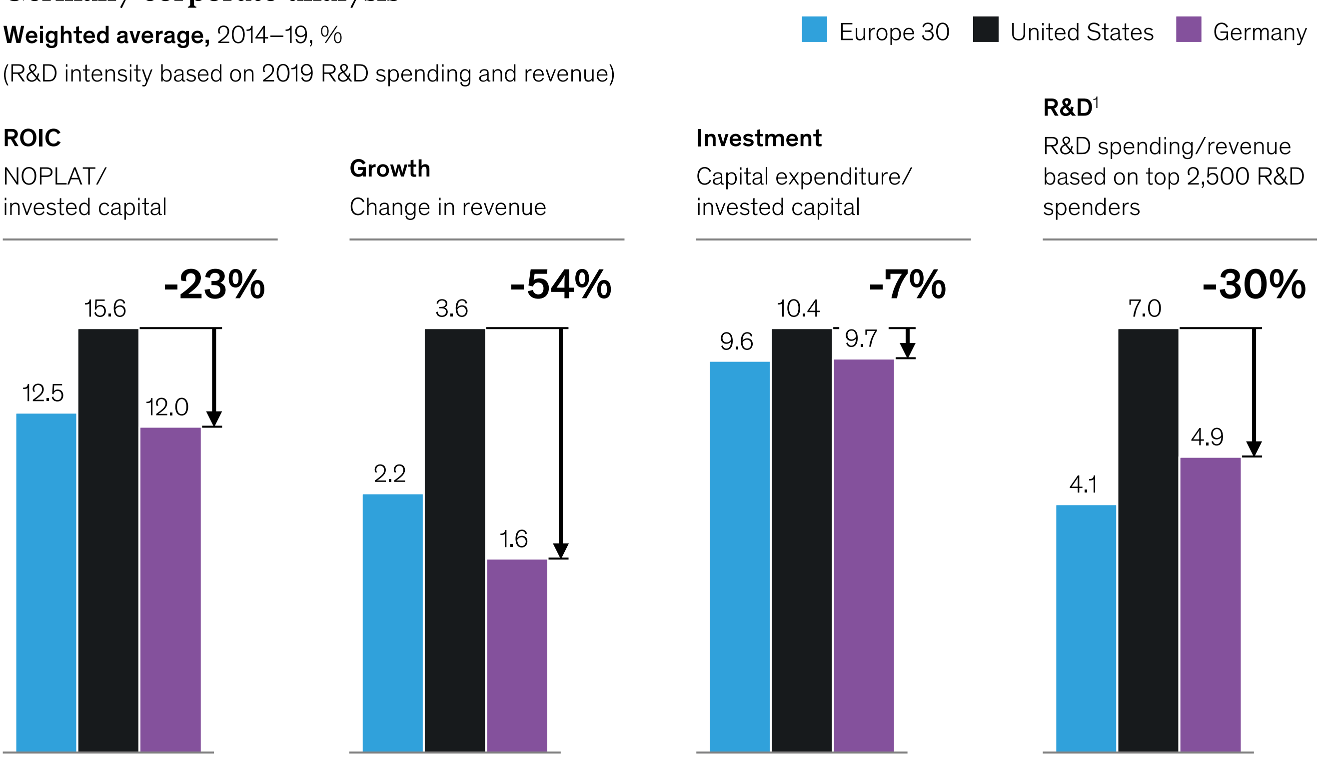
Turning to companies, capital expenditure relative to invested capital stock is on a par with the Europe 30 average and not far behind that of US counterparts (Exhibit 24). Germany is one of the highest spenders on R&D in the Europe 30, boosted by the vast R&D budgets of its automotive firms—although the rate of spending in 2019 relative to revenue was 30 percent below that of the United States. However, this above-average commitment to R&D has not been translating into higher return on invested capital and revenue growth, which lag behind that of large US companies by 23 percent and 54 percent, respectively.

45 Renewable capacity statistics 2021, International Renewable Energy Agency, March 2021.
46 "Germany faces a gigantic task to meet its CO_2 reduction goals, says country's new climate minister," Euronews, January 12, 2022.

Exhibit 24

Germany corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)

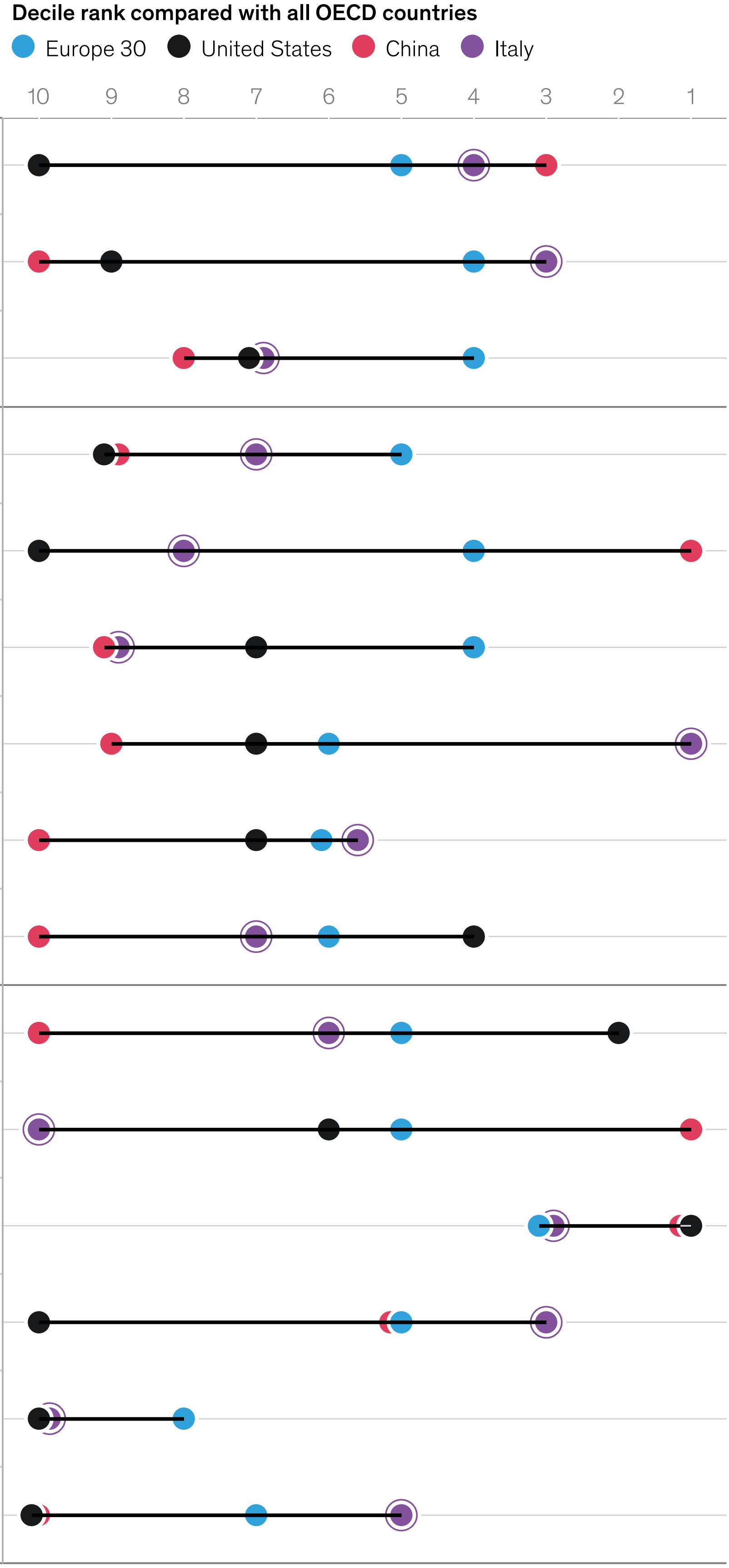


1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 118), growth (n = 135), investment (n = 118), R&D (n = 117). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Italy

Exhibit 25

Italy scorecard



Category	Metric
Sustainability	CO_2 emissions per capita (consumption), 2019 (metric ton)
	CO_2 emissions per unit of GDP, 2018 (kg per 2017 purchasing power parity $ of GDP)
	Fossil fuel consumption, 2019 (% of primary energy)
Inclusion and well-being	Income inequality, Gini index, 2018 or latest
	Poverty rate at national poverty lines, 2018 (% of population)
	Social Mobility Index, 2020
	Life expectancy, 2019 (years)
	Social Progress Index, 2020
	Life satisfaction index, 2020
Growth and prosperity	Per capita GDP, 2019 (purchasing power parity, constant international 2017 $)
	Per capita GDP growth, 2000–19 (purchasing power parity, compound annual growth rate, %)
	Inward foreign direct investment flows, 2019 ($ billion)
	Current account balance, 2020 (% of GDP)
	Public debt, 2020 (% of GDP)
	Private debt, 2020 (% of nominal GDP)[1]

1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

Italy's R&D spending relative to revenue nearly

75%

lower than US spending

Italy performs well on sustainability (Exhibit 25).[47] Its per capita emissions and emissions as a share of GDP are lower than the Europe 30 average, although its consumption of fossil fuels is significantly higher than the Europe 30 average—indeed, at US levels. But Italy does not have as strong a record on inclusion, growth, and prosperity. On inclusion, it is notable, for instance, that Italy matches but does not surpass China on social mobility. Its per capita GDP is below the Europe 30 average and has decreased from its 2000 level in constant international 2017 dollars. Private debt is relatively low, but public debt is high. Italy matches the Europe 30 average for inward foreign direct investment and has a much lower current account deficit than the average of its neighbors.

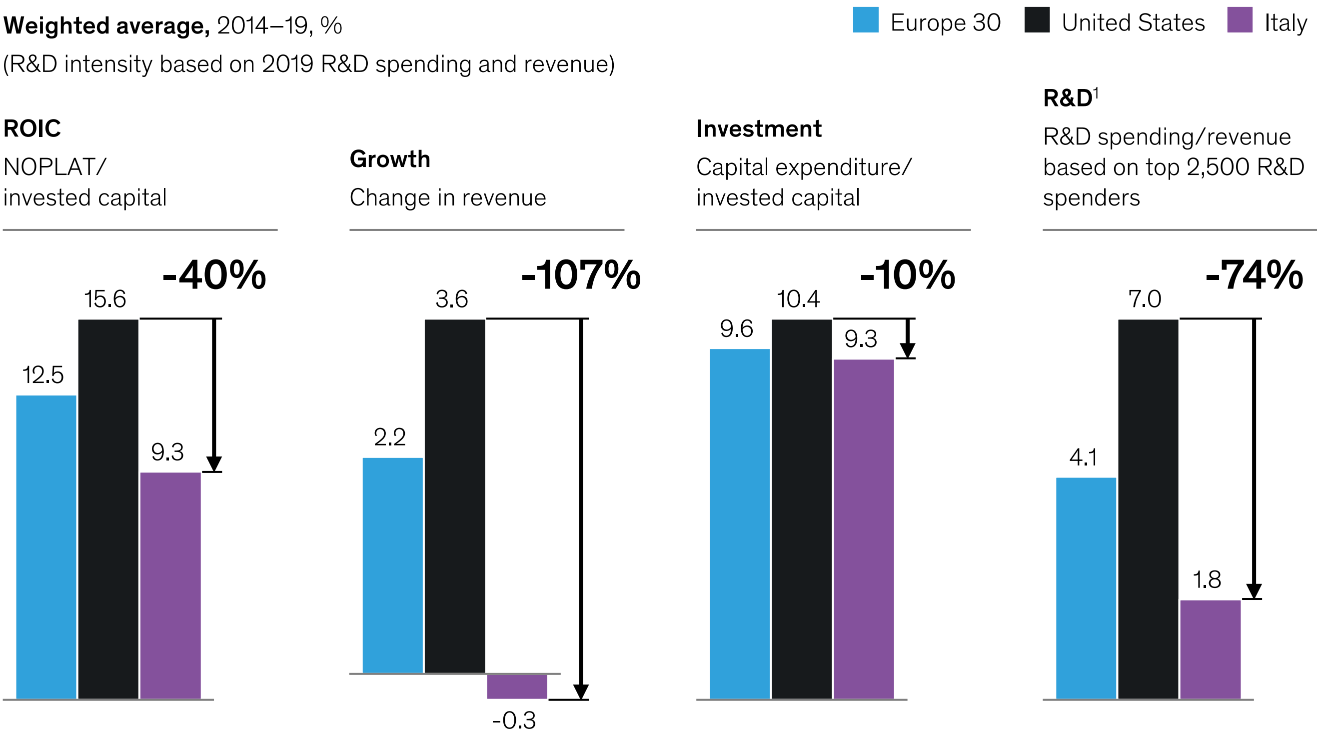
Corporate Italy is near the Europe 30 average and not far from US performance on capital expenditure relative to invested capital stock, but it lags significantly behind the Europe 30 average and the performance of US counterparts on return on invested capital, revenue growth, and R&D intensity (Exhibit 26). It is notable that Italy's R&D spending relative to revenue in 2019 was nearly 75 percent lower than that of the United States, and less than half of the Europe 30 average.

[47] Bruno Pellegrino and Luigi Zingales, *Diagnosing the Italian disease*, NBER working paper 23964, National Bureau of Economic Research, October 2017.

Exhibit 26

Italy corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)

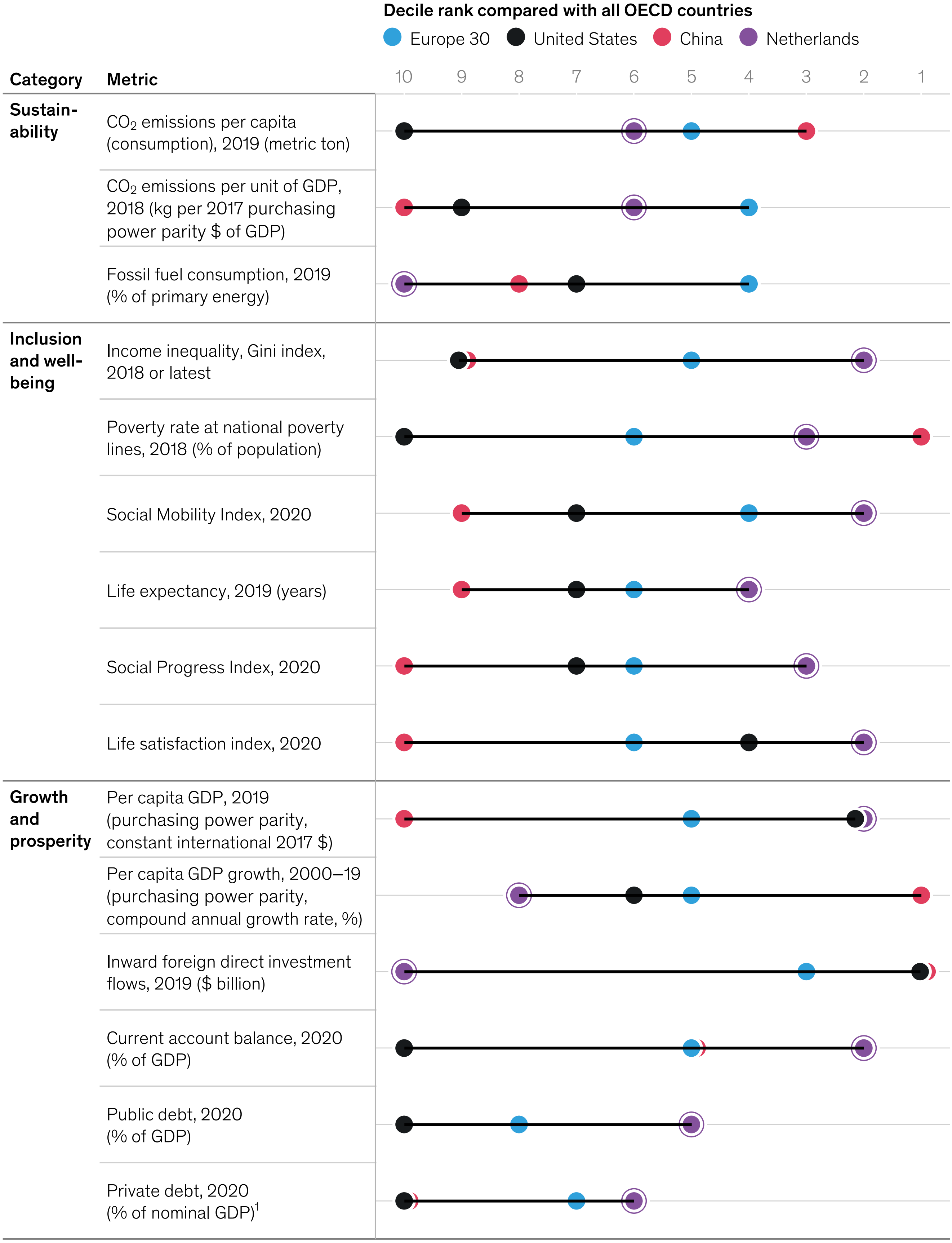


1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 47), growth (n = 61), investment (n = 47), R&D (n = 22). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

The Netherlands

Exhibit 27

Netherlands scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

$57k

per capita GDP in 2019 for the Netherlands vs $45,300 Europe 30 average

The Netherlands' per capita CO_2 emissions (consumption based) and CO_2 emissions per dollar of GDP (production based) are both higher than the Europe 30 average but much lower than the figures for the United States (Exhibit 27). Its fossil fuel consumption was 92 percent of primary energy in 2019, compared with the 74 percent average of the Europe 30—and much higher than for either China or the United States. In that year, 47 percent of primary energy generation came from oil, 38 percent from gas, and less than 8 percent from coal. The Netherlands' performance on inclusion is strong. Compared with China, the Europe 30 average, and the United States, it has lower income inequality and higher social mobility, life expectancy, social progress, and life satisfaction. The Netherlands also performs well on elements of growth and prosperity. Its per capita GDP in 2019 was just shy of $57,000 (at constant 2017 international dollars), considerably above the Europe 30 average of $45,300. However, inward foreign direct investment flows are weak in comparison with other regions, which could be explained by large financial flows following corporate restructurings.[48] The economy ran a relatively high current account surplus of about 7 percent of GDP in 2020, and it carries relatively low public and private debt (although some of the private debt links to the country's pension system setup).

Large corporations in the Netherlands lag behind both the Europe 30 average and their US counterparts on return on invested capital, with a gap of nearly 40 percent against the US average (Exhibit 28). They trail US companies by an even larger margin of 75 percent on growth in revenue and are behind the Europe 30 average. On R&D intensity, Dutch firms are close to the Europe 30 average but nearly 40 percent behind their US counterparts. Only on capital expenditure as a share of invested capital stock do large corporates in the Netherlands come close to the Europe 30 and US averages.

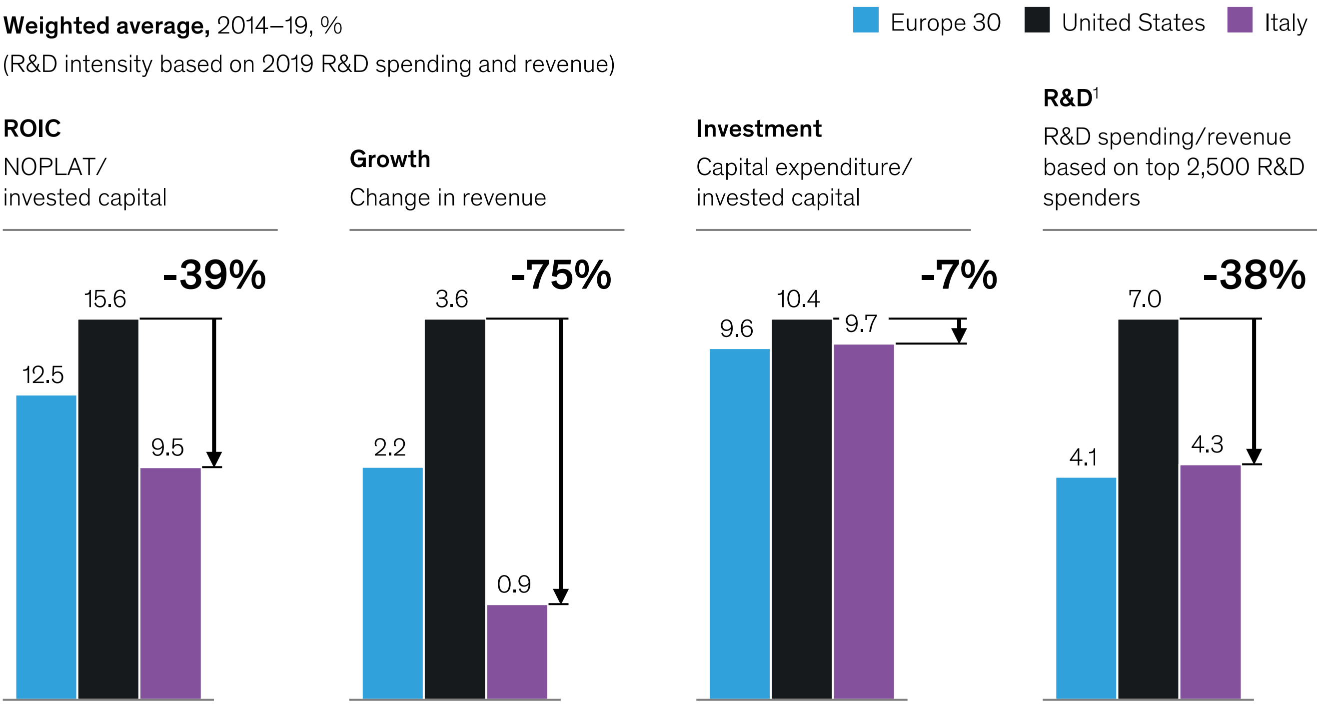
[48] "Foreign investment flows to developed countries slump by 58% in 2020," UNCTAD, June 21, 2021.

Exhibit 28

Netherlands corporate analysis

Weighted average, 2014–19, %

(R&D intensity based on 2019 R&D spending and revenue)

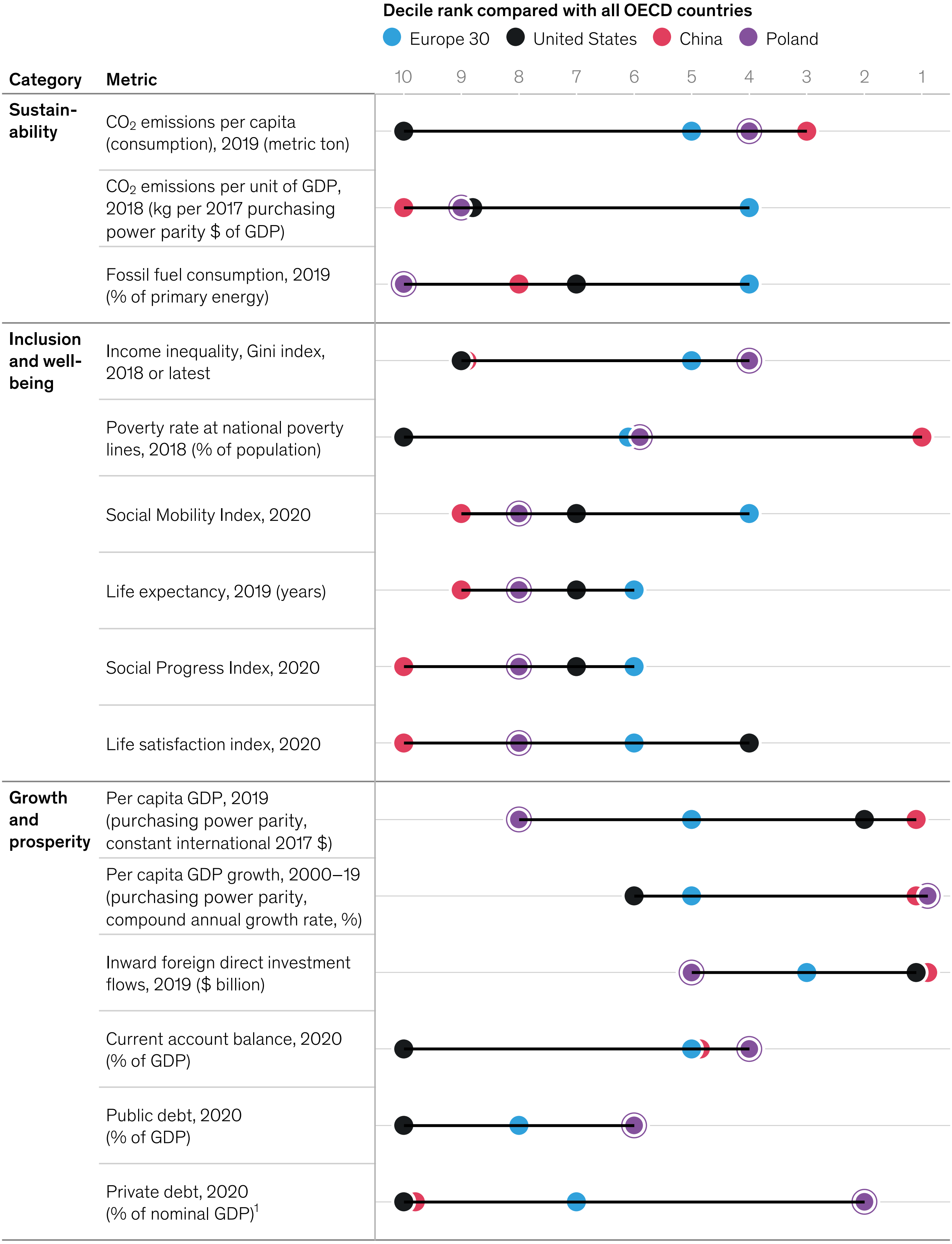


1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 47), growth (n = 61), investment (n = 47), R&D (n = 22). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Poland

Exhibit 29

Poland scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

Corporate Poland's return on invested capital

47%

below US counterparts

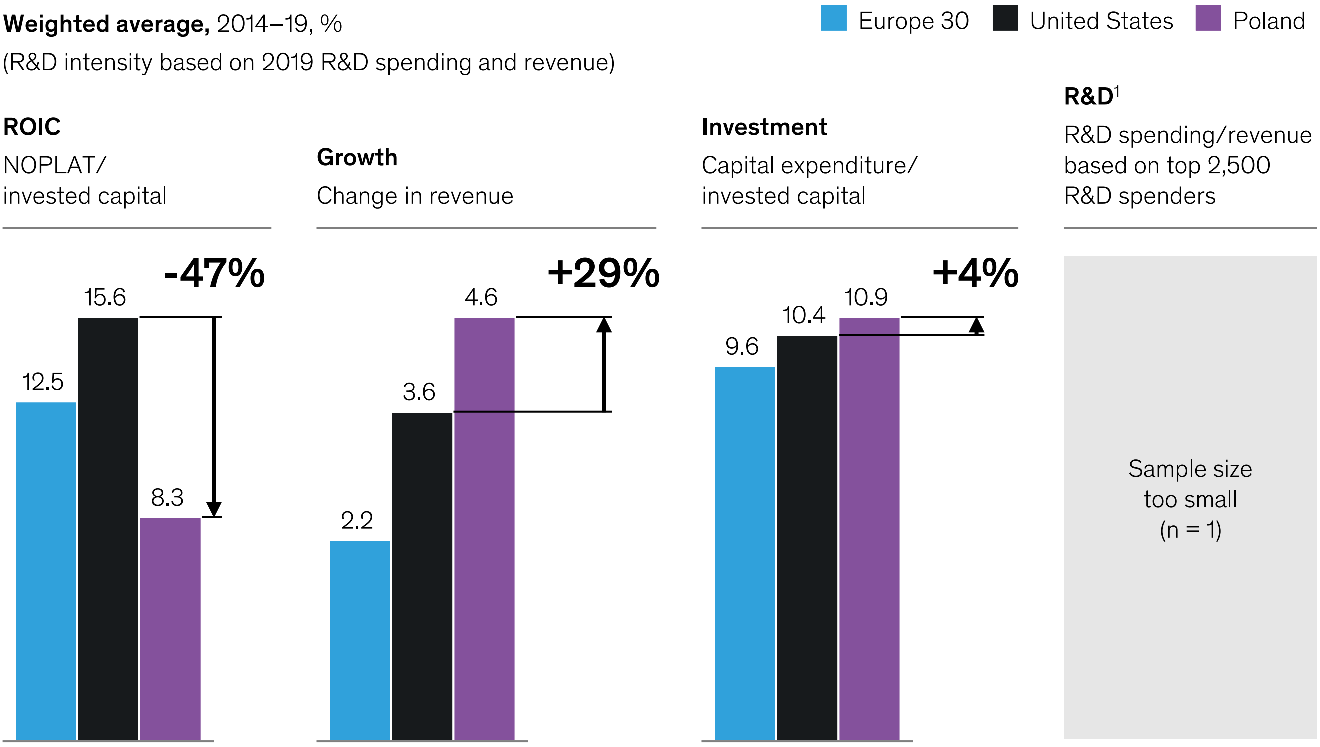
Poland's position on sustainability is mixed (Exhibit 29). Per capita carbon emissions were lower in 2019 than the average of the Europe 30 and only just higher than those of China. This position is partly a function of the stage of economic development. In both China and Poland, emissions per unit of GDP are significantly higher than in the Europe 30 and the United States. Moreover, Poland has significant higher consumption of fossil fuels as a percentage of primary energy consumption, with coal notably dominating the power sector. Poland also has a mixed record on inclusion. On the positive side, income inequality as measured by the Gini index is lower than in any of the three regions highlighted in this analysis. Its poverty rate—at the national poverty line—is in line with the Europe 30 average, below the rate in the United States but above the rate in China. On social mobility, life expectancy, social progress, and life satisfaction, Poland scores above China but below the Europe 30 average and the United States. On growth and prosperity, Poland's economy lags behind both the Europe 30 average and the United States on the level of per capita GDP, but per capita GDP is growing rapidly, and the gap is narrowing, while remaining far behind the Europe 30 average. Poland also has a healthy current account balance and relatively low levels of private debt compared with the three major regions.

Corporate Poland lags behind both the Europe 30 average and the United States on return on invested capital but is ahead on revenue growth and on capital expenditure as a share of invested capital (Exhibit 30). The sample size of large companies in the European innovation scoreboard was too small in Poland to provide comparative figures on R&D intensity.

Exhibit 30

Poland corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)



1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.

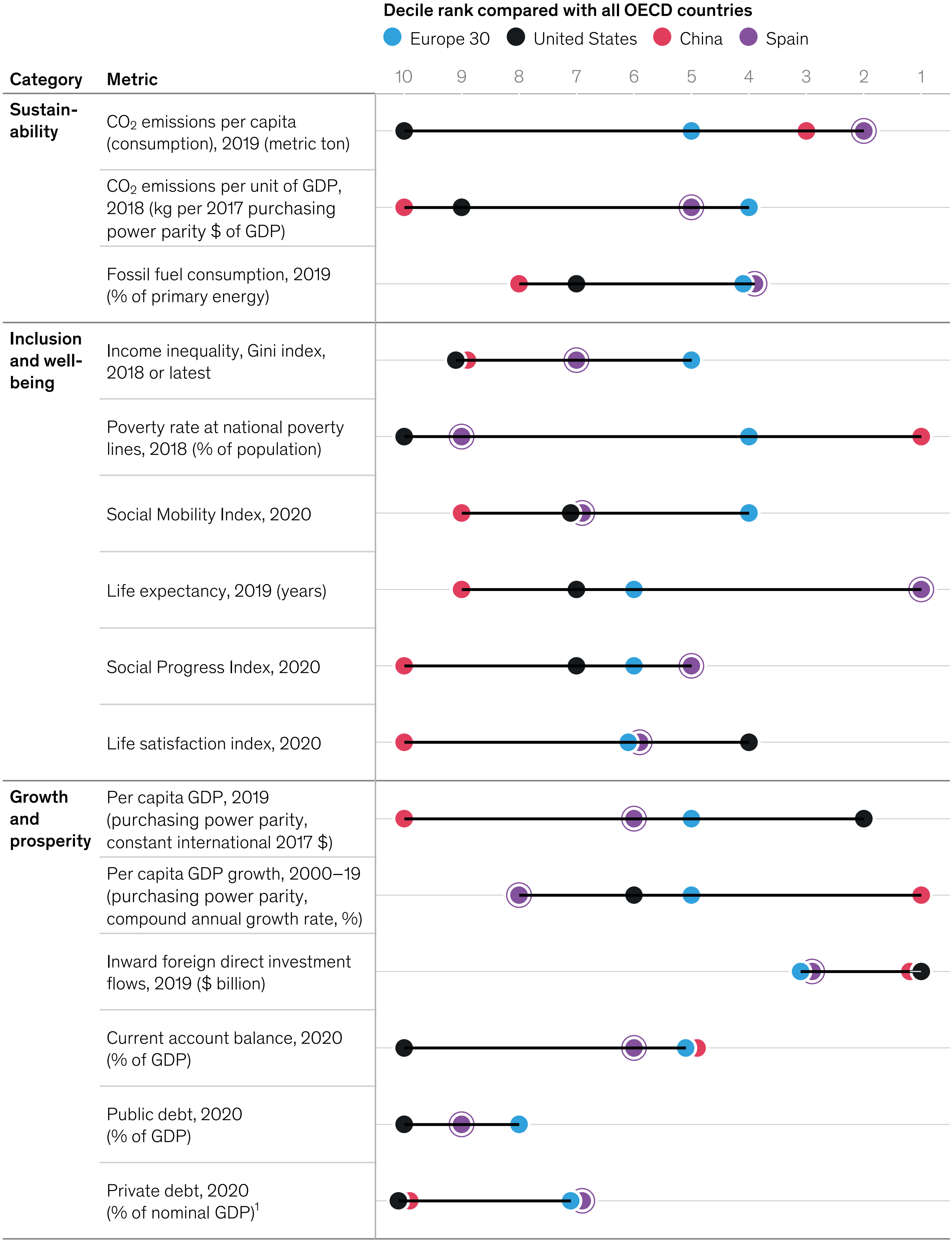
Note: Financial companies excluded. Sample sizes: ROIC (n = 23), growth (n = 23), investment (n = 23). Figures may not sum to 100% because of rounding.

Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Spain

Exhibit 31

Spain scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

R&D intensity of large Spanish companies

52%

lower than US counterparts

Spain has a strong record on sustainability, ahead of the Europe 30 average, the United States, and China on per capita CO_2 emissions in 2018 by some margin (Exhibit 31). This reflects Spain's high use of solar power. Performance on inclusion is mixed. Income inequality is higher than the Europe 30 average, and the rate of poverty far higher than that average. Yet Spain has an above-average score on the Social Mobility Index. The country clearly underperforms on growth and prosperity. Growth in per capita GDP between 2000 and 2019 was lower than that of China, the United States, and the average of the Europe 30, reflecting the fact that Spain suffered deeply from the banking and real estate crisis from 2008 and the eurozone crisis that followed.

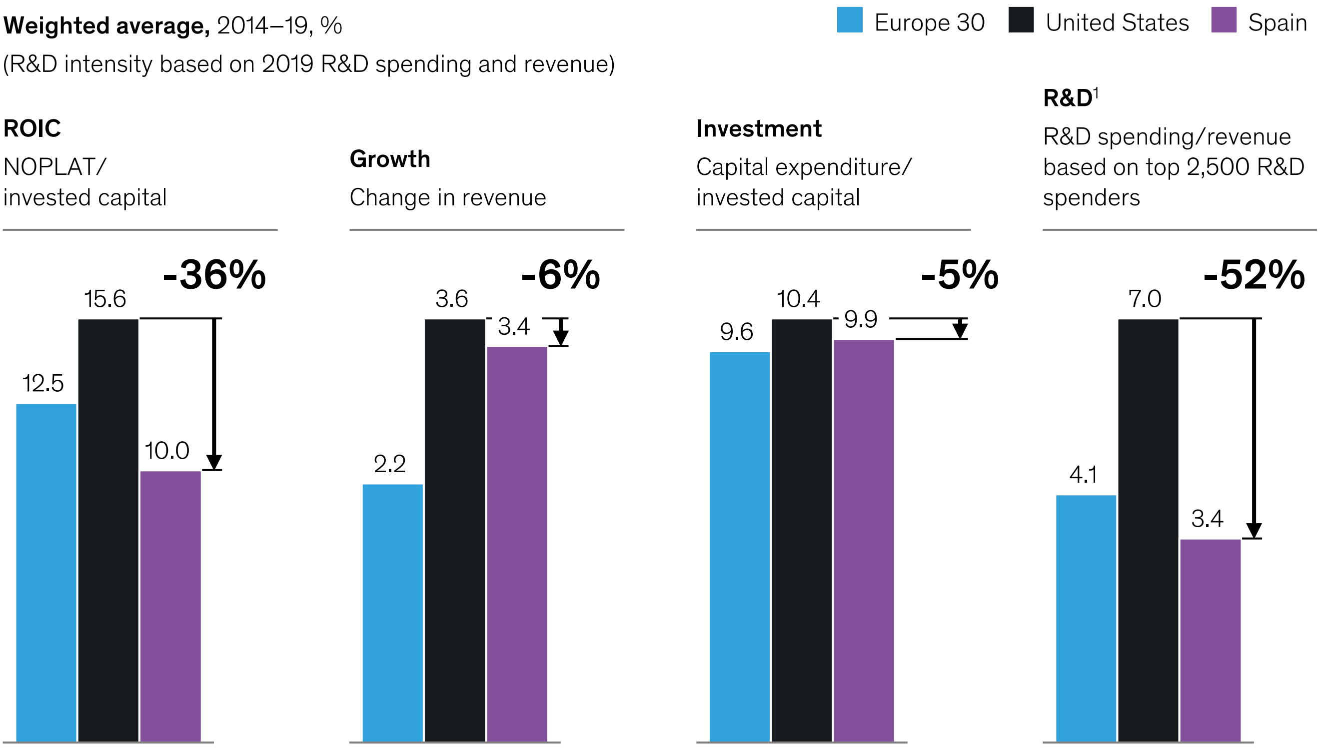
Looking at corporate performance, Spain underperforms both the Europe 30 average and US companies on return on invested capital and R&D intensity (Exhibit 32). Relatively weak return on investment capital may, to an extent, reflect a sector mix with high shares of infrastructure and retail. Interestingly, however, revenue growth is much higher than the Europe 30 average, and near that of US companies. This could reflect a strong bounce-back from the Spanish economic crisis that began in 2008.

Exhibit 32

Spain corporate analysis

Weighted average, 2014–19, %

(R&D intensity based on 2019 R&D spending and revenue)



1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.

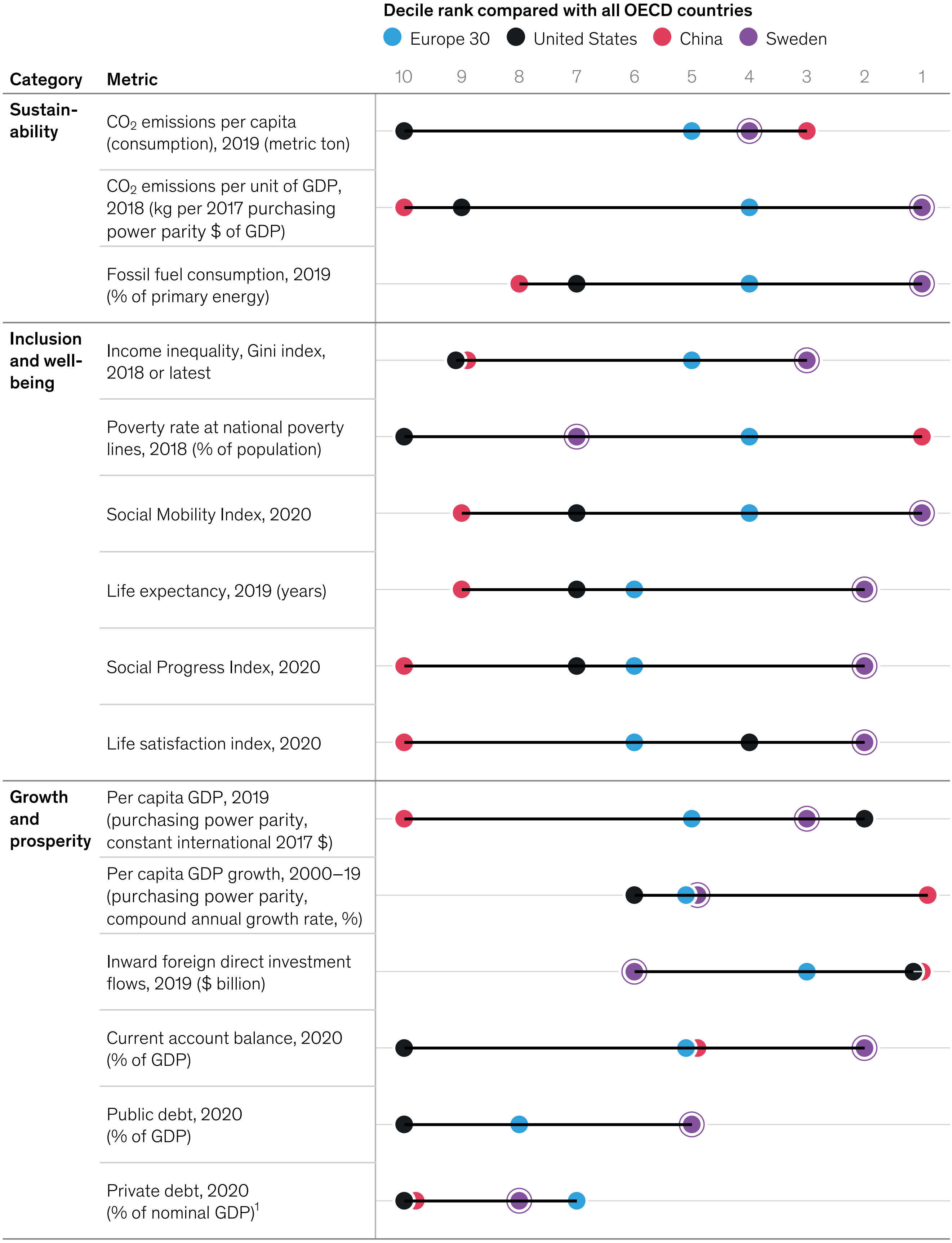
Note: Financial companies excluded. Sample sizes: ROIC (n = 42), growth (n = 50), investment (n = 42), R&D (n = 13). Figures may not sum to 100% because of rounding.

Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Sweden

Exhibit 33

Sweden scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

Large Swedish companies' capital expenditure relative to invested stock of capital nearly

20%

below US counterparts

In common with much of Scandinavia, Sweden has a strong record overall on all three elements of sustainable and inclusive growth (Exhibit 33). Its per capita CO_2 emissions are below the Europe 30 average, and on consumption of fossil fuels, it trails the rest of Europe, the United States, and China. Sweden's rate has been rising since 2011, which may reflect the fact that the country has welcomed many refugees. According to Eurostat, non-EU citizens are at the highest risk of poverty and social exclusion. Within the EU, the risk of poverty or social exclusion recorded for non-EU citizens was highest in Greece at 58 percent, followed by Sweden and Spain, both at 56 percent.[49] Sweden's poverty rate exceeds the Europe 30 average. However, Sweden performs strongly on inclusion. For instance, income inequality is significantly lower than the Europe 30 average, the United States, and China. Sweden also has a positive record on growth and prosperity. Its per capita GDP is well above the Europe 30 average and only modestly behind that of the United States.

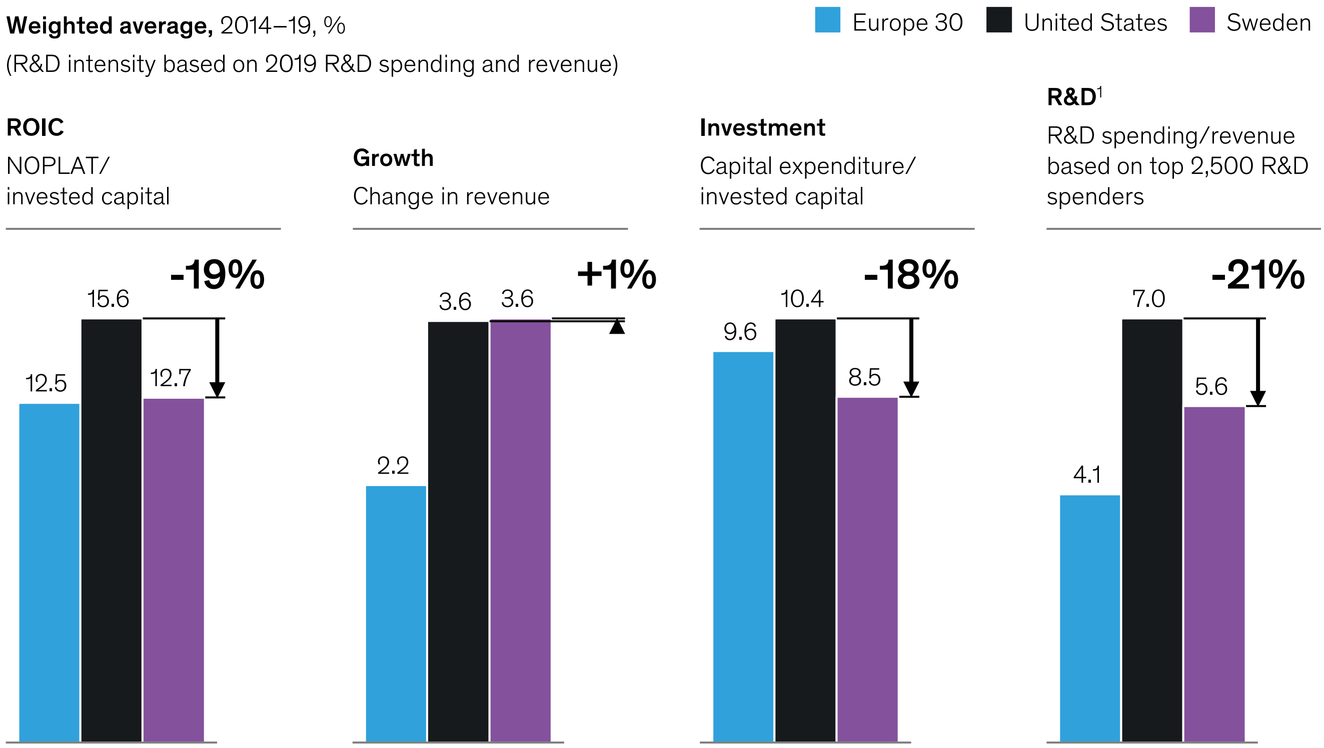
Sweden's companies are either on a par with or above the Europe 30 average on return on invested capital, revenue growth, and R&D intensity (Exhibit 34). Indeed, revenue growth is a touch above that of US corporations. Capital expenditure relative to invested stock of capital is nearly 20 percent below that of US companies and somewhat below the Europe 30 average.

[49] "Non-EU citizens: Highest risk of poverty or social exclusion," Eurostat, February 27, 2020.

Exhibit 34

Sweden corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)

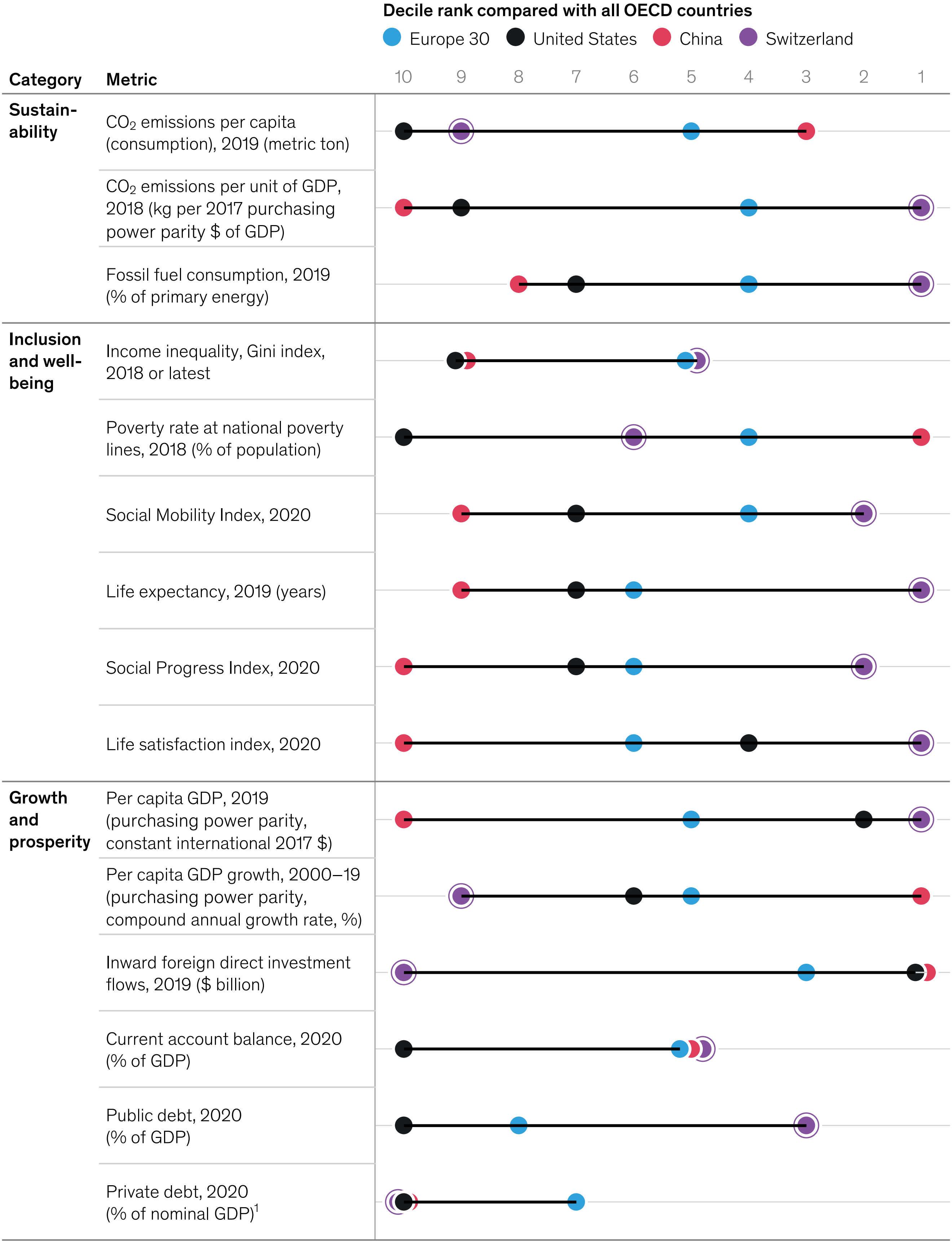


1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 79), growth (n = 85), investment (n = 79), R&D (n = 28). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

Switzerland

Exhibit 35

Switzerland scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

Return on invested capital of large Swiss companies

12%

above US counterparts

Switzerland's per capita CO_2 emissions (consumption based) were high relative to those of China and the Europe 30 average in 2018, but just below those of the United States (Exhibit 35).[50] However, it should be noted that Switzerland's relatively high emissions come largely from CO_2 embedded in imported products and services. Switzerland produces about 37 metric tons of CO_2 domestically per year but imports about 116 million metric tons.[51] The country's consumption of fossil fuels in 2019 was comparatively very low. As a share of GDP, Switzerland's emissions are far lower than in the rest of Europe and the other two major regions. On inclusion and well-being, Switzerland is in line with the Europe 30 average on income inequality but below average on its poverty rate at national poverty lines. However, on other indicators of well-being—social mobility, life expectancy, social progress, and life satisfaction—Switzerland is above the Europe 30 average, China, and the United States. Switzerland's record on growth has been below par; between 2000 and 2019, its per capita GDP growth was significantly far lower than for the Europe 30, China, and the United States. Moreover, inward foreign direct investment flows have been negative since 2018, when US tax reforms led to a large repatriation of capital and earnings by US parent companies.[52] Public debt is relatively low, but private debt is high, not least because of a taxation and pension system favoring mortgages.

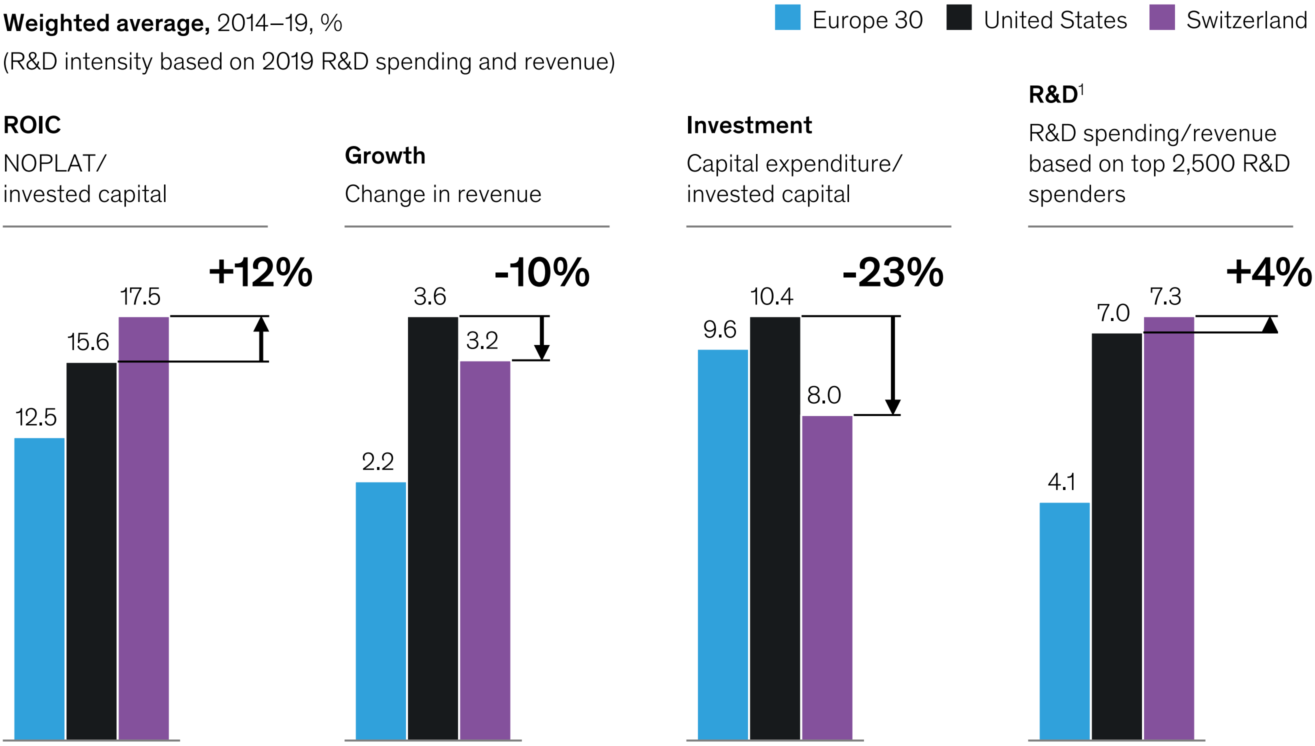
On return on invested capital, revenue growth, and R&D intensity, corporations headquartered in Switzerland outperform the Europe 30 average (Exhibit 36). On return on invested capital and R&D intensity, they also outperform US companies. Revenue growth is far higher than that of the Europe 30, which reflects the highly global exposure of large companies. Capital expenditure relative to invested capital stock is lower than the Europe 30 average and that of US companies.

50 Susan Misicka, "Swiss CO_2 emissions: Small country, big footprint," SWI swissinfo.ch, July 14, 2022; and "How much CO_2 does Switzerland emit?" Myclimate.org, last modified June 1, 2022.
51 *Which country produces the most CO_2 emissions?* Myclimate.org, 2019.
52 Ruth Strachan, "The state of play: FDI in Switzerland," Investment Monitor, updated October 2021.

Exhibit 36

Switzerland corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)

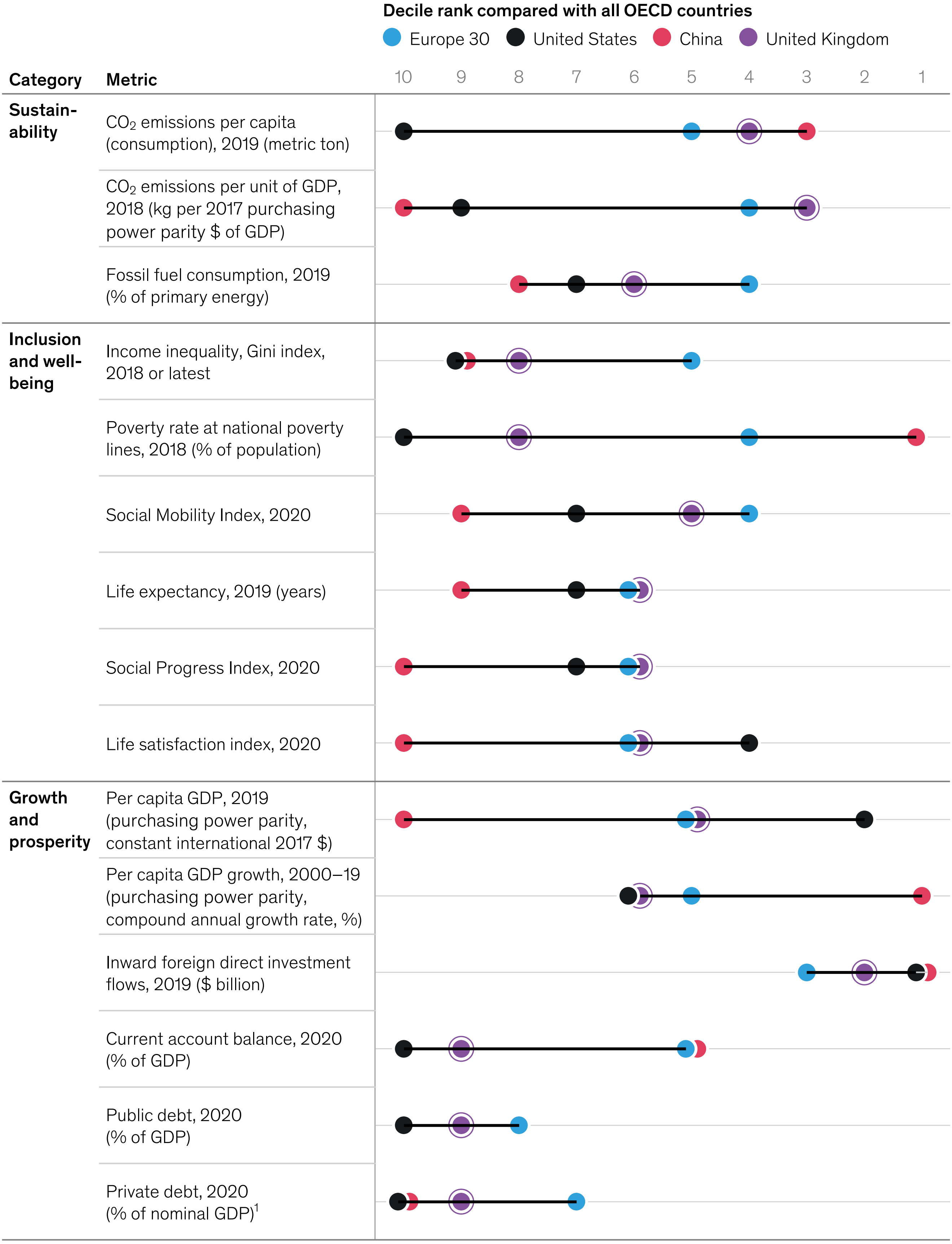


1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 76), growth (n = 94), investment (n = 76), R&D (n = 57). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

United Kingdom

Exhibit 37

United Kingdom scorecard



1. Household and business sector debt.

Source: OECD; World Bank; Eurostat; CEIC; Our World in Data; World Economic Forum; Social Progress Imperative; Gallup; McKinsey Global Institute analysis

The performance of the United Kingdom on sustainability is stronger than that of the Europe 30, with somewhat lower per capita emissions and lower emissions as a share of GDP (Exhibit 37). However, its use of fossil fuels is higher than the Europe 30 average (although lower than in China or the United States). On inclusion, income inequality and the poverty rate in the United Kingdom are significantly higher than the Europe 30 average. On a range of measures of well-being, the United Kingdom is in line with the Europe 30 average, although social mobility is somewhat below that average. On growth and prosperity, per capita GDP is in line with the Europe 30 average, but growth in per capita GDP lagged behind that average from 2000 to 2019. On other key metrics, including the current account balance, public debt, and private debt, the United Kingdom is not as well positioned as the Europe 30 average.

Large UK company revenue growth

~½

the Europe 30 average

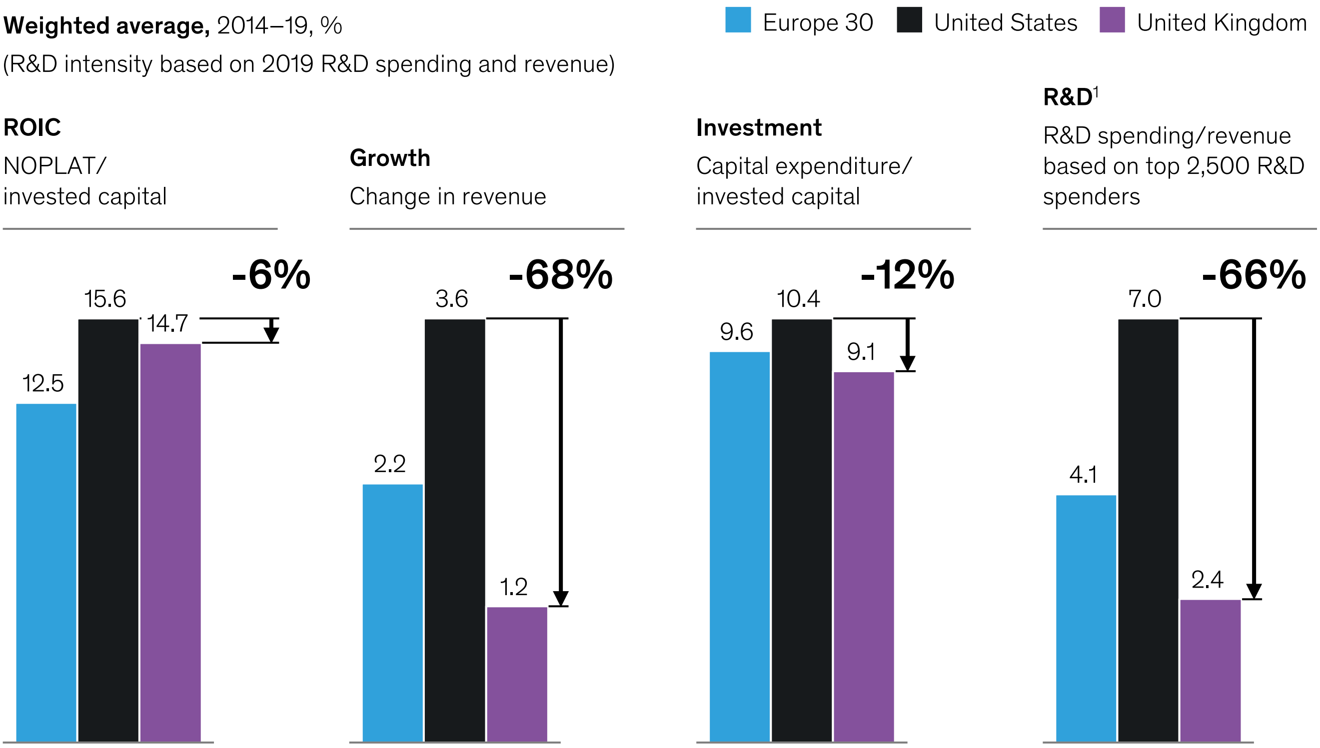
The picture for large companies in the United Kingdom is mixed (Exhibit 38). On the positive side, returns on invested capital stand out; they are higher than the Europe 30 average and close to the US level. Capital expenditure as a share of invested capital is broadly in line with the Europe 30 average and a little lower than in the United States. Revenue growth is only about half that of the Europe 30 average, and R&D intensity was weak in 2019.

In the next chapter, we look at relative performance on ten transversal technologies in more detail.

Exhibit 38

United Kingdom corporate analysis

Weighted average, 2014–19, %
(R&D intensity based on 2019 R&D spending and revenue)



1. R&D intensity based on EU Industrial R&D Investment Scoreboard 2020, with world's top 2,500 R&D spenders.
Note: Financial companies excluded. Sample sizes: ROIC (n = 211), growth (n = 239), investment (n = 211), R&D (n = 112). Figures may not sum to 100% because of rounding.
Source: McKinsey Corporate Performance Analytics Tool; EU Industrial R&D Investment Scoreboard, Eurostat 2020; McKinsey Global Institute analysis

4. Europe is falling behind on transversal technologies

As next-generation technologies take hold, they increasingly determine competitive dynamics for companies—and Europe's lagging position is a growing vulnerability.

This chapter digs into the specific technology advances on which Europe's future competitiveness and prosperity depend. We draw on previous McKinsey research that analyzed more than 40 individual technologies by technical maturity, industry impact, and momentum, ultimately homing in on ten technology trends that could reshape the future of markets and industries over the next few decades.[53] For every trend, McKinsey calculated a momentum score based on the growth of the underlying technologies, looking at patent filings, publications, news mentions, online searches, private investment, and the number of companies making those investments. Because these trends are spreading across sectors, we refer to them here as "transversal technologies."

This research examines where Europe stands with regard to each of the ten transversal technologies that McKinsey identified as having transformative potential (Exhibit 39). We analyze the comparative positions of China, the Europe 30, and the United States, and the results are sobering. We find that Europe lags on eight of the ten transversal technologies, trailing in all three of the dimensions we considered (innovation, production, and adoption). Its average factor against the leading or second-best region is, respectively, 0.6, 0.6, and 0.7 (see Box 3, "Understanding Europe's factor scores for innovation, production, and adoption"). Addressing these gaps will be critical to Europe's future competitiveness and resilience.

---

53 *The top trends in tech*, McKinsey Digital, 2021.

Europe lags on eight of ten transversal technologies, trailing in all three of the dimensions considered (innovation, production, and adoption).

Exhibit 39

Europe's future competitiveness and prosperity depend on ten transversal technologies.

Next-level automation
Next-gen robotics (eg, cobots), process virtualization (eg, digital twins) and additive manufacturing

Future of connectivity
Next-gen connectivity technology, mainly 5G networks and the Internet of Things

Distributed infrastructure
Centralization (cloud) and decentralization computing power infrastructure (edge computing)

Next-generation computing
Quantum computing and neuromorphic computing, unlocking computing's and processors' current capabilities

Applied AI
Deployment of AI algorithms helping computers to make sense of real-world data (eg, video, text, audio)

Future of programming
Next-gen environment for software developers thanks to smarter algorithms (incl Software 2.0, low-/no-code platforms)

Trust architecture
Framework enabling trusted data to flow through a service-oriented system in a verifiable way (incl blockchain, zero-trust security)

Bio Revolution
New wave of biological innovations including biomolecules, biosystems, biomachines, and biocomputing

Next-gen materials
Innovations in the properties, manufacturing processes, and market applications of materials (eg, nanomaterials, next-gen composites)

Future of cleantech
Low-carbon power sources (eg, solar, wind) and CCS, alternative proteins, batteries, clean hydrogen, and other decarbonization techs

Source: *The top trends in tech,* McKinsey; McKinsey Global Institute analysis

Box 3

Understanding Europe's factor scores for innovation, production, and adoption

For each of the ten transversal technologies, we analyze European competitiveness against the United States and China in three stages of product development: innovation, production, and adoption.

In the innovation stage, we use metrics such as number of publications, number or share of patents (both total and world-class patents), venture capital funding, research and development expenditure, and public funding (especially relevant when the technology in question is still in the early stage of development).

To assess the production stage, we used metrics such as private equity and corporate funding (including M&A) as well as the number and (when available) market share of leading players.

Finally, in the adoption stage, we compared the regions with metrics of adoption by end consumers (companies, consumers, or both), end-market market shares by region, and other ad hoc metrics specific to each of the transversal technologies (for example, number of robots installed for next-level automation and number of 5G subscriptions for future of connectivity).

The "European factor" refers to the relative European position versus the leading or second-best region on the range of metrics cited above. For instance, if Europe issues 200,000 patents per year in a given field while the corresponding number for the United States is 400,000, the factor is 0.5 times.

1. Next-level automation

Next-level automation includes robotics hardware, additive manufacturing, and virtualization processes such as digital twins that help to improve operational efficiency, shorten development cycles, and thus accelerate time to market.[54] This transversal technology is forecast to generate gross value added of €130 billion by 2040 and is set to drive change in multiple key sectors.

Across the three stages (innovation, production, and adoption), Europe is lagging behind the leading or second-best region, with an average factor of 0.8. Given its strong installed base and its current edge in production and adoption, Europe is well positioned, but patent activity and startup investments nevertheless suggest that some ground could be lost.

Why does this transversal technology matter?
Next-level automation and virtualization have huge transformative potential. Automating additional activities can enable businesses to improve performance by reducing errors and improving quality and speed—in some cases outperforming what humans can do.

€130b

gross value added forecast from next-level automation by 2040

Automation—to be specific, robotic automation—contributes to productivity. MGI has estimated that automation overall—including process automation, which is discussed in the section on applied AI in this chapter—could raise productivity growth globally by 0.8 to 1.4 percent annually. These technologies could touch almost every occupation. MGI estimates that about half of all the activities people are paid to do in the world's workforce could potentially be automated by adapting currently demonstrated technologies.[55] Digital twins and additive manufacturing do not have an impact on productivity in this way.

One of the core automation technologies is robotics hardware, which has three major segments. The first is industrial robots, including collaborative robots (cobots). Cobots are designed to perform tasks alongside human workers. The level of collaboration can vary, from coexistence to responsive interaction; in the latter case, the robot responds in real time to a person's movement. Second is professional service robots, which are used for specific commercial applications, such as automated guided vehicles, warehouse automation, or medical surgery robots. The third segment comprises domestic service robots, such as lawnmowers and toy robots.

The total robotics hardware market was valued at around $25 billion in 2020.[56] In terms of market value, industrial robots accounted for about 54 percent, professional service robots for around 28 percent, and domestic service robots for about 18 percent.

Boosted by a wider range of offerings and applications, cobots have recently been the fastest-growing segment of industrial robotics, increasing at 19 percent per annum from 2017 to 2020. This is still a nascent market, however, representing about 6 percent of total industrial robot installations in 2020 (a share that is expected to hit 13 percent in 2022).[57] The reality is that cobots do not often collaborate, but rather coexist in the same physical space without requiring a fence. This fenceless operation drives down associated infrastructure costs. Moreover, the robot arm is also five to ten times less expensive than a full-scale industrial robot arm, and this is driving their adoption for many tasks where the business case for robots has not yet been made.

The growth of professional service robots is now taking off, with an expected compound annual growth rate of about 31 percent between 2020 and 2023 (compared with about 8 percent for industrial robots).[58] This segment is expected to account for nearly half of the robotics hardware market by 2025. Within this segment, logistics and automated guided vehicles (AGVs) systems are expected to grow at about 19 percent per year to 2025, driven by sweeping automation in warehouses as e-commerce demand rises and delivery cycles shorten. Notably, AGVs are increasingly being replaced by autonomous mobile robots (AMRs).

---

54 *The top trends in tech*, McKinsey Digital, 2021.
55 *A future that works: Automation, employment, and productivity*, McKinsey Global Institute, January 2017.
56 *World robotics 2021*, presentation, live stream, World Robotics, October 28, 2021.
57 Statista, "Share of traditional and collaborative robot unit sales worldwide from 2018 to 2022," February 2021.
58 *World robotics 2021*, presentation, live stream, World Robotics, October 28, 2021.

AMRs are a step up from AGVs. While AGVs can detect obstacles in front of them, they cannot navigate round them. AMRs navigate using maps constructed by their software. By 2025, two-thirds of the market could consist of AMRs. Adoption of medical robots is also expected to soar in coming years, reflecting a wider scope of potential applications and the benefits of time and cost savings that enable improved clinical outcomes.[59]

Additive manufacturing, also commonly referred to as 3-D printing, is the process of building a physical object (often with plastics, steel, or ceramics) using 3-D-model data, typically layer upon layer.[60] The total market for additive 3-D printing stood at $13 billion in 2020.[61] The market is expected to grow at a 20 percent compound annual rate in the next ten years.[62] About 10 percent of current manufacturing processes across industries are expected to be replaced by additive manufacturing by 2030.[63]

Finally, virtualization and other dematerializing processes enable the virtual engineering and improved operating performance of physical assets. Digital twins are one of the primary examples; this involves creating a digital replica of a physical asset or process, combining data from both digital and physical worlds. The use of digital twins is expected to have tripled between 2018 and 2022, with 70 percent of manufacturers using them regularly and adoption rapidly increasing in construction.[64]

With its industrial prowess, Europe is still a robotics leader, but it is increasingly challenged by the United States on innovation and China on adoption

Europe has a convincing lead in the relative installed base of robotic automation technologies. However, China is catching up fast and has been the largest end market for industrial robots since 2014. Furthermore, the United States has been out in front on world-class patents for automation and process virtualization. The starkest gap is in venture capital; both the United States and China attracted far more funding for automation startups than Europe (Exhibit 40). While the focus of this section is robotic automation, Europe's relative position may be even less favorable in additive manufacturing and digital twin technologies.

$1b

venture capital funding on robotics in Europe in 2015–20 vs $5.4 billion for United States and $5.1 billion for China

Innovation

The United States filed the most patents for automation and process virtualization in 2019, at 7,197. The totals for Europe and China were 5,772 and 4,472, respectively.[65] The United States also led in terms of world-class patents that year, accounting for 31 percent of the global total; Europe was not far behind with 25 percent; China had 15 percent (for reference, the rest of Asia combined for 24 percent).[66]

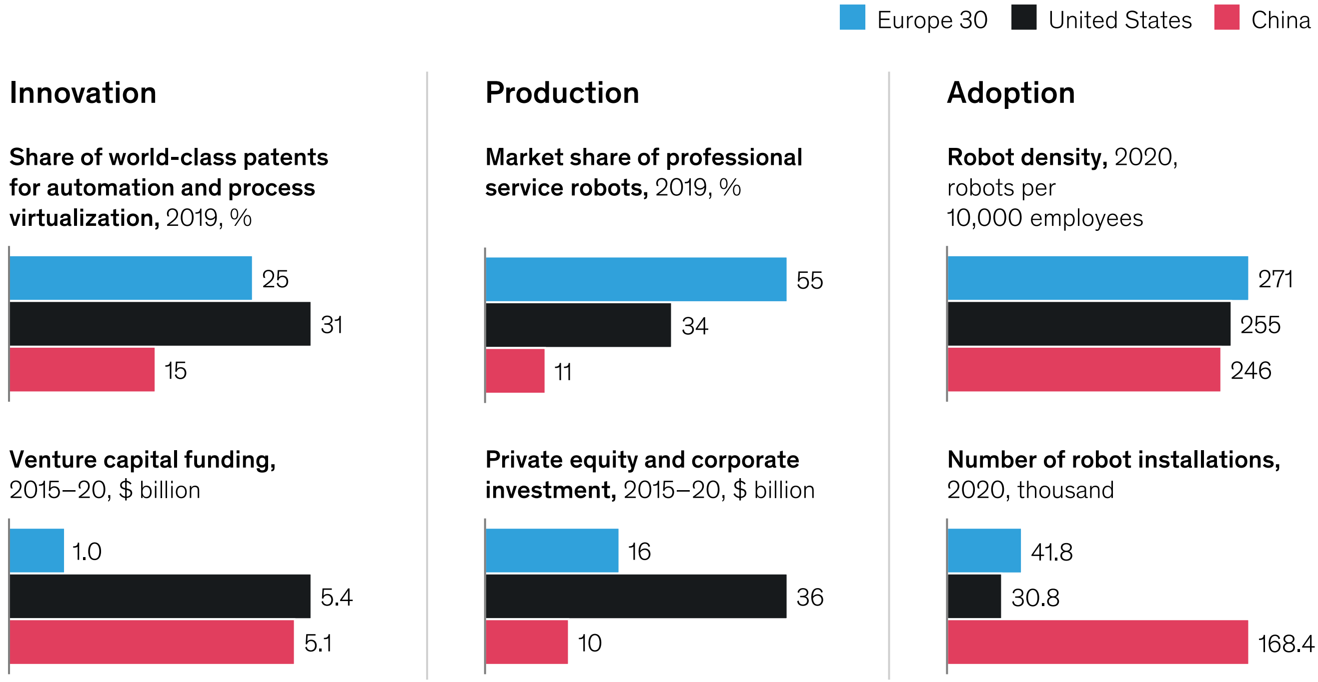
Between 2015 and 2020, the United States and China attracted about the same amount of venture capital funding on robotics, with $5.4 billion and $5.1 billion, respectively. Europe lagged well behind, at about $1.0 billion.[67] Europe has invested more heavily in certain segments such as medical robotics—an area where Europe has attracted nearly 4.5 times the venture capital as US startups in recent years.[68]

59 IFR World Robotics 2013-19 reports, Loup Ventures.
60 *The top trends in tech*, McKinsey Digital, 2021.
61 Jörg Bromberger, Julian Ilg, and Ana Maria Miranda, "The mainstreaming of additive manufacturing," McKinsey & Company, March 15, 2022.
62 *Additive manufacturing trend report 2021*, Hubs, 2021.
63 *The top trends in tech*, McKinsey Digital, 2021.
64 Ibid.
65 It should be noted that the three regions accounted for only about 22 percent of all patent fillings globally in 2019, according to the Innography patents database.
66 World-class patents are identified through the number of countries where a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s). See Jan C. Breitenger, Benjamin Dierks, and Thomas Rausch, *World-class patents in future technologies: The innovation power of East Asia, North America, and Europe*, Bertelsmann Stiftung, June 2020.
67 Cumulative venture capital funding between 2015 and 2020.
68 *Europe's private promise*, Morgan Stanley Research, March 2022.

Exhibit 40

Next-level automation

Europe lags behind on some metrics of innovation but leads on several metrics of production and adoption.



Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Production

Europe leads on production of robots in terms of volume but is behind the United States on external funding of more mature companies, that is, private equity and corporate investments.[69]

The four leading industrial robots OEMs as of 2020 represent 70 percent of the market in revenue terms. Two of them, ABB and Kuka, are European players, with 27 percent of the market combined. The other two players are Japanese, with 43 percent combined market share.[70]

Europe has a convincing lead in the production of professional service robots, with 55 percent of market share in 2019, followed by North America at 34 percent and Asia with 11 percent.[71] Europe also has nearly half of the world's service robot suppliers in 2019, with 438 companies, compared with 257 based in the Americas and 185 in Asia.[72]

Denmark-based Universal Robots leads global cobot production with a market share of about 37 percent. The next-largest manufacturers are FANUC (based in Japan) and Techman (Taiwan), each of which has 9 percent of the market, and Aubo, a Chinese company with 5 percent of the market.[73] The European market accounts for around 43 percent of Universal Robots' revenue; the Americas represent 29 percent and Asia–Pacific 27 percent of the company's revenue.[74]

69 PitchBook.
70 Based on Interact Analysis Industrial Robot report, 2020.
71 Néstor Duch-Brown, Fiammetta Rossetti, and Richard Haarburger, *AI Watch: Evolution of the EU market share of robotics: Data and methodology*, Joint Research Centre, European Commission, 2021.
72 IFR press conference, International Federation of Robotics, Frankfurt, September 24, 2020.
73 Maya Xiao, *The collaborative robot market – 2019*, Interact Analysis, January 2020.
74 *Teradyne Form 10-K annual report*, US Securities and Exchange Commission, February 2021.

Looking at private equity and corporate investments in robotics (M&A deals, minority stake acquisitions, and joint ventures) between 2015 and 2020, which typically target more mature companies, the United States led with about $36 billion.[75] Europe's figure was $16 billion and China's $10 billion. However, Europe ramped up investment in 2020 to about $7 billion, higher than the $5 billion invested in the United States in that year.[76]

271

robots per 10,000 employees in Europe vs 255 in the United States and 246 in China

Adoption

Europe is still the leader in terms of robot density. The region averages 271 units per 10,000 employees, compared with 255 in the United States and 246 in China.[77] But Europe's leading position reflects the heavy use of robots by a relatively small number of automation-intense companies and industries rather than broad adoption. In Germany, for example, just five plants account for 52 percent of the country's total robot stock.

China is catching up fast, having become the largest market for robot installation since 2014. Its robot density increased dramatically, from 68 in 2016 to 246 in 2020; its global ranking for density rose from 25th to ninth. In 2020, 168,400 industrial robots were installed in China, with the lion's share in the electronics and automotive industries. In the same year, 41,800 industrial robots were installed in Europe (with half of those in Germany) and 30,800 were installed in the United States.[78] However, those lower figures in Europe and the United States may partly reflect a shortage of raw and intermediate products due to COVID-19 restrictions.

2. Future of connectivity

The world's digital connections are getting faster and enabling new types of remote and automated processes in addition to communications and information flows, with 5G and the Internet of Things (IoT) being the most promising technologies.

Previous MGI research identified hundreds of use cases across more than 17 commercial domains that can run on an enhanced digital backbone, with the countries that are most connected today capturing much of the value.[79] McKinsey estimates that next-generation connectivity could generate between €1 trillion and €2 trillion in gross value added by 2040.

Europe lags on indicators across the three stages of development, with an average factor of 0.6. But the situation diverges depending on the technology. Europe is largely on a par with the other major regions on 5G but trails when it comes to the IoT. Looking at the individual stages, Europe is lagging on innovation and production, with a factor of 0.7 against the leading or second-best region, but it is far behind on production and adoption at 0.3.

Why does this transversal technology matter?

Superfast connectivity supports the creation of new services and business models linked to sensor-enabled intelligent products. It opens possibilities for new offerings such as predictive services and augmented-intelligence services. It also creates the potential for companies to personalize offerings more seamlessly across channels and to heighten customer experiences.

The most prominent connectivity technology is 5G, which enables connections with much higher speed, less latency, and dramatically reduced power consumption than its predecessors.[80] It supports, for instance, private networks, edge computing, and mission-critical applications. For this reason, 5G is a catalyst for many other technology trends, such as smart cities, Industry 4.0, and smart grids.[81]

[75] Corporate investment refers to merger and acquisitions deals, acquisitions of noncontrolling stakes in companies, and joint ventures.
[76] PitchBook.
[77] Calculated as number of robot installations per 10,000 employees in 2020. Globally, the top five countries for robot density in 2020 were South Korea (932), Singapore (605), Japan (390), Germany (371), and Sweden (289). See *World robotics 2021*, presentation, live stream, World Robotics, October 28, 2021.
[78] Ibid.
[79] *Connected world: An evolution in connectivity beyond the 5G revolution*, McKinsey Global Institute, February 2020.
[80] Hugo Yen, David Simpson, and Lindsay Gorman, *Tech factsheets for policymakers: 5G,* Spring 2020 series, Belfer Center for Science and International Affairs, Harvard Kennedy School, 2020.
[81] *The top trends in tech*: *Technology deep dive: 5G and the Internet of Things connectivity*, McKinsey & Company, 2021.

Up to 80 percent of the global population could have 5G coverage by 2030.[82] China and the United States could hit this milestone earlier—by 2023 and 2025, respectively, according to McKinsey telecoms specialists.

One of the most significant applications of 5G is the IoT, networks of connected devices. Sensors and actuators networked to computing systems can monitor or manage the health and actions of connected objects and machines.[83]

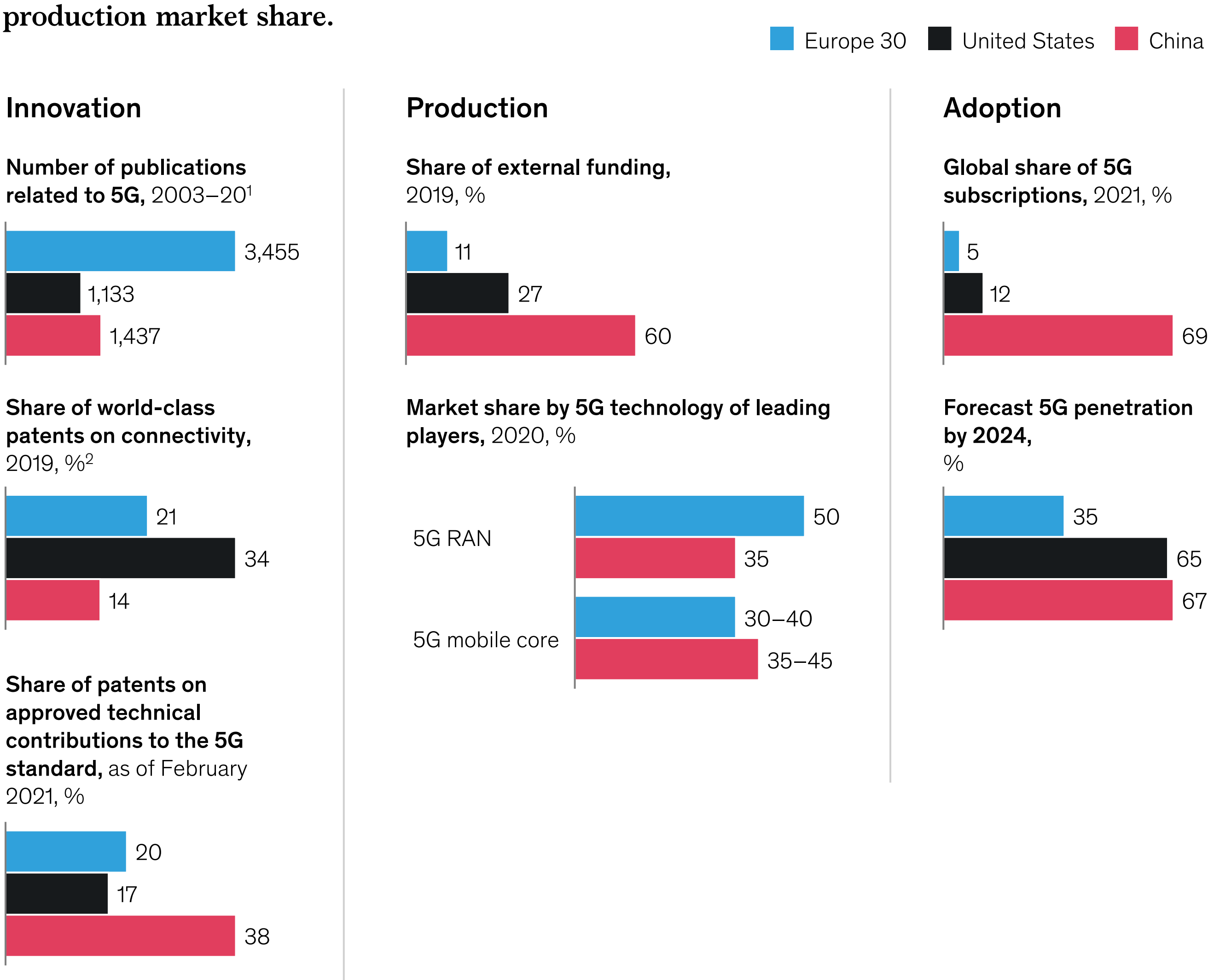
5G: China leads on many metrics but not knowledge creation
Between 2003 and 2020, Europe far outpaced the United States and China in 5G-related scientific publications. However, the United States holds more world-class patents. Europe and China each hold a lead in different segments of 5G technology production, while China is the world leader on 5G adoption (Exhibit 41).

[82] *The top trends in tech*, McKinsey Digital, 2021.
[83] *IoT value set to accelerate through 2030: Where and how to capture it*, McKinsey & Company, November 2021.

Exhibit 41

Future of connectivity (5G)

China leads on all dimensions except knowledge creation and shares lead with Europe on production market share.



1. Total publications of Europe 30 countries in top 20 productive countries.
2. World-class patents are identified through the number of countries in which a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s).

Note: For data sources, see report.
Source: Bertelsmann Stiftung; Dell'Oro; Ericsson; IPlytics; PitchBook; McKinsey Global Institute analysis

Innovation
While Europe produces the greatest number of scientific publications, the United States leads on world-class patents, and China has the edge in technical innovations. Between 2003 and 2020, Europe had a convincing lead in 5G-related scientific publications, with about triple the total of China and the United States.[84] However, the United States has the highest share of world-class patents at 34 percent, compared with Europe's 21 percent share and China's 14 percent.[85] For patents on approved technical contributions to the 5G standard, the picture is different—China had 38 percent of patents in 2021, Europe 20 percent, and the United States 17 percent.[86]

Production
Europe and China each hold an edge in different aspects of 5G technology production. European players (Ericsson and Nokia) captured nearly 50 percent of the radio access network (RAN) market in 2021; two Chinese players (Huawei and ZTE) captured 35 percent.[87] In the mobile core network market, Huawei and ZTE held between 35 and 45 percent of the global market in 2021, followed closely by Ericsson and Nokia with shares of 30 to 40 percent combined.[88]

Looking ahead, a move toward Open RAN standards will likely shift a higher share of value to software development—a domain in which, traditionally, US firms have competitive strength.

Adoption
China leads the world in 5G adoption. As of January 2022, it had about 916,000 5G base stations against 50,000 in the United States and 112,000 in Europe.[89] China is by far the biggest market for 5G subscriptions, with 69 percent of the global total, compared with 12 percent for the United States and 5 percent for Europe in 2021. By 2027, China is forecast to maintain its lead over the United States and Europe, but to a somewhat lesser extent, with 30 percent, 15 percent, and 9 percent of global 5G subscriptions, respectively. [90] In 2024, penetration of 5G (measured as the percent of connections) is forecast to be highest in China at 67 percent, followed closely by the United States with 65 percent; Europe is expected to be well behind, at 35 percent.[91]

<½

IoT-related patent filings in Europe than in China

On IoT, China leads on metrics for innovation and adoption, but the United States leads on investment and revenue
In IoT-related patent filings, Europe has produced less than half of China's world-leading tally. Among the world's largest IoT companies, the share of revenue generated by US players is more than triple that of European players (Exhibit 42).

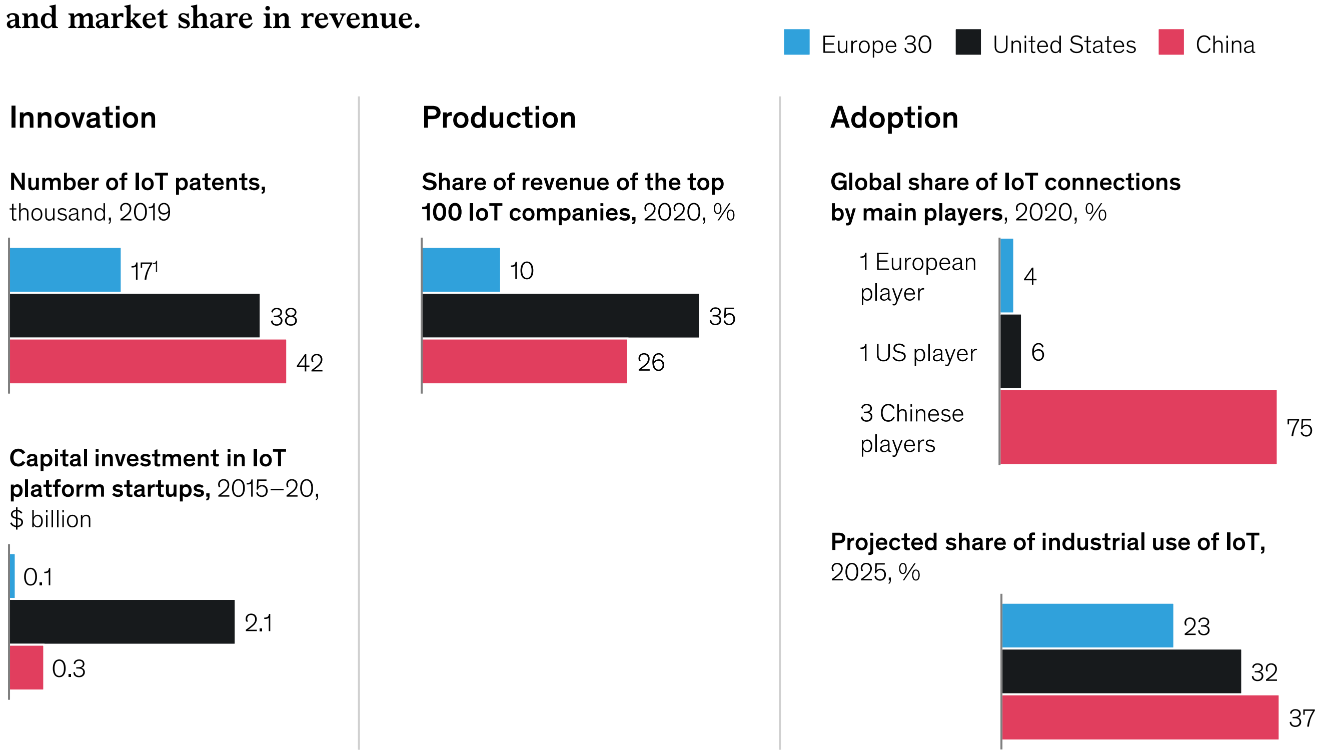
---

84 Nida Aslam et al., *Exploring the development and progression of 5G: A bibliometric analysis of scholarly production*, DigitalCommons@University of Nebraska, 2020.
85 World-class patents are identified through the number of countries where a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s). See Jan C. Breitenger, Benjamin Dierks, and Thomas Rausch, *World-class patents in future technologies: The innovation power of East Asia, North America, and Europe*, Bertelsmann Stiftung, June 2020.
86 *Who is leading the 5G patent race? A patent landscape analysis on declared SEPs and standards contributions*, Iplytics, February 2021.
87 "Report: Ericsson displaces Huawei to become top RAN vendor in 2021," *The Edge Markets*, January 30, 2022.
88 *Market research reports on mobile radio access network (RAN)*, Dell'Oro, 2022.
89 *5G scoreboard*, European 5G Observatory, January 2022.
90 *Ericsson mobility report*, Ericsson, November 2021.
91 IHS Markit; European 5G Observatory; McKinsey analysis.

Exhibit 42

Future of connectivity (IoT)

China leads on metrics of innovation and adoption, and the United States on investment and market share in revenue.



1. Combined tally of the most active originators of patents in France, Germany, Spain, Sweden, and United Kingdom.
Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Innovation

As of 2019, China had filed the most IoT patents, with 42,000, nearly 2.5 times the European tally. The United States was close behind, with about 38,000.[92]

From 2015 to 2020, the United States had by far the highest total investment in startups (about $2.1 billion) and the highest average commitment per startup (about $55 million). In China, the comparable figures were about $325 million and $45 million. Europe came in well below, at $60 million and $3.3 million.[93]

Production

The United States currently holds the largest market share in the IoT. In 2020, 35 percent of the revenue generated by the world's 100 largest IoT companies went to US-based companies. This compares with 26 percent generated by Chinese companies and 10 percent generated by European companies.[94]

Adoption

China is the global leader in IoT adoption. Its three largest telecommunications players provided 75 percent of global IoT connections in 2020, up sharply from 27 percent in 2015.[95] AT&T in the United States and Vodafone in the United Kingdom had shares of 6 percent and 4 percent of cellular IoT, respectively. By 2025, China and the United States are also expected to lead in the industrial use of IoT, with about 37 percent and 32 percent of the global market, respectively. Europe is forecast to have a share of some 23 percent.[96]

---

[92] IPlytics GmbH data.
[93] PitchBook data.
[94] *Top 100 companies: Internet of Things*, Statista.
[95] Knud Lasse Lueth, *State of the IoT 2020: 12 billion IoT connections, surpassing non-IoT for the first time*, IoT Analytics, November 2020.
[96] Share of total number of industrial IoT sensors. See James Blackman, *Industrial IoT connections to double to 37bn by 2025, spurred by manufacturing*, Enterprise IoT Insights, November 2, 2020.

3. Distributed infrastructure

<0.1%

of global market capitalization of cloud and edge companies is European

Distributed infrastructure encompasses cloud and edge computing. Cloud computing enables companies to use computing power in centralized locations. Off-site centralized servers are central to the business models of anything as a service (XaaS) companies providing infrastructure (IaaS), system infrastructure software (SISaaS), platforms (PaaS), and software (SaaS). However, the cloud is not an exclusive tool for all workloads. Edge computing, which consists of on-site, nearby, or decentralized infrastructure and devices, is placed near the locations where insights need to be generated or data need to be stored. These resource-dense centers decrease latency time by more efficiently retrieving data from the centralized and dense cloud, reducing cost. Edge computing increases speed and lowers concern about data privacy since computation happens more locally (with central control). This aligns well with the EU's General Data Protection Regulation and other data residency regulations.

McKinsey estimates that distributed infrastructure will generate gross value added of €400 billion to €1.6 trillion by 2040 as the market grows.

Europe lags behind on distributed infrastructure, with an average factor of 0.3—one of the lowest scores of the ten transversal technologies. Europe has an insignificant share in the production stage (0.1) as well as an innovation gap (0.2). Its adoption factor is closer, at 0.7.

Why does this transversal technology matter?
McKinsey has estimated that cloud computing can unlock more than $1 trillion in value for Fortune 500 companies alone. Almost all of that comes from business innovation and optimization rather than simply lowering IT costs. Distributed infrastructure essentially democratizes computing power. The most powerful benefits to businesses are accelerated time to market, less complex innovation, easier scalability, and lower risk. Cloud platforms enable companies to deploy new digital experiences for customers in days rather than months. They enable analytics that would not have been possible or would have been too expensive on traditional platforms.[97]

Cloud computing is a relatively mature market, but it continues to grow. Spending on cloud-related services (IaaS, SISaaS, PaaS, and SaaS) is expected to more than double between 2021 and 2025, from $385 billion to $809 billion.[98]

Edge computing is a smaller and comparatively nascent segment. However, spending on edge hardware, services, and software is expected to grow rapidly at a forecast compound annual rate of 16 percent between 2021 and 2025, from $153 billion to $275 billion, with 50 percent of that on edge services.[99]

Growth in cloud and edge computing comes at the expense of spending on traditional IT infrastructure. By 2025, McKinsey estimates that more than 75 percent of enterprise-generated data will be processed by edge or cloud computing.[100]

The United States leads on metrics of innovation, production, and adoption, with Europe and China sharing second place
The United States is the clear global leader in distributed infrastructure, with Europe and China lagging but roughly matching each other. The US lead holds across patents and market share (Exhibit 43). In fact, the top ten cloud and edge companies by market capitalization are all based in the United States. European players account for less than 0.1 percent of global market capitalization.

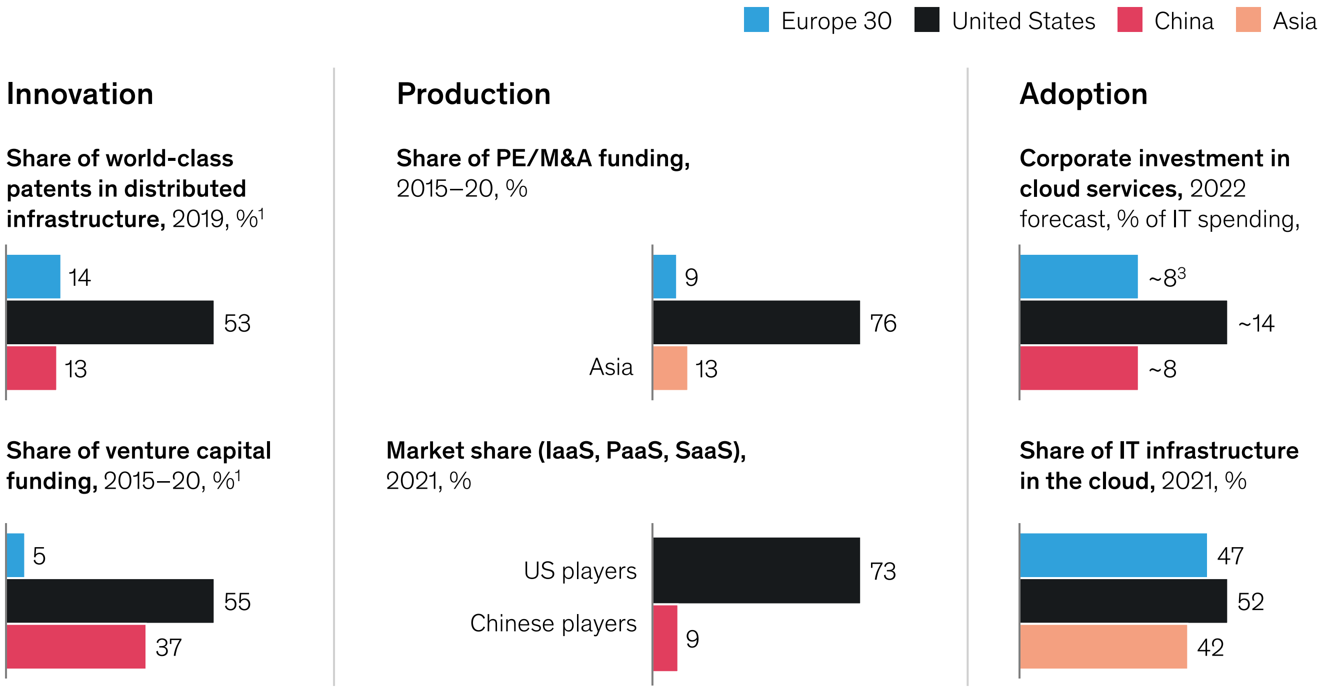
---

97 "Three actions CEOs can take to get value from cloud computing," *McKinsey Quarterly*, July 2020; *The cloud transformation engine*, McKinsey Digital; Jayne Giemzo, Mark Gu, James Kaplan, and Lars Vinter, "How CIOs and CTOs can accelerate digital transformations through cloud platforms," McKinsey Digital, September 2020.
98 "IDC forecasts worldwide 'whole cloud' spending to reach $1.3 trillion by 2025," IDC, September 14, 2021.
99 "New IDC spending guide forecasts double-digit growth for investments in edge computing," IDC, January 13, 2022.
100 *The top trends in tech*, McKinsey Digital, 2021.

Exhibit 43

Distributed infrastructure

The United States leads on metrics of innovation, production, and adoption.



1. World-class patents are identified through the number of countries in which a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s).

Note: For data sources, see report.

Source: McKinsey Global Institute analysis

Innovation

The United States leads on metrics of knowledge, with 53 percent of world-class patents as of 2019. For Europe, the figure is 14 percent, and for China, 13 percent.[101] The United States also captured 55 percent of all global venture capital funding for distributed infrastructure startups between 2015 and 2020, compared with 37 percent for Asia (including China) and 5 percent for Europe.[102]

Production

Here again, the United States leads—on funding, revenue, and market capitalization. It accounted for 76 percent of private equity and M&A funding between 2015 and 2020. Asia (including China) had 13 percent, and Europe less than 10 percent.[103] Four US companies—Alphabet, Amazon, Microsoft, and Meta (then Facebook)—contributed more than 70 percent of the $111 billion of total global investment in cloud in 2019. Three Chinese companies—Alibaba, Baidu, and Tencent—had a combined share of 10 percent. No European player spent more than $1 billion.[104]

101 World-class patents are identified through the number of countries where a patent is actively held, the relevance of the technology, and the number of citations of the patents in other patent applications; the country is identified by the address of the patent holder(s). See Jan C. Breitenger, Benjamin Dierks, and Thomas Rausch, *World-class patents in future technologies: The innovation power of East Asia, North America, and Europe*, Bertelsmann Stiftung, June 2020.

102 PitchBook.

103 Ibid.

104 Company report via Deutsche Bank Research, 2020.

Six US companies (Alphabet, Amazon, IBM, Microsoft, Oracle, and Salesforce) accounted for 73 percent of revenue from cloud services in 2021. Chinese players had a share of 9 percent, with no European player capturing more than 2 percent of the market.[105] Looking at specific segments, the picture is similar. First, in the IaaS segment, European players have an insignificant market share, with no company accounting for more than 1 percent as of 2020. In contrast, US companies accounted for 67 percent of global revenue, and Chinese companies held 14 percent.[106] In the case of SaaS, the United States generated 85 percent of revenue in 2020, the United Kingdom 7 percent, and China 4 percent. However, China appears to be taking market share from both the United Kingdom and the United States at an increasing pace.[107]

Finally, looking at the market capitalization of cloud computing companies as of 2019, the top ten companies in the world are all based in the United States.[108] European players account for less than 0.1 percent of global market capitalization.

Adoption
European companies are lagging behind their US peers on investment in cloud services. Gartner estimated that US companies would direct about 14 percent of their total IT spending to the cloud, while many European (French, German, Italian, Spanish) companies and China are expected to spend about 8 percent each by 2022. Within Europe, the Netherlands and the United Kingdom stand out but are still not on a par with the United States.[109] The highest share of IT infrastructure in the cloud is in the Americas, at 52 percent; Europe's figure is 47 percent, and Asia's is 42 percent as of 2021.[110]

4. Next-generation computing

Next-generation computing largely comprises quantum computing and neuromorphic hardware. Quantum computing harnesses the principles of quantum mechanics to deliver advances in computation to solve complex problems, typically statistical in nature, that are difficult for current computers to handle.[111] Neuromorphic processing units are hardware inspired by the human brain. They are one of the key types of specialized hardware emerging to overcome the limitations of general-purpose central processing units, such as energy consumption and data rate limitations from accessing external memory. Neuromorphic hardware can be designed to reflect the structure of neural networks, leading to performance and energy improvements for training and inference.

The technology could generate up to €1 trillion in gross value added across industries by 2040.[112] Of this, between €300 billion and €600 billion of value could be generated in automotive, chemicals, finance, and pharmaceuticals.[113]

Europe is significantly behind the leading or second-best region with an average factor of 0.5 across the three stages, even though European governments have increased funding for next-generation computing.

105 "Amazon, Microsoft & Google grab the big numbers—but rest of cloud market still grows by 27%," Synergy Research Group, October 28, 2021; and Felix Richter, "Amazon leads $180-billion cloud market," Statista, February 8, 2022.
106 Lionel Sujay Vailshery, *Vendor share from the public cloud services IaaS market worldwide 2015–2020*, Statista, February 2022.
107 Kimberley Mlitz, *Global software as a service market share forecast 2020–2025, by select country*, Statista, March 2021.
108 "World top 25 cloud computing companies list by market cap as on Nov 7th 2019," Value Today.
109 Laurence Goasduff, "Cloud adoption: Where does your country rank?" Gartner, August 19, 2019.
110 *Equinix 2020–21 Global Tech Trends Survey—DX in the wake of the pandemic*, Equinix, 2021.
111 *What is quantum computing?* IBM Quantum.
112 *The next tech revolution: Quantum computing*, McKinsey & Company, March 2020.
113 *Quantum computing use cases are getting real—what you need to know*, McKinsey & Company, December 2021.

35%

of publications related to quantum computing and related fields from Europe since 2010

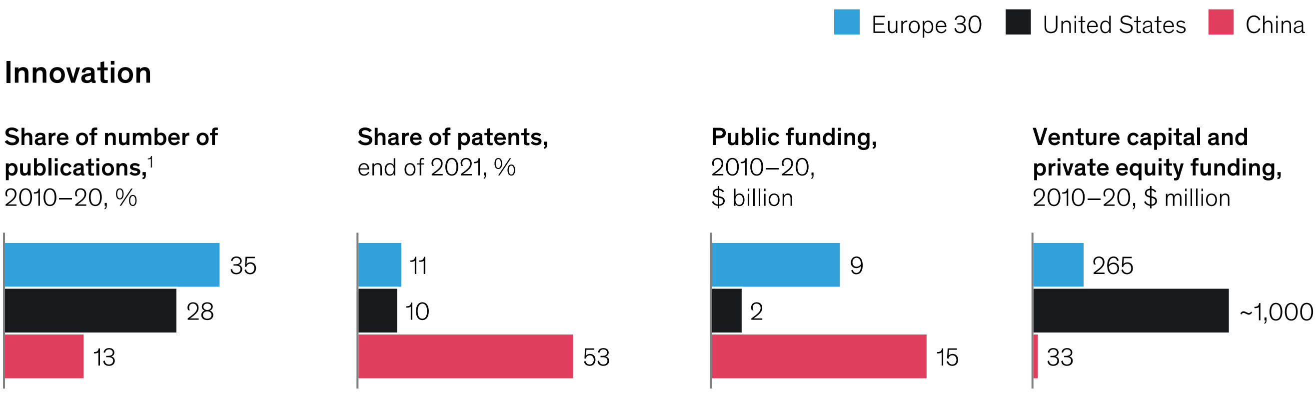
Why does this transversal technology matter?
Next-generation computing can radically accelerate development cycles and lower barriers to entry across industries. High computational capabilities enable new ways to use AI, including, for instance, molecule-level simulation. This can significantly reduce the testing needed for a range of applications, leading to disruption in industries such as materials, chemicals, and pharmaceuticals. It can enable highly personalized product development, including in medicine, and faster diffusion of self-driving vehicles. In biological and biomedical research, for instance, scientists used to rely on finding random mutations to identify beneficial traits, but the interaction between biology and ever faster and more sophisticated computing is helping to accelerate the R&D process and raise its productivity.[114] In 2020, the global quantum computing market was valued at $412 million.[115]

The United States and China are ahead in the quantum computing race on many indicators
China leads both the United States and the Europe 30 on share of world-class patents, the United States is well ahead of both other regions on private investment, and China has the most public investment of the three regions. Europe is catching up and leading with publications related to quantum computing and related fields. Today, the field is nascent (which is why we do not include an analysis of production or adoption), but it is expected to experience substantive innovation and investment in coming years (Exhibit 44). Europe has recognized the importance of this transversal technology with nearly $9 billion in public funding up to 2021.[116] However, private investment in this field by US and Chinese tech giants is far greater.

[114] *The Bio Revolution: Innovations transforming economies, societies, and our lives*, McKinsey Global Institute, May 2020.
[115] "IDC forecasts worldwide quantum computing market to grow to $8.6 billion in 2027," IDC, November 29, 2021.
[116] "Overview on quantum initiatives worldwide—update 2022," Qureca, March 10, 2022.

Exhibit 44

Next-generation computing
China leads on patents and public investment, the United States on private funding, and Europe on publications.



1. Includes only top 10 geographies.
Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Innovation

Europe leads on publications related to quantum computing and other related fields. Since 2010, the region has generated 35 percent of relevant articles globally. The US figure was 28 percent, and China's 13 percent.[117]

McKinsey data show that Chinese researchers had 53 percent of patents related to quantum computing at the end of 2021, the EU approximately 11 percent, and the United States about 10 percent.[118]

The United States and China are investing heavily in quantum computing. Of the top ten major tech companies investing in quantum computing, 50 percent are based in the United States and 40 percent in China; the EU is not represented in the top ten.[119] In the United States, tech firms including Alphabet, Amazon, Hewlett-Packard, IBM, and Microsoft are investing their own capital in in-house quantum computing innovation and research. In China, the same applies to Alibaba, Baidu, Huawei, and Tencent. The companies do not disclose most of their investment publicly, but some announcements have given an idea of scale. For instance, IBM said it invested $400 million in quantum computing research initiatives in 2021.[120] Between 2017 and 2019, Alibaba invested $15 billion in a three-year program of quantum computing R&D.[121] Alphabet announced plans to spend several billion dollars to build a new fault-tolerant quantum computer by 2029.[122] Companies such as Alibaba, Amazon, IBM, and Microsoft have already launched commercial quantum computing cloud services.[123] With time, the complexity as well as the types of problem that can be addressed will increase.[124]

The United States also has a lead on venture capital and startup investment. As of the end of 2021, announced and raised startup funding in quantum computing totaled $2.1 billion, more than double the tally in 2020.[125] Between 2010 and 2021, venture capital funding in North America totaled $1 billion; in Europe, the figure was $265 million. Private funding of quantum computing overall is expected to continue to increase sharply as the technology commercializes, and the United States is expected to maintain its lead.[126] Of the ten largest venture capital deals in quantum computing ever recorded, four involved US companies; two others were in the United Kingdom.[127] China is not represented in the top ten venture capital deals, but, again, it is difficult to know for certain what funding is under way. Of the top 11 quantum computing startups, four are US-based and one is Europe-based.[128] They include IonQ, Rigetti, Zapata, and PsiQuantum in the United States, and Quantinuum in Europe.[129] Chinese startups do not feature much on such lists, but there is evidence of activity. For instance, in 2021, Origin Quantum unveiled China's first homegrown quantum computing operating system.[130]

On public funding of quantum computing, China is in the lead, with Europe a close second. By 2021, China had invested between $10 billion and $15 billion of public funding. Europe has committed nearly $9 billion of combined EU and national investment in quantum research and infrastructure. The United States committed about $2 billion.[131]

117 Annika Pflanzer, Wolf Richter, and Henning Soller, "A quantum computing wake-up call for European CEOs," McKinsey Digital, December 2021.
118 *Quantum Technology Monitor*, McKinsey & Company, June 2022.
119 *Quantum computing market research report: By offering, deployment type, application, technology, industry – industry share, growth drivers, trends and demand forecast to 2030*, Research and Markets, February 2020; and "What is quantum computing? Top 18 quantum computing companies," Predictive Analytics Today, accessed July 2022.
120 Damon Poeter, "IBM partners with U.K. on $300m quantum computing research initiative," VentureBeat, June 4, 2021; *2020 annual report*, IBM.
121 "Alibaba pumps US$15 billion into quantum computing and AI," Ali Technology, November 11, 2017.
122 Sara Castellanos, "Google aims for commercial-grade quantum computer by 2029," *Wall Street Journal*, May 18, 2021.
123 *Quantum computing use cases are getting real—what you need to know*, McKinsey Digital, December 2021.
124 Alexandre Ménard, Ivan Ostojic, Mark Patel, and Daniel Volz, "A game plan for quantum computing," *McKinsey Quarterly*, February 6, 2020.
125 *The Quantum Technology Monitor*, McKinsey & Company, May 2022.
126 *Quantum computing use cases are getting real—what you need to know*, McKinsey Digital, December 2021.
127 PitchBook; Crunchbase.
128 *Quantum computing market research report: By offering, deployment type, application, technology, industry – industry share, growth drivers, trends and demand forecast to 2030*, Research and Markets, February 2020.
129 Quantinuum is a new entity produced by a merger between Cambridge Quantum, based in the United Kingdom, and US-based Honeywell Quantum Solutions. The new entity will split its workforce 50-50 with half of its employees in the United Kingdom and the other half in the United States. See Paul Smith-Goodson, "Quantinuum: A new quantum computing company is formed from merger of Honeywell Quantum and Cambridge Quantum," *Forbes*, December 1, 2021.
130 Li Ziyue, "China's Origin Quantum has raised funds to catch up with IBM," *Nikkei Asia*, February 5, 2021.
131 "Overview on quantum initiatives worldwide—update 2022," Qureca, March 10, 2022.

€1t–€2t

of gross value added could come from applied AI by 2040

5. Applied AI

This technology applies AI algorithms to enable computers to make sense of real-world data, including video and images (using computer vision), text (using natural language processing), and audio (using speech technology). It contributes to the digitization of natural environments, eliminating labor needs or complementing labor where technology can work better. This is done by training algorithms with sample data, recognizing patterns, interpreting, and then acting on the information.[132]

The technology could generate €1 trillion to €2 trillion of gross value added by 2040.

Europe lags very significantly behind on many metrics for applied AI, with an average factor of 0.4 across the innovation, production, and adoption stages. This is despite increased public funding and the fact that the region leads on publications.

Why does this transversal technology matter?
AI applications will eventually augment the way humans interact with machines. They will power automation, accelerate R&D and development cycles, and eliminate repetitive tasks. To give just a few examples, machine learning can be used to detect anomalies and therefore enable predictive maintenance and quality control in manufacturing. AI-driven logistics optimization can cut costs by enabling real-time forecasting. AI can also provide customer service and improve personalization through the use of improved speech recognition and more efficient processing.[133]

Applied AI is likely to have a significant impact over the next decade, not only economically but also on security issues. (AI is vital in swarm intelligence used in defense applications, for example.)[134] The global AI market was valued at $36 billion in 2020 and was already up to $57 billion in 2021.[135] It is expected to be valued at more than $360 billion by 2028, representing compound annual growth of 30 percent between 2021 to 2028.[136]

A 2021 McKinsey Global Survey indicated that AI adoption has continued to rise globally; 56 percent of all respondents said that they had adopted AI in at least one function, up from 50 percent in 2020.[137] Previous MGI research looked at five broad categories of AI (computer vision, natural language, virtual assistants, robotic process automation, and advanced machine learning) and estimated that about 70 percent of companies will have adopted at least one of the five by 2030. The analysis found that AI had the potential to deliver additional global economic activity of about $13 trillion by 2030, or 1.2 percent additional GDP growth per year. If delivered, this impact would compare well with that of other general-purpose technologies through history.[138]

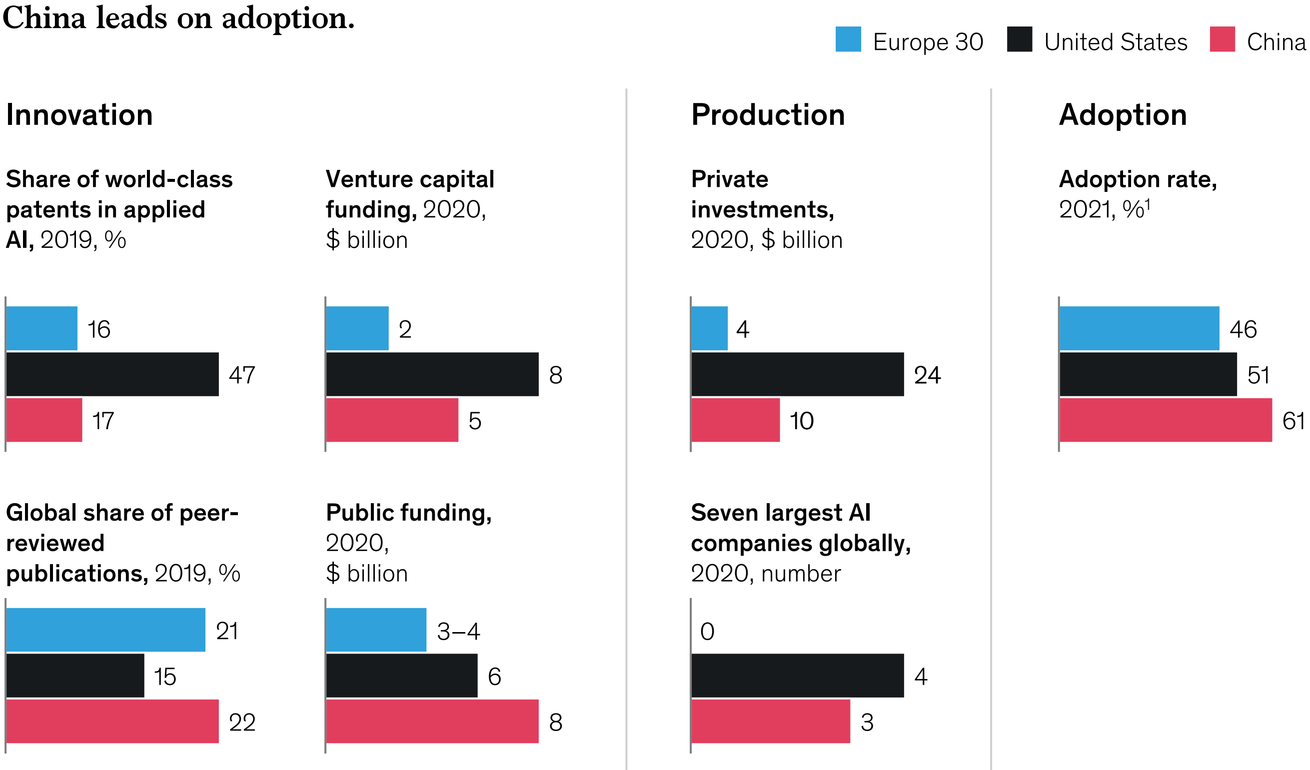
The United States is the world's AI leader
Today, the United States leads in applied AI, being home to corporations responsible for 65 percent of global private investment. For its part, China is a full-spectrum peer competitor with high adoption of certain AI applications.[139] Europe is in third position but is ramping up, having committed $3 billion to $4 billion in public funding to AI development in 2019. However, front-runners are in a position to capture the majority of the economic value that will eventually be created (Exhibit 45).[140]

132 *The top trends in tech*, McKinsey Digital, 2021.
133 *Notes from the AI frontier: Insights from hundreds of use cases*, McKinsey Global Institute, April 2018.
134 Swarm intelligence is an AI approach inspired by natural behavior to solve optimization problems.
135 *Artificial intelligence market: Global industry trends, share, size, growth, opportunity and forecast 2022–2027*, IMARC.
136 *Artificial intelligence (AI market size, share & COVID-19 impact analysis)*, Fortune Business Insights.
137 *The state of AI in 2021*, McKinsey & Company survey, December 2021.
138 *Notes from the AI frontier: Modeling the impact of AI on the world economy*, McKinsey Global Institute, September 2018.
139 Graham Allison et al., *The great tech rivalry: China vs the U.S.*, Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021.
140 *Notes from the AI frontier: Tackling Europe's gap in digital and AI*, McKinsey Global Institute, February 2019.

Exhibit 45

Applied AI

The United States leads on some metrics of innovation and production; China leads on adoption.



1. Firms that adopted at least one AI technology by 2021.
Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Innovation

The United States currently leads on several indicators of AI innovation. In 2019, it had a 47 percent share of AI-related world-class patents; China had a 17 percent share and the EU 16 percent.[141] In the same year, however, China had the biggest share—22 percent—of peer-reviewed AI publications in the world; Europe had 21 percent, and the United States 15 percent.[142] A majority of these publications are generated in academia, but government institutions are the second-largest source of publications in Europe and China. In contrast, in the United States, the second-largest source of publications is corporations.

The United States also leads on AI venture capital investment, with $8 billion of funding in 2020 against $5 billion in China and $2 billion in Europe.[143] China led in public investment, with an estimated $8 billion ($5 billion nondefense and $2 billion defense) in 2018.[144] In 2020, US public investment in AI was $6 billion, of which $5 billion was for defense.[145] The closest comparative figures for public investment in AI in Europe are for 2019, when the region invested an estimated $3 billion to $4 billion; this total includes spending both by the EU and by member states and individual countries.[146]

[141] Rebeca Gelles et al., *PARAT – Tracking the activity of AI companies*, data visualization, CSET, June 2021.
[142] *Artificial Intelligence Index report 2021*, Stanford University Institute for Human-Centered Artificial Intelligence, March 2021.
[143] PitchBook.
[144] Upper bound estimate, 2018. See Karen Hao, "Yes, China is probably outspending the US in AI—but not on defense," *MIT Technology Review*, December 2019.
[145] *Artificial Intelligence Index report 2021*, Stanford University Institute for Human-Centered Artificial Intelligence, March 2021.
[146] *AI Watch 2020: EU AI investments*, European Commission, September 2021.

6x

more investment in AI by private companies in the United States than in Europe

Production
The United States invested six times as much as Europe in AI private companies, and more than twice as much as China. In 2020, the US private sector invested about $24 billion in AI, compared with $10 billion in China and $4 billion in the EU.[147]

AI market share is also highest in the United States, which has a combination of established tech giants and startups with the potential to disrupt hardware and cybersecurity. Of the seven giants of the AI age, four (Alphabet, Amazon, Meta, and Microsoft) are in the United States, and three (Alibaba, Baidu, and Tencent) are in China. The United States is also home to two hardware giants, Intel and Nvidia.[148] Of the ten AI startups with the highest valuations, five are in the United States, four in China, and one in Europe (Switzerland).[149]

Adoption
Europe lags behind the United States and China in adoption of practical AI applications, including facial recognition, voice recognition, and fintech.[150] According to McKinsey's Global Survey on Artificial Intelligence 2021, about 61 percent of Chinese organizations had adopted AI in at least one business function.[151] This compared with 51 percent of organizations in North America and 46 percent of those in Europe.[152] Use of this technology is growing quickly. In each of the three regions, company adoption of at least one AI technology roughly doubled between 2018 and 2021.

In speech technology, Chinese firms are attracting more users than their US counterparts in every language, including English. In facial recognition, SenseTime and Megvii have developed cutting-edge applications that can identify individuals from China's population of 1.4 billion in seconds. However, concerns about privacy have limited adoption in both the EU and the United States.[153] The world's top voice recognition startup, China's iFlytek, has 700 million users, almost twice the number of people who speak to Apple's Siri. In fintech, significant usage of Chinese mobile apps has generated increased data about individual consumer behavior, which can feed into other fintech applications including AI-driven assessments. WeChat Pay's 900 million Chinese users far outnumber Apple Pay's 44 million users in the United States, for example. While two-thirds of Americans still rely on credit cards, 90 percent of urban Chinese primarily use mobile payments (spending $150 on mobile platforms for every dollar Americans spend). [154]

6. Future of programming

The future of programming describes the changing environment for software developers due to smarter algorithms that require less manual coding. It is sometimes referred to as "Software 2.0."

According to several estimates, the worldwide market for low- and no-code solutions is expected to grow fivefold, from about $13 billion in 2020 to anywhere from $65 billion to $80 billion in 2025.[155] McKinsey estimates a value at stake for this technology of roughly $150 billion by 2040.

On metrics of innovation, Europe is estimated at 0.3 the size of the sole leader, the United States.

---

147 *Artificial Intelligence Index report 2021*, Stanford University Institute for Human-Centered Artificial Intelligence, March 2021.
148 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021.
149 "Leading global AI unicorn startups 2021, based on maximum valuation," Statista, April 2021.
150 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021.
151 Chinese adoption rate is based on 74 respondents.
152 "The state of AI in 2020," QuantumBlack AI by McKinsey, survey, November 2020.
153 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021.
154 Ibid.
155 Gartner, Research and Markets, and Grand View Research. See "How big is the global low-code/no-code market and how fast it is growing?" SpreadsheetWEB, July 12, 2021.

27%

of global venture capital funding of Software 2.0 and engineering analytics companies for Europe vs 73% for the United States

Why does this transversal technology matter?

Software 2.0 refers to the concept of machine-written programs to reach an operator- or human-set goal, such as winning a game of chess.[156] The focus of the programmer thus can shift from designing the code to designing the overarching framework and ensuring that the correct data are used as the input into machine learning. A prominent example of this technology is low- or no-code platforms. As the name suggests, these are platforms that allow users to tackle problems previously addressable only by trained coders, eliminating the need for 90 percent of programming time. Code is still written, but the user creates the program through an intuitive interface that does not require as much knowledge of coding as before. Gartner estimates that 70 percent of applications will be developed via low- and no-code platforms by 2025, compared with less than 25 percent in 2020.[157]

Software 2.0 enables rapid scaling and diffusion of data-rich AI-driven applications. It can enable use cases like autonomous vehicles that are possible only with AI models. It also makes it easier for organizations to customize existing code and automate mundane programming tasks. Broadly, too, this technology will further accelerate emerging trends in machine learning that can surmount some of the complexities that currently hamper the development and application of AI models.

This technology could reduce the workforce required for software development and analytics to a fraction of its current levels; alternatively, if the workforce is held constant, Software 2.0 could accelerate software development. Netflix, for instance, has reduced time to deployment 16-fold.[158]

The United States leads on metrics of innovation and production, far ahead of Europe, while China does not appear to have a significant presence

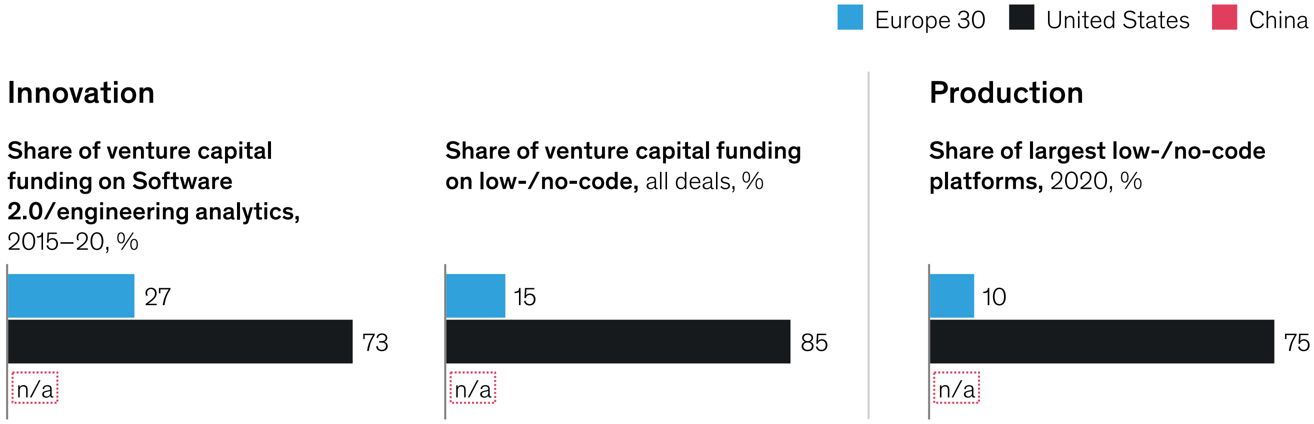
The United States is well ahead of Europe, with 73 percent of global venture capital funding of Software 2.0 and engineering analytics companies, followed by Europe with 27 percent.[159] China and the rest of the world do not have a significant presence. Looking specifically at low- and no-code startups, venture capital funding is largely concentrated in the United States, which has 85 percent of the total; Europe's figure is 15 percent.[160] The United States is also ahead on production, being home to 75 percent of the largest low- and no-code platforms; Europe accounts for 10 percent of such platforms.[161] However, this market is relatively fragmented; most applications serve niche needs and have relatively low economies of scale (Exhibit 46).

156 *The top trends in tech*, McKinsey Digital, 2021.
157 "Gartner forecasts worldwide low-code development technologies market to grow 23% in 2021," Gartner, February 16, 2021.
158 Ibid.
159 PitchBook.
160 Crunchbase.
161 Gartner.

Exhibit 46

Future of programming

The United States leads on innovation investment and production.



Note: For data sources, see report.
Source: McKinsey Global Institute analysis

7. Trust architecture

A trust architecture provides a framework that enables data to flow through a service-oriented system in a verifiable way. Technologies include blockchain, an environment in which users trust a system without necessarily trusting any of its components.[162] While blockchain is most commonly associated with digital currencies, it can also underpin many other applications, such as the tracking of international trade shipments and smart contracts that can replace paper-based documentation systems.[163] Trust architecture also includes zero-trust security, an approach to preventing data breaches by eliminating the concept of trust by default from an organization's network architecture and instead following the principle of "never trust, always verify" through strict access controls and frequent authentication.[164] It should be noted, however, that advances in quantum computing could supersede some of the current use cases.

McKinsey estimates that the technology could generate up to €800 billion in gross value added by 2040. Gross value added will tend to accrue largely to adopters of the technology.

Europe lags behind the United States in trust architecture, with a factor of 0.5 scored across the innovation, production, and adoption stages.

Why does this transversal technology matter?
Trust architecture is important as a way to mitigate cyberrisk, helping commercial organizations and individuals verify information, identities, and transactions, conducting business with fewer intermediaries and delays.

Two metrics illustrate the relevance of these technologies. Funds equivalent to about 10 percent of global GDP could be stored on blockchain technology by 2027.[165] And about nine billion records were compromised in 2019 because of insufficient security.[166]

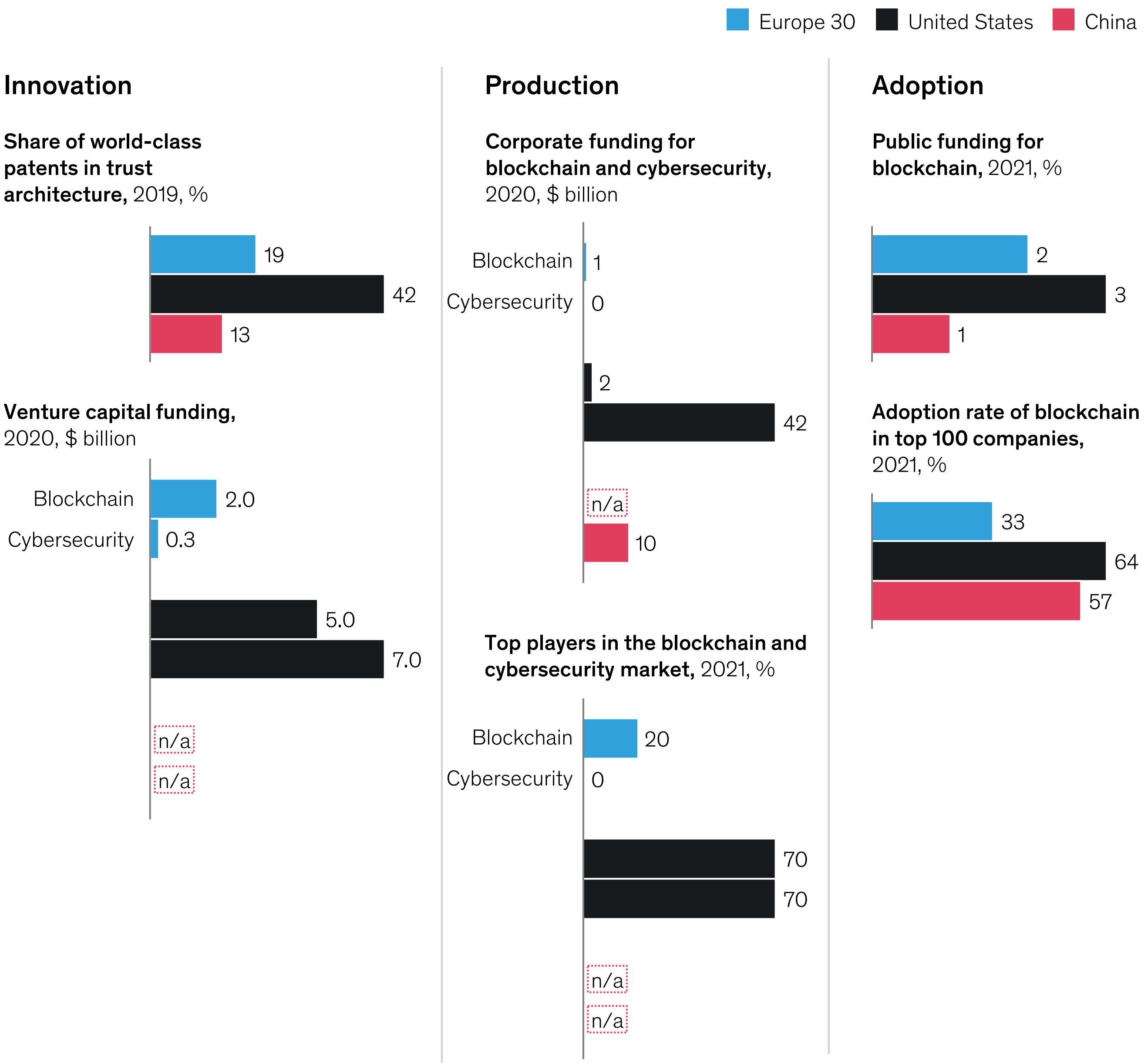
162 Kevin Werbach, *The blockchain and the new architecture of trust*, MIT Press, November 2018.
163 *Globalization in transition: The future of trade and value chains,* McKinsey Global Institute, January 2019.
164 *The top trends in tech*, McKinsey Digital, 2021.
165 Adrian Ogée, *Blockchain is not a magic bullet for security, Can it be trusted?* World Economic Forum, August 2019.
166 *The top trends in tech*, McKinsey Digital 2021.

The United States is some distance ahead of Europe on metrics of innovation, production, and adoption
The United States has driven many of the advances in trust architecture and is home to a majority of the world's top blockchain players (Exhibit 47). This trend has particular relevance in the country for a number of reasons, including the lack of a standard national ID, a large unbanked population that relies on paper payments, and a payment infrastructure that is not as modernized as European systems. These issues create a greater need for solutions that can improve the speed and security of payments and transactions. Europe, by contrast, does not have the same kind of business case.

Exhibit 47

Trust architecture

The United States leads on metrics of innovation, production, and adoption.



Note: For data sources, see report.
Source: McKinsey Global Institute analysis

$2b

US private investment in blockchain vs $800 million from EU companies in 2020

Innovation
The United States leads on world-class patents with 42 percent of the global total. Europe's share is 19 percent, and China's 13 percent. The United States is also in front on venture capital funding for trust architecture. In 2020, venture capital blockchain funding totaled $5 billion in the United States, compared with $2 billion in the EU. In the case of cybersecurity venture capital funding, the United States was even further ahead, with total funding of $7 billion versus $260 million in the EU.[167]

Production
The United States leads on private corporate funding. In the case of blockchain, US companies invested $2 billion in 2020, compared with $800 million from EU companies. US private investment in cybersecurity was $42 billion versus the EU's $370 million in 2020.[168]

US players dominate this field. Seventy percent of the top blockchain technology players are US companies (JP Morgan, Linux, IBM, Coinbase, Accenture, Microsoft, and Goldman Sachs); 20 percent are in Europe (Ethereum, Swift). The United States also has 70 percent of the top players in the cybersecurity software space: Cisco, Akamai, Forcepoint, Palo Alto Networks, Illumio, Okta, Unisys.[169] Others are in Australia and Canada.

Adoption
The United States leads in government funding of blockchain, which totaled nearly $3 billion in 2021. The EU figure was $2 billion, and the China figure $1 billion.[170] Corporations in China and the United States also lead on adoption of blockchain technologies. In 2021, 64 percent of the top 100 US companies had implemented blockchain; in China, the share was 57 percent, and in the EU 33 percent.[171]

8. The Bio Revolution

Advances in biological sciences and the accelerating development of computing, automation, AI, and data analysis have coincided to fuel a wave of biological innovation that MGI has characterized as the Bio Revolution. This is a broad landscape of innovation across technologies and domains. MGI focused on four areas: biomolecules, or the mapping, measuring, and engineering of molecules; biosystems, the engineering of cells, tissues, and organs; biomachines, the interface between biology and machines; and biocomputing, or the use of cells or molecules such as DNA for computation.

We estimate that gross value added of €300 billion to €500 billion could be generated by this group of transversal technologies in 2040.

Europe trails with a factor of 0.6 across the three stages, scoring broadly on par on innovation with 0.8, but lagging behind on production (0.4) and adoption (0.5).

Why does this transversal technology matter?
The Bio Revolution is a growing and already broad area of innovative technology. MGI cataloged a pipeline of about 400 visible use cases in multiple industries, almost all of which are scientifically feasible today. These applications alone could have direct annual global economic impact of $2 trillion to $4 trillion over the next ten to 20 years. More than half of the direct impact of the applications is likely to be outside health, primarily in agriculture and consumer products. The economic impact of biomolecules and biosystems accounts for about 95 percent of the estimated total impact—between $1.7 trillion and $3.4 trillion. Biomachines account for about 5 percent at $100 billion to $200 billion, and biocomputing, a growing if nascent area, less than 1 percent of the total.[172]

Considering potential knock-on effects, new applications yet to emerge, and additional scientific breakthroughs, the full potential could be far larger. To give a sense of the potential scale, as much as 60 percent of today's physical inputs to the global economy are either

---

[167] PitchBook.
[168] Ibid.
[169] Jenn Fulmer, "Top zero trust security solutions & software 2022," IT Business Edge, July 8, 2021.
[170] "Global spending on blockchain solutions forecast to be nearly $19 billion in 2024, according to new IDC spending guide," IDC, April 19, 2021.
[171] Lucas Schweiger, "81 of the top 100 public companies are using blockchain technology," Blockdata, October 2021.
[172] *The Bio Revolution: Innovations transforming economies, societies, and our lives*, McKinsey Global Institute, May 2020.

biological (such as wood and animals raised for food) or nonbiological (cement or plastics) inputs that could be produced or substituted using biology. At least 45 percent of the current global disease burden could be addressed using science that is conceivable today.[173]

While European academics are prolific, the United States leads on innovation, with China catching up

Europe led on research publications with twice the volume of the United States and three times the number from China between 2018 and 2020. However, the United States filed more patents than either of the other regions and invested more in early-stage funding—$29 billion during this period, compared with $6.4 billion for China and $6.2 billion for Europe. Europe has only one company in the world's biotech top ten. US companies originated twice as many of the therapeutics approved between 2018 and 2020 as European companies. China is catching up rapidly on all dimensions (Exhibit 48).[174]

---

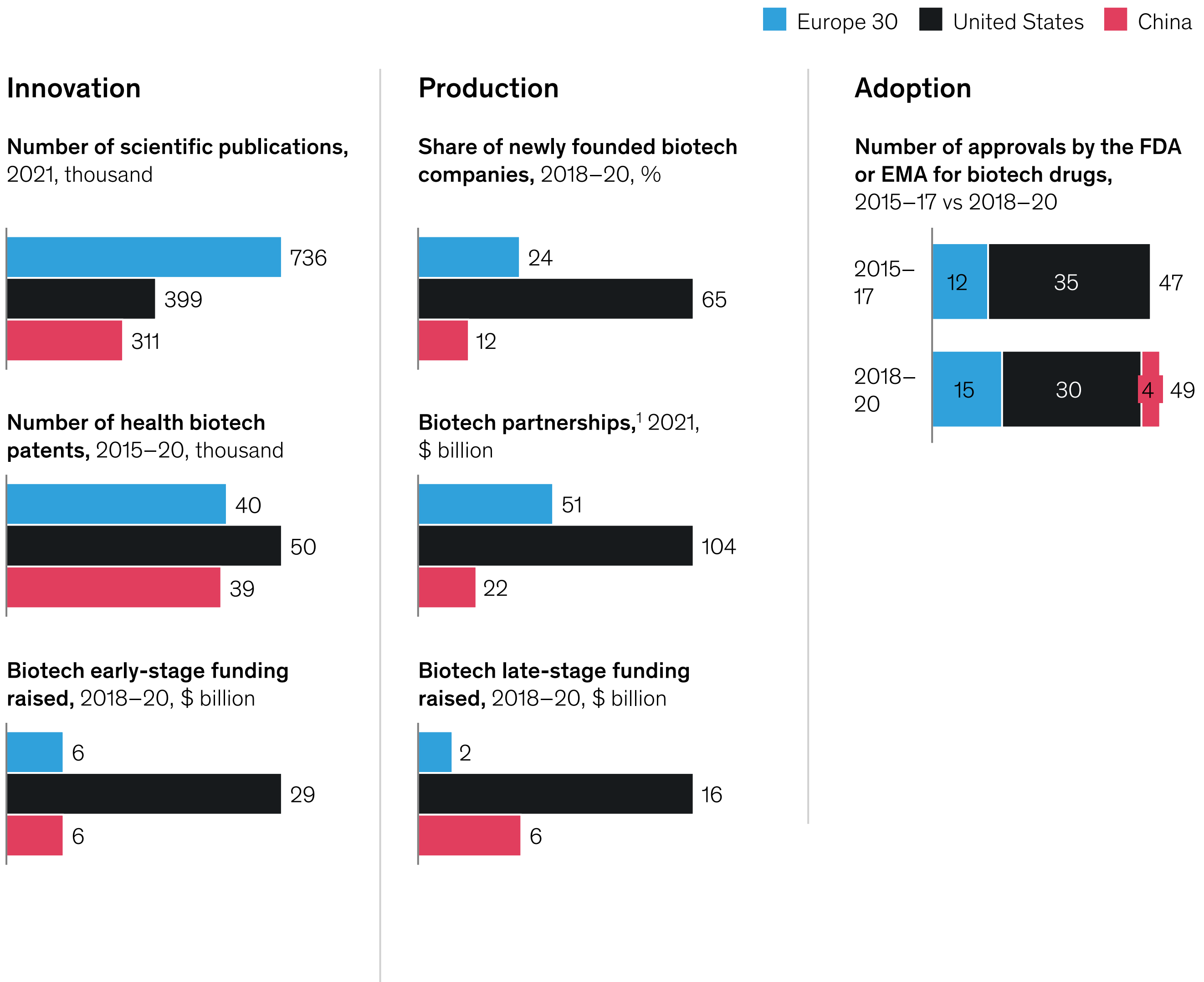
[173] Ibid.

[174] Metrics in this section are based on biotech and therapeutics, and do not cover Bio Revolution innovations in agriculture or tech-bio combinations.

Exhibit 48

Bio Revolution

Europe leads on scientific publications, but the United States leads on production and adoption.



1. Includes licensing deals, commercial collaboration, joint ventures, etc.

Note: For data sources, see report.

Source: McKinsey Global Institute analysis

Innovation
In 2021, European institutions had a convincing lead in the number of pharmaceutical-related scientific publications, with 736,000, more than the United States and China combined.[175] On the top 50 percent of publications—an indicator of high-quality research—Europe matched the United States from 2014 to 2017 (with 243,000 and 242,000, respectively). China was behind, with 95,000, but its tally grew quickly, at a 33 percent rate, between 2011–15 and 2014–17.[176]

65%

of new biotech companies in 2018–20 in the United States, vs 24% in Europe and 12% in China

The United States filed some 50,000 biotech patents between 2015 and 2020, followed by Europe with about 40,000 and China with about 39,000. In 2021, China had the most biotech patents granted, with about 23,500, a dramatic increase from just 8,000 in 2020. Meanwhile, the United States had 11,900 biotech patents granted, and Europe had nearly 5,500 in 2021.[177]

Finally, between 2018 and 2020, the United States led on total early-stage funding with $29 billion, compared with China and Europe at $6.4 billion and $6.2 billion, respectively.[178] The gap in early-stage biotech funding between Europe and the United States is widening, while China has been catching up with Europe. Between 2015–17 and 2018–20, Europe's funding grew by 13 percent per year, compared with 17 percent for the United States and 18 percent for China.[179]

Production
Half of the world's top 25 biotech companies in 2022 in market capitalization are based in the United States. Europe is home to five, including the Danish company Novo Nordisk, the world's number one. China had three players in the top 25 in 2022.[180]

Regarding the next generation of biotech, the United States was home to 65 percent of all newly founded biotech companies between 2018 and 2020, compared with 24 percent for Europe and 12 percent for China.[181] Between 2015–17 and 2018–20, China's share rose from 8 percent to 12 percent.[182] While China's manufacturing leadership lies in non-tech-intensive segments such as generic drugs and biosimilars, it has demonstrated innovative leadership in certain technologies. For instance, Nanjing Legend Biotech emerged as the leader in CAR T-cell therapies in 2017.[183] In partnership with Johnson & Johnson, the company secured approval from the US Food and Drug Administration (FDA) in March 2022.[184]

Adoption
The majority of new biotech therapies approved between 2018 and 2020 originated from US companies. In that period, US companies achieved about 30 FDA and European Medicines Agency (EMA) approvals, versus 15 for European companies.[185] Although many more biotechs are listed in China, their global presence so far is limited. In 2020, Chinese biotech companies had had only four drugs approved by the FDA and the EMA.[186]

175 PubMed (2022) via *Unchartered waters: Can European biotech navigate through current headwinds?* McKinsey & Company and Bio€quity Europe, May 2022.
176 Number of publications in the region, compared with other publications in the same field (biomedical research and life sciences) and year, which belong in the top 50 percent of most frequently cited publications; calculated by summing all top 50 percent publications of several universities. The analysis considered 141,120 universities worldwide, including about 48,000 in Europe, about 24,000 each in China and the United States, and some 44,000 in the rest of the world. See CWTS Leiden Ranking (2020) in *The Bio Revolution: Innovations transforming economies, societies, and our lives*, McKinsey Global Institute, May 2020.
177 Innography IP; McKinsey IP analysis in *Unchartered waters: Can European biotech navigate through current headwinds?* McKinsey & Company and Bio€quity Europe, May 2022.
178 *Innovation hotspots to drive the next act in Europe*, McKinsey & Company and Bio€uity Europe, May 17, 2021.
179 Ibid.
180 Alex Philippidis, "Top 25 biotech companies of 2022," *Genetic Engineering & Biotechnology News*, April 4, 2022.
181 McKinsey Corporate Performance Analysis Tool.
182 *Innovation hotspots to drive the next act in Europe*, McKinsey & Company and Bio€uity Europe, May 17, 2021.
183 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Belfer Center for Science and International Affairs, Harvard Kennedy School, December 2021.
184 Angus Liu, "Johnson & Johnson, Legend's CAR-T Carvykti enters myeloma ring with FDA nod," Fierce Pharma, March 1, 2022.
185 *Innovation hotspots to drive the next act in Europe*, McKinsey & Company and Bio€uity Europe, May 17, 2021.
186 Farah Master, "Analysis: China's biotech sector comes of age with big licensing deals, global ambitions," Reuters, September 16, 2021.

Finally, the United States leads other regions on public funding of biotech with a budget of around $9 billion annually. Europe's public funding from both the EU and its constituent countries comes to about $5 billion a year. China's annual public spending is estimated at about $2 billion per year.[187]

9. Next-generation materials

Next-generation materials refers to major innovations in the properties, manufacturing processes, and market applications of metals, polymers, ceramics, composites, and coatings. Innovations in materials can occur on different scales. They can, for instance, include improved structural properties at the nanometer scale, novel surface geometries at the micrometer scale, and creation of new materials markets and applications at a global scale.[188] In this report, we chose to focus on three categories of next-generation materials that have significant impact on several industries and innovate in physical and environmental performance. Overall, this technology could generate gross value added of about €70 billion by 2040.

Europe leads on some metrics in next-generation materials overall, with a factor of 1.3. It leads in production, with a factor of 2.0, and in adoption, with a factor of 1.2, while lagging behind the United States on some metrics of innovation, with a factor of 0.7.

Why does this transversal technology matter?
Materials design and the invention of new materials have very broad impact across sectors, from transportation to health and renewable energy. They can change the economics of a wide range of products and services by being more efficient and potentially cheaper to produce from a total-cost-of-ownership standpoint. Future construction materials will enable the reduction of the sector's carbon footprint.

We focus on these three large subsegments of next-generation materials:

— **Nanomaterials.** Nanotechnology includes carbon nanotubes, nanoparticles, graphene, titanium dioxide, and other new materials. Applications are relevant to cleantech, aerospace, and medical technology, among other sectors. This segment was valued at nearly $2 billion in 2020, and that is expected to grow at a 35.5 percent compound annual rate from 2020 to 2026.[189]

— **Composites.** These include fiber-reinforced polymers (for instance, glass and carbon), ceramic matrix composite, metal matrix composite, reinforced concrete, translucent concrete, engineered wood, plywood, engineered bamboo, wood-plastic composite, cement-bonded wood fiber, and syntactic foams.[190] The largest of these segments, fiber-reinforced polymers, was valued at an estimated $34 billion in 2020 and is expected to grow at a compound annual growth rate of 4 percent from 2020 to 2024.[191] When considering the next step in the value chain, including composite products, components, design, and tooling services, the market reached a value of $78 billion in 2020, and it is expected to grow at 9 percent per year to 2025.[192]

— **Future construction materials.** Responsible for about 25 percent of greenhouse gas (GHG) emissions, the construction industry faces a major decarbonization challenge. Concrete is the largest contributor, accounting for about 4.5 percent of global GHG and 7 percent of CO_2 emissions in 2019. Reducing its environmental footprint can be achieved via several avenues, including redesigning with alternative building materials, such as cross-laminated timber (CLT), and reducing emissions per unit of building material by

187 United States: annual budget of National Institutes of Health and Biomedical Advanced Research and Development Authority (BARDA; China: annualized budget announcement of the Precision Medicine Initiative and Key Scientific and Technological Grant; Europe: public R&D investment for biotech of individual European countries and Cluster 1 of Horizon Europe program.
188 *Next generation materials: Technology assessment*, US Department of Energy, 2015.
189 *Global nanotechnology market*, BCC Research, December 2021.
190 *Composites 2020: A multitude of markets*, CompositesWorld, January 2019.
191 *Composites market: Trends, opportunities, and analysis*, Lucintel, June 2020.
192 *JEC Observer: Current trends in the global composites industry 2020–2025,* JEC, 2021.

using additives to make concrete stronger and to lower the cement concentration in concrete—green cement. [193] The global green cement market was estimated to be valued at $22 billion to $27 billion in 2021 and is expected to grow between 8 and 13 percent per year in the next five to 10 years.[194] While relatively nascent, the CLT market is estimated to have been $1.1 billion in 2021 and is expected to grow by 14.5 percent per year to 2027.

Nanomaterials: The United States leads on most indicators, but Europe is strong on funding and patents

Europe and the United States each held about one-quarter of global world-class patents in 2019, and the two are approximately equal on venture capital spending and global nanomaterials suppliers. However, Europe leads in corporate investment and adoption; it was the largest end market in 2020 (Exhibit 49).

Innovation

Europe and the United States broadly match each other on patents, with more than 25 percent of world-class patents in 2019. China is some way behind but because of Japan's strong position, East Asia as a whole (excluding China) is on a par with Europe and the United States.[195] Looking at venture capital investment from 2015 to 2020, the United States had a slight lead with about $1 billion, compared with Europe's $900 million; both were far ahead of Asia (including China) with $518 million. However, this picture varies across subsegments. Europe has invested twice as much venture capital as the United States in graphene in recent years, for instance.[196]

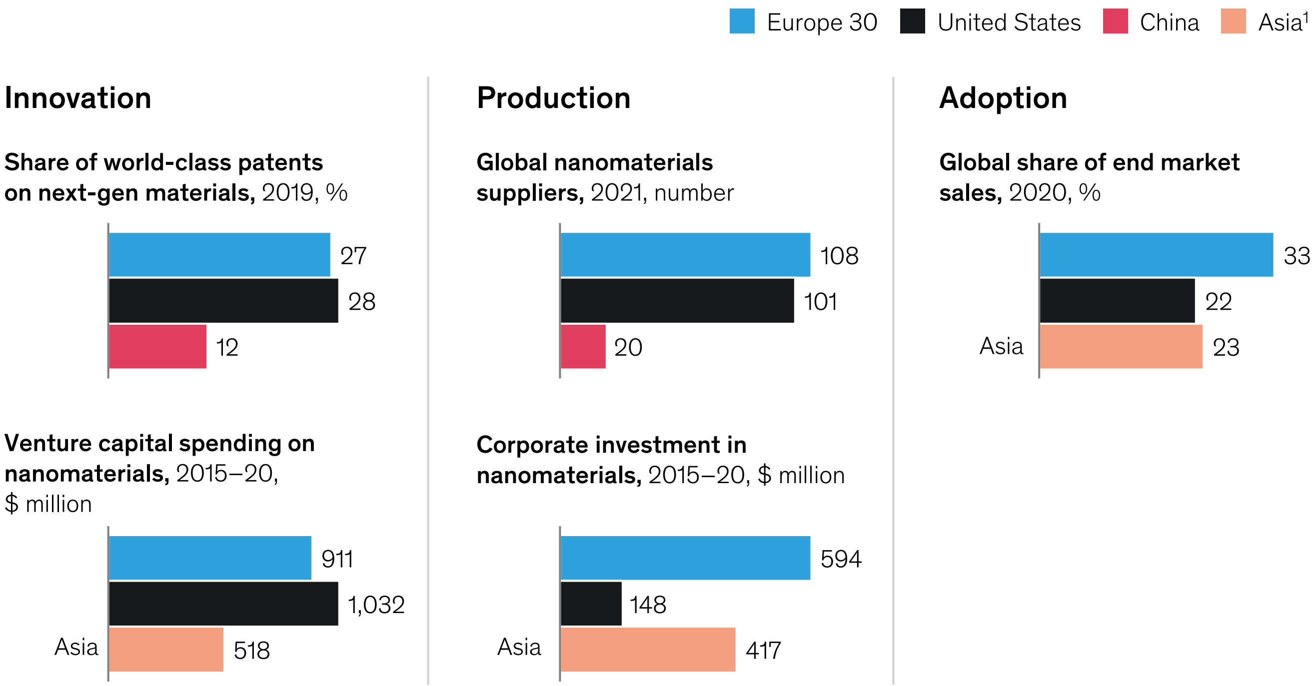
---

[193] Thomas Hundertmark, Sebastian Reiter, and Patrick Shulze, "Green growth avenues in the cement ecosystem," McKinsey & Company, December 2021.
[194] *Green cement market: Global industry trends, share, size, growth, opportunity and forecast 2022–2027,* IMARC, 2021.
[195] Jan C. Breitenger, Benjamin Dierks, and Thomas Rausch, *World-class patents in future technologies: The innovation power of East Asia, North America, and Europe*, Bertelsmann Stiftung, June 2020.
[196] *Europe's private promise*, Morgan Stanley Research, March 1, 2022.

Exhibit 49

Next-generation materials (nanomaterials)

Europe leads on metrics of production and adoption, but the United States has a slight lead on metrics of innovation.



1. Including China.
Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Production

Across all nanomaterial segments, Europe has slightly more global suppliers than the United States (108 versus 101); both are well ahead of China, which has 20 nanomaterials suppliers with global footprints.[197] In the largest segment (carbon nanotubes), the United States has a greater number of global suppliers, while Europe has some of the world's leaders, including Nanocyl, which produces multiwall carbon nanotubes, and OCSiAl, one of the largest single-wall carbon nanotube producers. Many European players are among the top global suppliers of graphene, including Directa Plus, Haydale Graphene, and Versarien. Europe also captured the largest share of corporate investment in nanomaterials from 2015 to 2020, with $594 million against the $148 million invested in the United States and $417 million in Asia (including China).[198]

Adoption

Europe accounted for 33 percent of global sales, compared with 22 percent for the United States and 23 percent for Asia (including China).[199]

Next-generation composites

While China is the largest end market for fiber-reinforced polymers, the United States, Europe, and Japan are the leaders in production.

Composites have applications in many markets. Europe is a leading adopter in aerospace (because of the presence of Airbus and its supplier ecosystem) and in oil and gas. China leads in automotive, followed closely by Europe, where stringent emissions regulations have led manufacturers to shift to lighter-weight materials. China and Europe together lead in electronics. The United States leads in boatbuilding and marine, sports and recreation, civil infrastructure, construction, and utility infrastructure. The United States and Europe are on a par on industrial applications (Exhibit 50).[200]

Innovation

The United States was far in front in venture capital investment in carbon fiber startups, between 2015 and 2021 with $912 million and 156 deals. In that segment, Europe posted $149 million in funding across 108 deals, while China stood at $85 million and 29 deals.[201]

Production

Europe and the United States are roughly even, with ten and nine top global suppliers of composites, respectively; China has five. However, the United States and China captured the largest shares of market in volume in the largest subsegments (glass fiber and carbon fiber). Europe's strength in next-generation composites resides in its intermediate players operating in high-end applications and differentiating themselves from others through innovation rather than on price; examples include Gurit and Saertex. Looking beyond the three regions, Japan has a very strong position in next-generation composites (notably in carbon fiber) with global leaders Toray Industries, Teijin Limited, and Mitsubishi Rayon.

Adoption

China was the largest end market for fiber-reinforced polymers (especially carbon and glass, the largest segments of next-generation composites). It represented 27 percent of the global market in 2020, followed by the United States with 24 percent and Europe with 21 percent.[202]

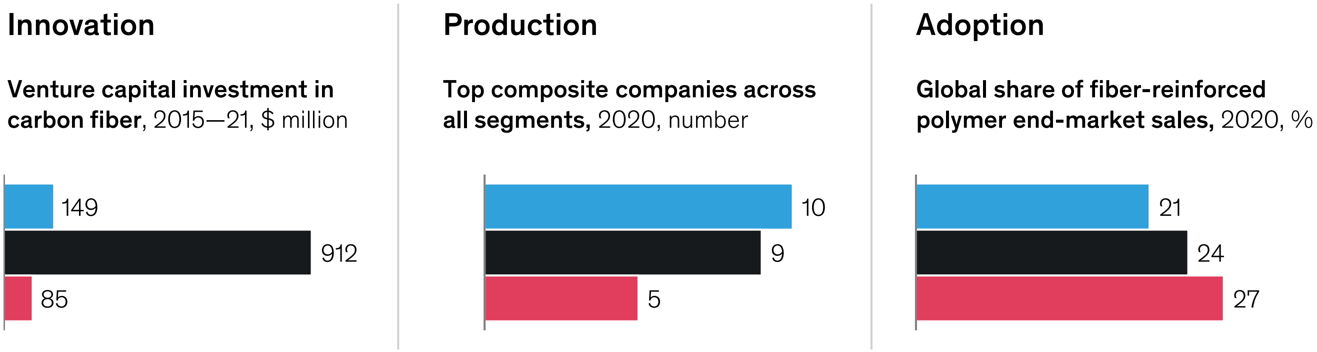
---

[197] There may have more Chinese large players but with a national footprint. See *Nanotechnology nanomaterial suppliers*, Nanowerk.
[198] PitchBook.
[199] *Global nanotechnology market*, BCC Research, December 2021.
[200] *Composites 2020: A multitude of markets*, CompositesWorld, January 2019.
[201] PitchBook.
[202] *Composites market: Trends, opportunities, and analysis*, Lucintel, June 2020.

Exhibit 50

Next-generation materials (composites)

The United States and Europe are at par on some metrics of production; China leads in adoption market volume.



Note: For data sources, see report.
Source: McKinsey Global Institute analysis

Future construction materials

Europe matches the United States for innovative companies in construction materials overall. Looking at specific subsegments, Europe appears to lead in the production of both green cement and CLT courtesy of its large incumbents. Europe and the United States share leadership on adoption, depending on the market (Exhibit 51).

Innovation

Of the six companies leading innovation in construction materials, three are based in the United States and three in Europe.[203] One of the most promising next-generation materials for construction is green cement. Startups active in this field are mostly US-based; they include Calera Corporation, Ceratech, and Solidia Technologies. However, Europe also has a strong presence, with companies such as Ecocem and Cenin.[204] Broadly speaking, Europe appears to be ahead of the United States in next-generation construction materials, including green cement, with China third.

Production

Again thanks to its large incumbents, Europe leads in the production of green cement, with three companies in the top ten players in the market; the United States and China have one each.[205] European players also have a strong position in the CLT industry, with production shares of between 60 and 65 percent.[206] Global leader Stora Enso had 20 percent of the global market in 2020, and several large players are located in Austria, Germany, and Switzerland.[207]

3 of top 10

green cement players are European vs 1 each in the United States and China

Adoption

North America remains the largest end market for green cement, with approximatively 35 to 45 percent of market share in 2020. However, Europe is gaining ground significantly because of a supportive regulatory environment, tax reliefs, and other benefits.[208] Europe holds about 40 percent of the end-market share in CLT, while the United States has approximatively 15 percent.[209]

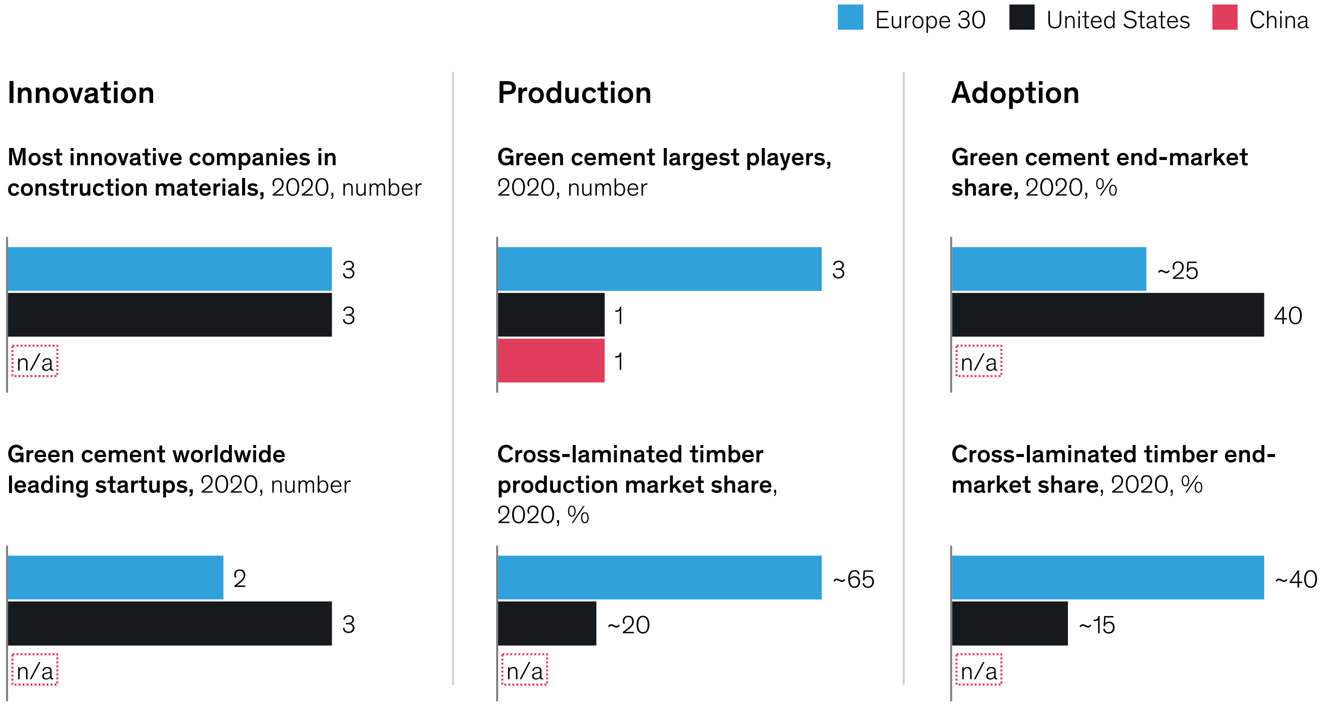
---

[203] *Construction materials—global market trajectory & analytics*, Research and Markets, April 2021.
[204] *Green cement market by product*, Allied Market Research, accessed April 2022.
[205] *Green cement market: Global industry trends, share, size, growth, opportunity and forecast 2022–2027*, IMARC, 2021.
[206] *Cross laminated timber market,* Fortune Business Insights, 2020; and *Cross laminated timber market,* Grand View Research, 2021.
[207] Stora Enso Roadshow presentation Q4 2020, February 2021.
[208] "Global green cement market to cross USD 678.2 mn by 2026," Global Market Insights, October 27, 2020.
[209] *Cross laminated timber market,* Fortune Business Insights, 2020; and *Cross laminated timber market,* Grand View Research, 2021.

Exhibit 51

Next-generation materials (future construction materials)

Europe leads in metrics of production, while overall matching the United States in innovation and adoption, depending on the market.



Note: For data sources, see report.
Source: McKinsey Global Institute analysis

10. The future of cleantech

Cleantech is an umbrella term for a wide range of technologies. It encompasses solar, wind, and hydro power, all of which are well established, as well as newer technologies that are breaking through, including fusion, next-generation energy storage, and hydrogen. In this section we focus on six technologies in the innovation stage (nuclear fusion; carbon capture, use, and storage [CCUS]; smart grids; next-generation batteries; long-duration energy storage [LDES]; and hydrogen) and six in the production stage (solar, wind, hydrogen, nuclear fission, hydropower, and energy storage).[210]

This transversal technology could generate gross value added of up to €400 billion by 2040. Europe leads on innovation, lags on production, and is on a par with China on adoption; the average factor is 1.0.

Why does this transversal technology matter?
Clean technologies are sliding down the cost curve and becoming more disruptive to traditional business models. They are beginning to affect both the structure of industries and their competitive dynamics. These technologies will clearly have a significant impact on energy industries, the power sector, transportation, buildings and infrastructure, and other areas.

In the EU, McKinsey has estimated that stakeholders will need to allocate an additional €5 trillion (an average of €180 billion a year) to clean technologies and techniques in order to transition to net zero and that doing so would ultimately lower operating costs. From 2021 to 2050, the EU would save an average of €130 billion annually in total system operating costs, with most savings coming in transportation.[211]

The global cleantech market was valued at $285 billion in 2020 and is forecast to expand to $425 billion in 2026.[212] About 75 percent of global energy is expected to be produced by renewables by 2050.[213]

Europe's head start in cleantech has started to wane
Europe was the clear cleantech pioneer between 1990 and 2010, but its lead subsequently began to diminish.

Europe has the most ambitious emissions reduction targets; the EU has committed to reducing the region's emissions by 55 percent by 2030.[214] The region leads on patents and venture capital funding; it also uses the highest share of renewables in its overall energy mix. Yet China now dominates cleantech production in nearly all areas, often with market shares of more than 50 percent. On innovation, the United States is generating more breakthrough technologies (Exhibit 52).

[210] Tom Hellstern, Kimberly Henderson, Sean Kane, and Matt Rogers, "Innovating to net zero: An executive's guide to climate technology," McKinsey & Company, October 2021.
[211] *How the European Union could achieve net-zero emissions at net-zero cost*, McKinsey Sustainability, December 2020.
[212] "Global clean energy technologies market size expected to grow to USD 423.7 billion by 2026," Facts & Factors, August 10, 2021.
[213] *The top trends in tech*, McKinsey Digital, 2021.
[214] *2030 Climate Target Plan*, European Commission, September 2020.

Exhibit 52

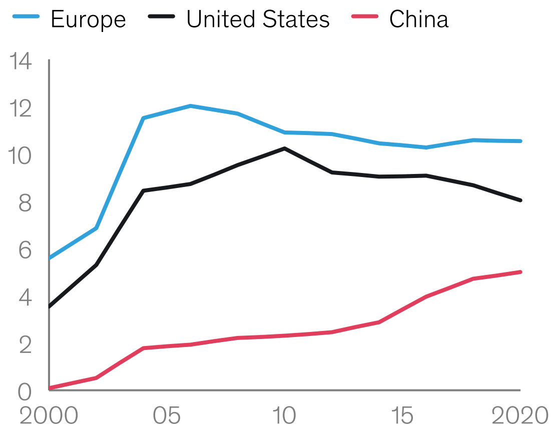
Cleantech

Europe leads on metrics of innovation and per capita capacity but lags on future cleantech.

Europe United States China

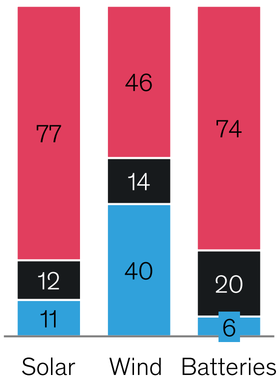
Innovation

Patents F2+ families, number, 2020



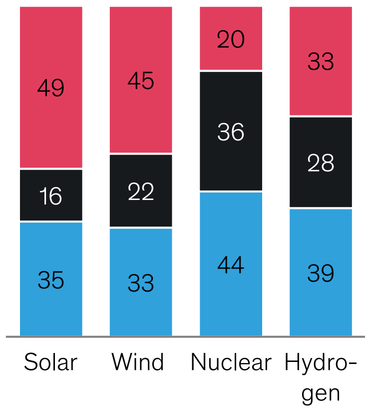
Production

Production, % of total GW produced, 2020

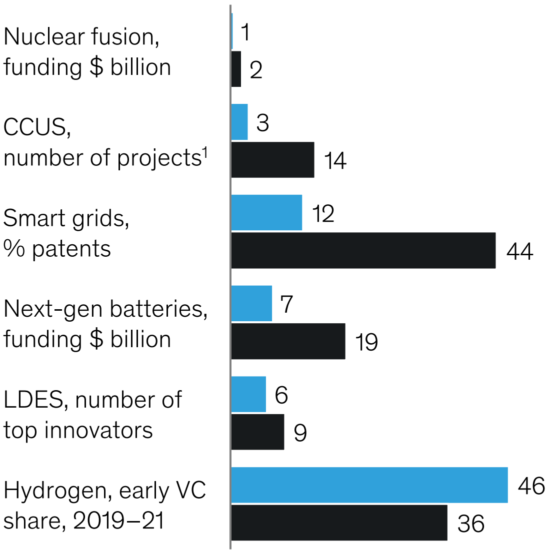


Adoption

Total GW installed, 2020, %



US/Europe comparison on future cleantech



1. Commercial CCUS projects operational in 2021.

Note: For data sources, see report.

Source: McKinsey Global Institute analysis

Innovation
Europe leads on cleantech innovation in patents. Looking at family 2+ international patents for environment-related technologies, Europe filed 11,000 patents in 2018; the US figure was 8,000, and China's was 5,000. However, the pace of fillings slightly decelerated in Europe and the United States, while China's filings have continued to grow.[215]

14

commercial CCUS projects operating in United States in 2021 vs 3 each in Europe and China

On venture capital investment, Europe has historically lagged behind the United States but has recently reversed that trend. Between 2013 and 2019, $60 billion was invested globally in cleantech startups. Of that, $29 billion went to the United States and Canada, $20 billion to China, and $7 billion (or 12 percent of the total) to Europe.[216] However, Europe outpaced China and the United States in 2020, with $6.2 billion of venture capital investment in cleantech.[217] Europe's stronger venture capital investment showing appeared to be set to continue, with $7 billion committed as of June 2021. In 2020, public R&D investment in Europe in cleantech reached $10.4 billion, while the United States invested $8.2 billion.[218]

The United States has a clear lead on several metrics for breakthrough technologies, specifically on six key technologies: nuclear fusion, CCUS, smart grids, next-generation batteries, LDES, and hydrogen. Europe, however, leads on green hydrogen (just behind Japan).[219]

— **Nuclear fusion.** Of 23 companies showcased by the Fusion Industry Association in 2021, 13 are in the United States, seven in Europe, and one in China. In recent years, about $2.4 billion of funding went to private companies, with private funding representing nearly 95 percent of the total. Of this, 80 percent went to the top four companies, all of which are based in the United States.[220]

— **CCUS.** In 2021, the United States had 14 commercial CCUS projects in operation, and Europe and China three each.[221] The high number in the United States is thanks to the US 45Q tax credit for carbon sequestration alongside complementary policies such as California's Low Carbon Fuel Standard (LCFS). The LCFS provides a credit of $50 per ton of CO_2 that is permanently stored, and $35 per ton used in enhanced oil recovery or other beneficial uses for 12 years from the commencement of operation of the project. Looking ahead, European countries are now more heavily investing in infrastructure, with 35 commercial CCUS projects as of 2021. In comparison, the United States has 56 projects, and China has three.

— **Smart grids.** Looking at the top 20 players in total patents filed, the United States accounts for 3,200 patents, a share of 44 percent. China has 1,200 patents, or 22 percent of the total, and Europe has 850 patents, or 12 percent. US-based Qualcomm leads patenting in this area with 2,500 patents, or 34 percent of the global total.[222]

— **Next-generation batteries.** Looking at the top 50 innovative companies in funding since creation, the United States is far ahead, with $19.1 billion investment and 26 companies. Europe has about one-third of these figures, with $7.0 billion investment and 17 companies.[223] China is lower still, with about $3.0 billion.[224] However, funding is highly concentrated in the largest battery manufacturers. Europe's major player, Northvolt, had accumulated investment of $6.5 billion as of May 2022 by developing the world's first low-carbon battery at scale.[225]

---

215 OECD.
216 "Climate tech investment grows at five times the venture capital market rate over seven years," PwC Global, September 23, 2020.
217 Jules Besnainou and Lucy Chatburn, *Seizing the EU's man on the moon moment*, Cleantech Group, 2021; James Thorne, "China's VC giants take aim at climate tech," PitchBook, December 1, 2021; and Leah Hodgson, "Hot or not: Where European VC funding went in 2020," PitchBook, December 24, 2020.
218 *Energy technology RD&D budgets: Overview*, IEA, May 2022.
219 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021; and Jason Deign, "10 countries moving toward a green hydrogen economy," Greentech Media, October 14, 2019.
220 *The global fusion industry in 2021*, Fusion Industry Association.
221 *Global status of CCS 2021: CCS accelerating to net zero*, Global CCS Institute, 2021.
222 "The biggest owners of patents, SEPS and standard contributions for smart energy technology," IAM, August 2021.
223 "Top 84 startups, developing energy-efficient batteries, Energy Startups, January 2022.
224 Chris Randall, "SVOLT raises €833 million in financing round," electrive.com, December 13, 2021.
225 "Top 84 startups, developing energy-efficient batteries," Energy Startups, January 2022.

- **LDES.** The first two unicorns in this field are US companies: ESS Inc. and Form Energy. Their market capitalization is already ten times that of their European counterparts.[226] A gravity storage US startup, Energy Vault, was listed on the New York Stock Exchange and had already attained unicorn status as of early 2022.[227] However, European startups have strengthened their presence on the LDES Council launched at the COP26 climate summit in fall 2021. Currently, 16 European startups are taking part in the council, up from only six at its inception. In North America, 11 startups are part of the LDES Council, compared with nine in 2021.
- **Hydrogen.** Between 2019 and mid-2021, Europe attracted 46 percent of global early-stage venture capital for hydrogen-related startups, compared with 36 percent for the United States.

Production

Europe leads in hydrogen production and is second to China in production of the other most important cleantech categories. China is also the major producer of the raw materials required in the cleantech supply chain. Looking in turn at the major cleantech categories:

3

European wind power manufacturers in 2020 top ten vs 6 in China and 1 in the United States

- **Solar.** China has seven of the ten leading module players in solar manufacturing.[228] China built 70 percent of the world's solar photovoltaics in 2019.[229] Seven Chinese manufacturers account for more than three-quarters of the revenue of the top ten players.[230]
- **Wind.** Of the top ten wind power manufacturers in 2020, six were Chinese, three European, and one based in the United States. Looking at the total installed capacity of those players, China accounted for 46 percent, Europe 40 percent, and the United States 14 percent.[231] China represents 57 percent of the revenue of the top ten players, and Europe 43 percent.[232] China started to overtake Europe on wind power manufacturing by the end of 2015.[233]
- **Hydrogen.** Europe has three of the top seven H2 players. The top manufacturers are Linde Group (Europe), Air Liquide (Europe), Air Products (United States), Air Water (Japan), Taiyo Nippon Sanso (Japan), Messer Group (Europe), and Yingde Gases (China). The market is highly fragmented, with the top five manufacturers holding only a 5 percent share of the market.[234]
- **Nuclear fission.** While there are debates on whether nuclear fission is categorized within cleantech, as of February 2022, the EU Commission approved in principle a Complementary Climate Delegated Act including, under strict conditions, specific nuclear and gas energy activities in the list of economic activities covered by the EU taxonomy. [235] The United States accounted for 42 percent of the revenue of the top ten players in 2020. China had 26 percent, and Europe less than 5 percent.[236]
- **Hydropower.** Europe and the United States each have three of the world's top ten manufacturers.[237]
- **Energy storage (batteries).** In 2019, China produced 73 percent of the worlds lithium-ion batteries, the United States 10 percent, and Europe 6 percent. But Europe's aggressive investment and policies could boost its position. Forecasts for 2029 suggest that Europe could capture 16 percent of production, while China is seen as continuing to dominate with 70 percent, and the United States maintaining a share of 9 percent. Between April

226 Capital IQ.
227 Andy Colthorpe, "Gravity storage startup Energy Vault gets New York Stock Exchange listing," Energy Storage News, February 14, 2022.
228 McKinsey Sustainability Practice.
229 Sarah Ladislaw and Nikos Tsafos, "Beijing is winning the clean energy race," *Foreign Policy*, October 2020.
230 Capital IQ.
231 *Global wind report 2019*, Global Wind Energy Council, 2019.
232 Capital IQ.
233 Alex Pashley, "China overtakes EU to become global wind power leader," *Guardian*, February 11, 2016.
234 *Hydrogen market 2021 overview by industry size, market share, future trends, growth factors and leading players research report analysis by report Ocean*, Market Watch, December 23, 2021.
235 "EU taxonomy for sustainable activities," European Commission.
236 Capital IQ.
237 Ibid.

2019 and April 2020, China installed 46 new mega factories, Europe installed six, and the United States four. China accounts for more than 80 percent of some steps of the battery manufacturing process.[238]

Besides manufacturing, China has sprinted ahead of the US and Europe to dominate other key links of the cleantech supply chain, including raw materials and energy storage. China accounts for large shares of several key inputs needed for solar panels, batteries, and other green tech, including chemical lithium (50 percent of global production), polysilicon (60 percent), rare earth metals (70 percent), natural graphite (70 percent), cobalt refining (80 percent), and rare earths refining (90 percent). The United States imports 40 percent of its lithium, 80 percent of its cobalt, and 100 percent of its graphite.[239] In Europe, 70 to 80 percent of the nickel, lithium, and cobalt required for batteries and electrical installations is imported.[240] Through the Renewable Energy Directive (RED II), Europe aims to have renewable energy increase to 32 percent in its energy mix by 2030; it may need to increase imports of these composites to achieve that goal.[241]

50%

of installed electricity from renewables in Europe vs 41% in China and 25% in the United States

Adoption

Europe had the highest share of renewables in its overall energy mix in 2020, with 50 percent of its installed electricity capacity coming from renewables; China's share was 41 percent, and the US share was 25 percent. In total electricity produced, China leads with 1.7 terawatt-hours, with Europe at 1.2, and the United States at 0.6. In per capita terms, Europe had 2.3 gigawatt-hours per million while China had 1.2.[242]

Looking at public and private capital expenditures on the deployment of low-carbon technology, Europe led in 2020 by investing $166 billion into the energy transition (that is, renewables, energy storage, electric vehicles and heating, hydrogen, and carbon capture and storage). China was second with $135 billion, and the United States third with $85 billion. Within Europe, the top five countries on private and public investment are Germany ($39 billion), the United Kingdom ($26 billion), France ($20 billion), the Netherlands ($19 billion), and Spain ($13 billion).[243] Looking at the individual types of cleantech:

— **Solar.** In 2020, China had the highest installed capacity, with 34 percent of the world's solar PV capacity, having added 50 gigawatts in 2019. Europe had 24 percent, and the United States 11 percent. Europe leads on installed capacity per capita, with 295 watts per capita, versus 147 watts in China.[244]

— **Wind.** In 2020, China had the highest installed capacity, with 38 percent of the global total, and it is adding 20 gigawatts a year. Europe had 28 percent, and the United States 19 percent.[245]

— **Hydro.** In 2020, China had 28 percent of global capacity installed, Europe 17 percent, and the United States 8 percent.[246]

— **Nuclear.** In 2020, Europe led with 117 gigawatts (of which 61 gigawatts were in France), which was 29 percent of the world's total installed capacity. The United States had 96 gigawatts installed or 24 percent of the total, and China 50 gigawatts or 13 percent.[247]

— **Electric vehicles.** Until recently, China had the largest EV market, with 1.2 million vehicles out of the global total of 2.3 million, and vehicles were largely supplied by domestic players. However, Europe caught up and moved marginally ahead of China in 2020; its EV

238 "Written testimony of Simon Moores, Managing Director, Benchmark Mineral Intelligence," Benchmark Mineral Intelligence, June 24, 2020.
239 Graham Allison et al., *The great tech rivalry: China vs the U.S.,* Harvard Kennedy School Belfer Center for Science and International Affairs, December 2021.
240 "Lithium, cobalt, nickel: Europe will be forced to import 70% of its mineral needs," Trends, January 1, 2022.
241 "Renewable energy—recast to 2030 (RED II)," EU Science Hub, European Commission.
242 *Renewable capacity statistics 2021*, International Renewable Energy Agency, March 2021.
243 *Energy transition investment trends*, Bloomberg NEF, 2021.
244 *Renewable capacity statistics 2021*, International Renewable Energy Agency, March 2021.
245 Ibid.
246 Ibid.
247 Ibid.

market grew at a compound annual rate of 180 percent, with supply largely coming from players within the region.[248]

— **Hydrogen.** Europe is the world's largest market, representing 35 percent of the global total, while China accounts for 30 percent and the United States less than 30 percent.[249] China and Europe each invested about $2 billion in 2020; the United States invested $150 million.[250] On R&D investment, China leads with about $600 million in 2020.[251] The Europe 30 invested $390 million, and the United States $170 million in that year.[252]

Europe's lagging position on all but two out of the ten transversal technologies identified as being pivotal for performance across sectors leaves companies competitively vulnerable—even in sectors in which the region has traditionally had strongholds. In the next chapter, we look at some potential ideas that European political, regulatory, and business decision makers might consider in order to enable corporations in the region to up their scale and speed and thereby level the playing field with their counterparts in other major economies.

---

248 McKinsey Electric Vehicle Index 2021.
249 *Hydrogen generation market 2021 overview by industry size, market share, future trends, growth factors and leading players research report analysis by report Ocean*, Market Watch, December 23, 2021.
250 *Road map to a US hydrogen economy*, Fuel Cell and Hydrogen Energy Association, October 2020.
251 *China's hydrogen industrial strategy*, Center for Strategic and International Studies, February 2022.
252 *Energy technology RD&D budgets: Overview*, International Energy Agency, October 2021.

Until recently, China had the largest EV market, with 1.2 million vehicles out of the global total of 2.3 million, and vehicles were largely supplied by domestic players. However, Europe caught up and moved marginally ahead of China in 2020.

5. A range of impediments stand in the way of progress

Europe needs to address a range of impediments that may prevent it from competing in the face of increasing disruption and winner-takes-most dynamics. They include broad and complex issues such as inflexible labor markets, lagging digital infrastructure, and a suboptimal environment for attracting tech and entrepreneurial talent, among others. From a wide range of challenges, four stand out: fragmentation leading to lack of scale, a lack of established technology ecosystems, less developed risk-capital funding, and a regulatory environment that could be more supportive of disruption and innovation (Exhibit 53).

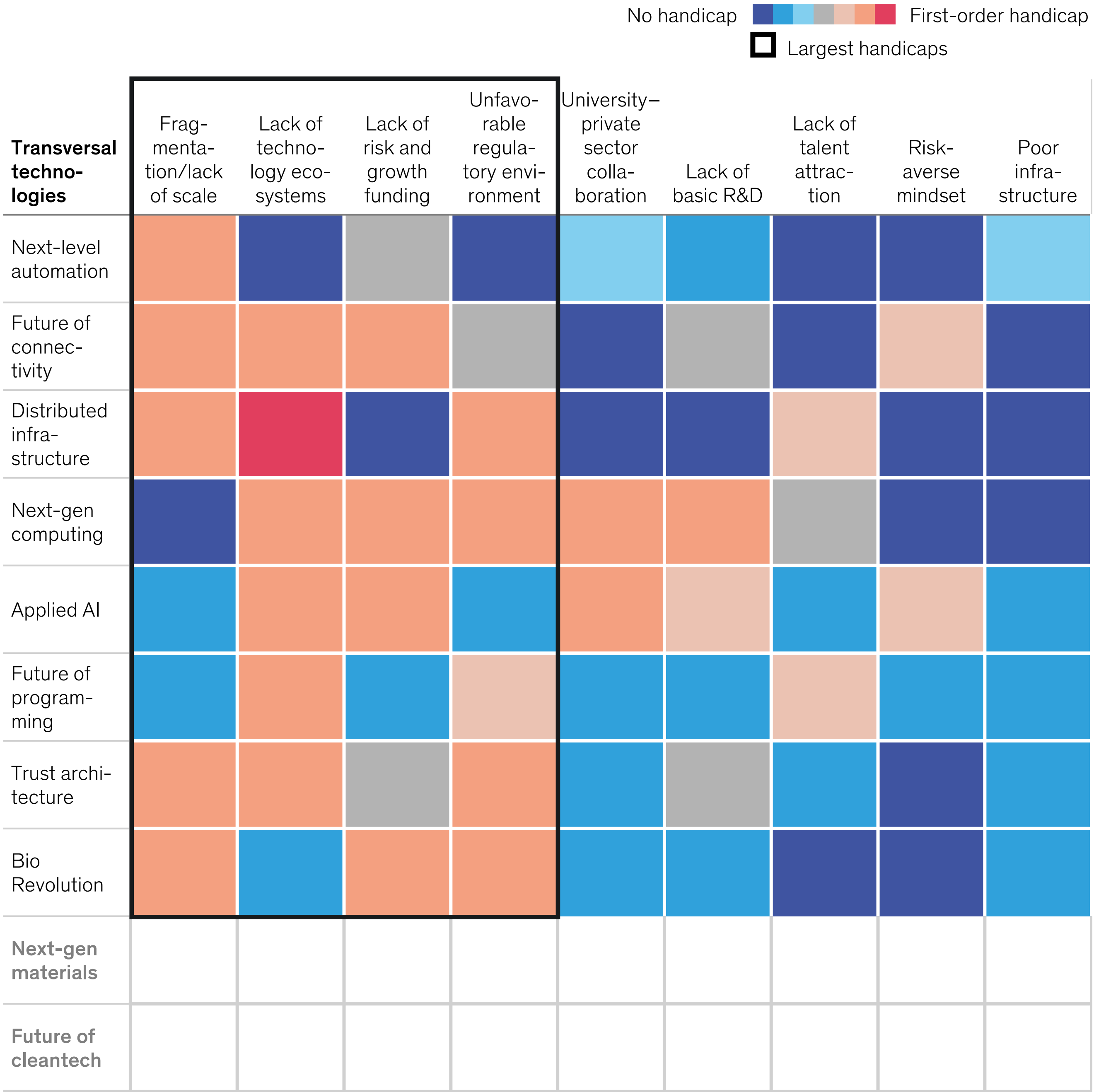
These four impediments feed through to others, overall making Europe a less appealing environment to start new companies and attract tech and entrepreneurial talent. Fragmentation and a lack of scale-up capital compromise European companies' operations. A relative lack of developed and dynamic tech ecosystems contributes to the absence of a level playing field for European corporates. Regulation needs to be tailored in such a way as enabled rapid decision making, agility, and innovation. Other impediments seem to be consequences of these four rather than root causes. Take entrepreneurial talent as an example. If Europe were to fix its scale, venture capital, and ecosystems gaps as well as the regulatory approach, there is a high chance that this talent would seek and find opportunities in Europe rather than elsewhere. All the impediments that we look at in this chapter reinforce one another. For instance, if venture capital is insufficient, it is less likely that ecosystems can develop, and vice versa.[253]

[253] Bill Butcher, "The art of picking winners," *Financial Times*, February 5, 2022.

From a wide range of challenges, four stand out: fragmentation leading to lack of scale, a lack of established technology ecosystems, less developed risk-capital funding, and a regulatory environment that could be more supportive of disruption and innovation.

Exhibit 53

As economies of scale and scope become more important, Europe's fragmentation and lack of tech ecosystems become critical.



Source: McKinsey Global Institute analysis

Fragmentation and lack of scale

Europe has a similar GDP to that of the United States but is at a structural disadvantage in scale because of fragmentation. The EU alone has 27 countries with 24 official languages, and differences in laws and regulations (although they are converging), culture, consumer behavior, and even distribution and marketing channels among them. Consider that a European startup can address a market similar to the size of the continental United States only by accessing all 27 member countries that belong to the Single Market—but an incomplete Single Market with a range of regulatory approaches (Exhibit 54). Companies scaling up in Europe cite a lack of regulatory harmonization as the second most important barrier for growth.[254]

The fragmented European value pool means that the region's startups are forced to internationalize earlier in their journey—with all the effort that entails. About 70 percent of European unicorns have established a global or partly global geographic footprint to reach unicorn status, compared with 50 percent of US unicorns.[255] In itself, early internationalization is positive; what is less positive is that European companies are scaling more slowly and often in the United States before they return to Europe.

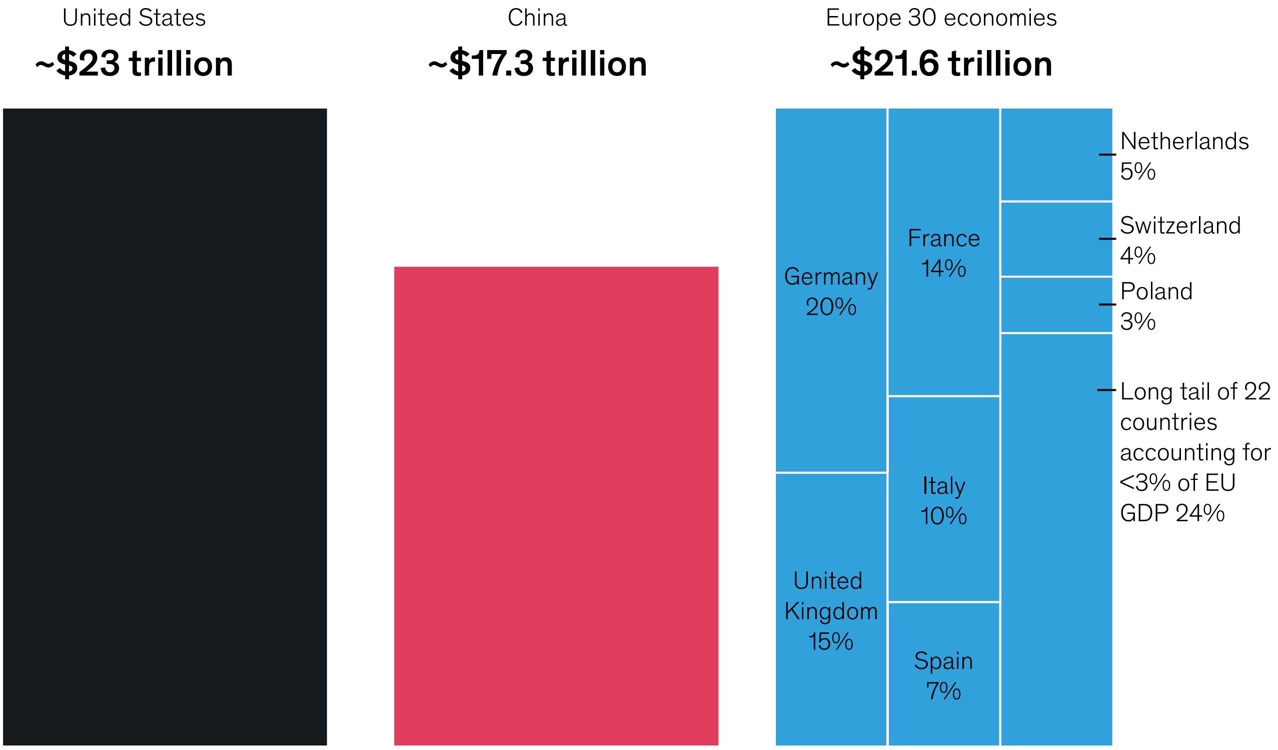
---

[254] Ibid.
[255] "Europe's start-up ecosystem: Heating up, but still facing challenges," McKinsey & Company, October 11, 2020.

Exhibit 54

European companies have smaller domestic markets than American and Chinese peers.

GDP, current $, 2021



Note: Figures may not sum to 100% because of rounding.
Source: World Bank; Eurostat 2021; IHS Markit; McKinsey Global Institute analysis

In AI, the fragmentation of the digital market in EU member states makes it more difficult to create large, integrated data sets for training AI models.[256] In the United States, the collection and management of data are concentrated in a few big technology companies. The scale of China's technology ecosystem is anchored on tech giants such as Alibaba, Baidu, and Tencent, and the fact that more than 70 percent of Chinese consumers are omnichannel shoppers who generate an explosion of consumer data. According to Ericsson estimates, China's data traffic may grow by 25 percent per year between 2021 and 2027, enabling it to maintain its position as the world's largest source of consumer data.[257] Chinese citizens shared more data than those in those in other countries—45 percent versus 25 to 35 percent in the United States and Western Europe, according to one survey—if that means they obtain choice, tailored products and services, and higher quality.[258] The availability and scale of data sets are essential for training AI systems where products and services are rapidly moving from pattern recognition and insight generation to more sophisticated forecasting techniques requiring extensive databases.[259]

In the case of trust architecture, cybersecurity governance models differ among EU member states, and even within them, the responsibility for cybersecurity is often divided among many entities. These differences may make cooperation in responding to cross-border incidents and exchanging intelligence on potential threats more difficult even at the national level (let alone the European level).[260] Analysis of national audit offices by the European Court of Auditors revealed that weaknesses in public authorities' governance arrangements and risk management were perceived as the highest risks.[261]

As for the Bio Revolution, the fragmentation of the European market is a key challenge. The marked differences among countries' healthcare systems create multiple paths to innovation and financing for companies.[262] In funding, for instance, the pool of public and private capital for biological innovation is expanding in Europe, but Europe's investor base is dispersed. Between 2018 and 2020, 47 percent of the early-stage venture funding raised by European biotech companies was from investors in their home country, compared with 25 percent from European investors outside of the home market, which is nearly on a par with the share of US investors (21 percent).[263] The fact that so much of such funding is raised in local markets in Europe, and those local markets are, by definition, relatively small compared with, say, the entirety of the United States, goes some way to explain Europe's scale-up funding gap.

Lack of established technology ecosystems

37

European decacorns in July 2021 vs 134 in the United States

Technology ecosystems matter for several reasons. First, much innovation is now concentrated in digital, and the presence of large firms with large data sets and a larger network of users is needed to roll out innovation rapidly. Notably, examining the top ten tech companies in each of the United States and Europe by spending on R&D, the US top ten spends about four times the amount (Exhibit 55).

Second, there is a strong feedback loop: the most successful ecosystems and firms are those that attract an ever-greater share of global talent and capital, making them yet more successful. Third, a high share of founders has previously learned the ropes in the most successful large firms, and they bring some of the founding capital from the stock options they were given.

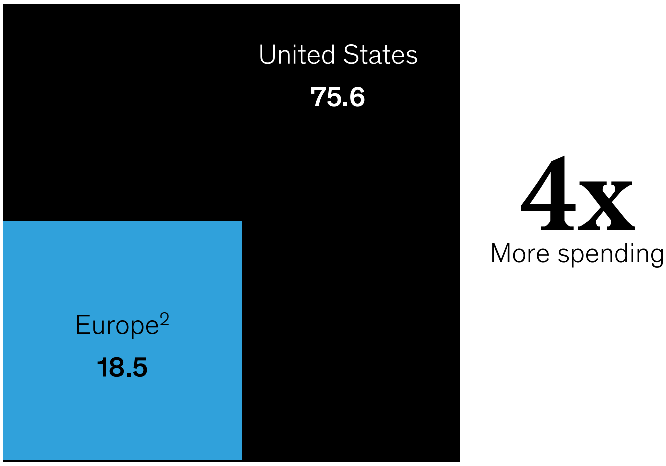
Europe does have impressive ecosystems, including Germany's Mittelstand, the Paris-Region competitiveness cluster, and the pharma-biotech Golden Triangle between London, Oxford, and Cambridge. However, Europe is far from matching the United States and other

256 *Artificial intelligence, blockchain, and the future of Europe: How disruptive technologies create opportunities for a green and digital economy*, European Commission and European Investment Bank, June 2021.
257 *Ericsson mobility report*, Ericsson, November 2021.
258 *Five consumer trends shaping the next decade of growth in China*, McKinsey & Company, November 2021.
259 Ibid.
260 *Challenges to effective EU cybersecurity policy*, European Court of Auditors, March 2019.
261 Ibid.
262 Frank Le Deu and Jorge Santos da Silva, "Biotech in Europe: A strong foundation for growth an innovation," McKinsey & Company, August 2019.
263 *Innovation hotspots to drive the next act in Europe*, McKinsey & Company and Bio€uity Europe, May 2021.

Exhibit 55

Top ten US tech companies spend four times more than Europe's top ten.

R&D spending of top 10 US and European tech companies by R&D spending,[1] 2018, € million



1. Top ten largest spenders on R&D in the Global 2,500, 2018; tech refers to software and technology equipment sectors.
2. Europe: EU + Switzerland + United Kingdom.

Source: EU Industrial R&D Investment Scoreboard, 2018; McKinsey Global Institute analysis

economies on technology ecosystems, particularly in ICT (Exhibit 56). Europe lacks first-wave technological companies, with only 37 "decacorns" (private venture-backed companies valued at more than $10 billion) as of July 2021. There are 134 in the United States. This disparity that may now turn into a disadvantage for Europe in future battlegrounds.[264] Europe has no cluster at the level of China's Shenzhen or, in the United States, Silicon Valley and the cluster around Boston and Cambridge, Massachusetts, home to the Massachusetts Institute of Technology. According to a ranking of the world's largest clusters of inventive activity based on patent filings, Paris is the only European center in the top ten, ranked tenth.[265]

Yet because of path dependency, a gap in technologically capable firms and ecosystems will now make it harder to keep pace in the future.

In the case of trust architecture, for instance, Europe's lagging position on 5G, and its dependence on China for 5G infrastructure, leaves it vulnerable. These shortcomings in connectivity affect Europe's global public cloud market and data control. In 2020, the top five IaaS providers (Amazon, Microsoft, Alibaba, Google, and Huawei) accounted for 80 percent of the cloud market, which is valued at $64 billion.[266]

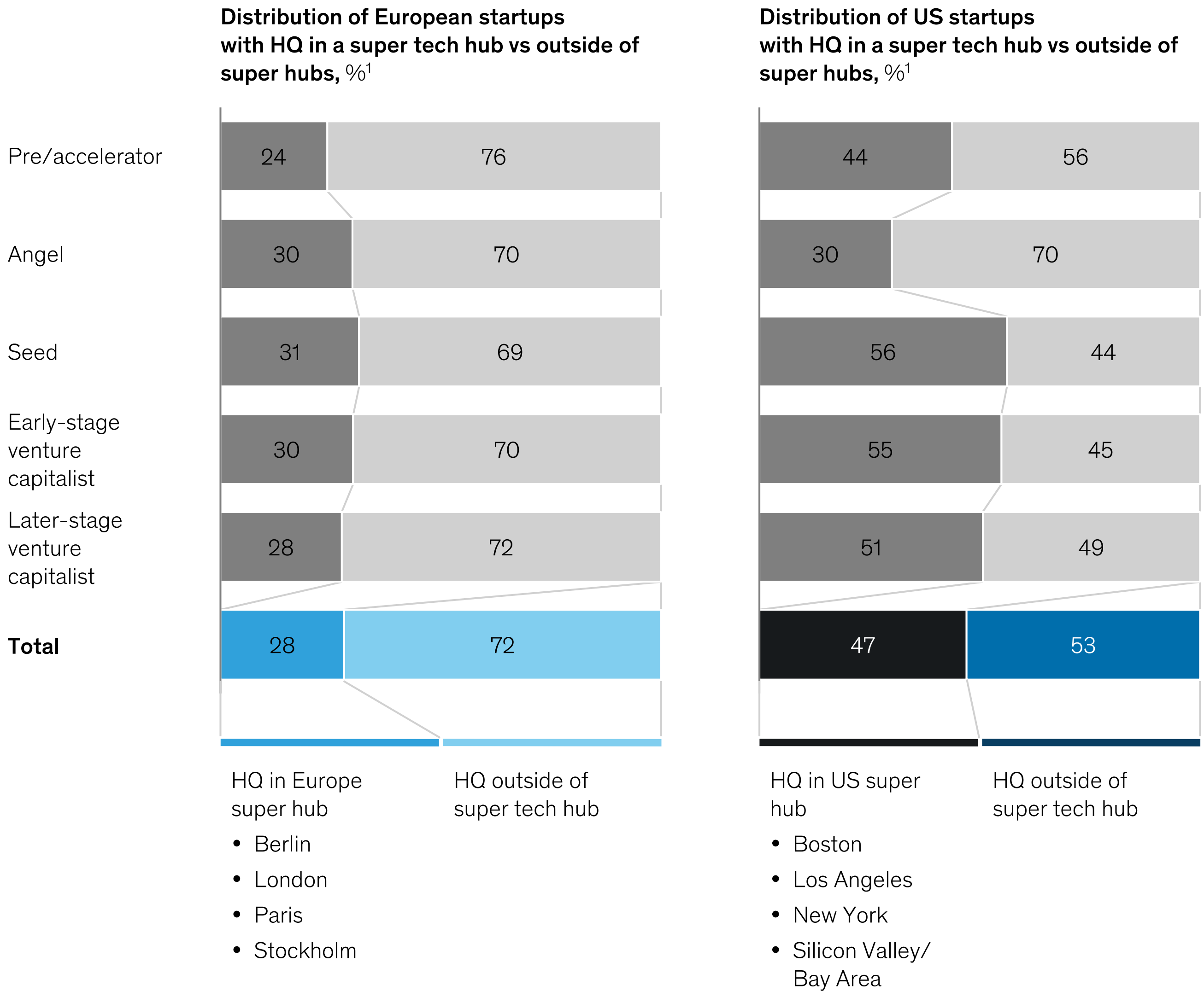
Fifty-six percent of global private corporate investment in AI ($24 billion) was in the United States, largely accounted for by a few US tech giants.[267] Europe's lack of tech companies of comparable scale explains why it lags on AI funding. The EU, the European Investment Fund, and the European Investment Bank are launching new investments to support AI in the EU, but these efforts may not be sufficient to overcome path dependency and relatively weak ecosystems.

Path dependency is also relevant in next-generation computing and the future of programming. On the first, a large share of private investment is taking place in-house at large US tech giants with funding totaling $1 billion, four times that in Europe.

[264] Orla Browne, *The rise of the European decacorns*, Dealroom, July 2021.
[265] The cluster around Tokyo-Yokohama ranks first, followed by Shenzhen–Hong Kong, San Jose–San Francisco, and Seoul. See Kyle Bergquist, Carsten Fink, and Julio Raffo, *Identifying and ranking the world's largest clusters of inventive activity*, economic research working paper number 34, World Intellectual Property Organization, May 2017.
[266] "Gartner says worldwide IaaS public cloud services market grew 40.7% in 2020," Gartner, June 28, 2021.
[267] Statista.

Exhibit 56

Startups in Europe are less concentrated around top tech hubs than those in the United States.



1. Active venture capital–backed companies that raised any venture capital round since January 1, 2017.
Source: PitchBook; McKinsey Global Institute analysis

3 largest US biotech funds

2x

as large as European counterparts

Less developed risk-capital funding

Europe has a more conservative capital market structure and a lack of angel investor money from successful founders that links back to its lack of established technology ecosystems. European firms thus have less ample access to risk capital and venture capital. Historically, Europe has devoted much less to venture capital funding than the United States—3.4 times less in 2019 and 2.8 times less in 2021. In 2021, Crunchbase data show, the United States attracted 47 percent of global venture capital funds invested, Europe 17 percent, and China 12 percent. However, the gap between Europe and the United States narrowed to 2.8 times in 2021. Europe remained ahead of China. In 2021 in the United States, venture capital funding totaled $300 billion. China's figure was $131 billion and Europe's $103 billion (for the EU-27, Switzerland, and the United Kingdom).[268]

[268] See Jessica Hamlin, "U.S. venture capital shattered records in 2021," *Institutional Investor*, January 6, 2022; Leah Hodgson, "Hot or not: Where European VC funding went in 2021," PitchBook, January 4, 2022; and Coco Liu, "China venture funding hits record $131 billion despite crackdown," Bloomberg, January 9, 2022.

There are several reasons for this.

— **Late to the game.** While the first US venture capital firm was established in 1946, Europe did not enter the venture capital sector until the 1990s.

— **Less government support.** Academic research has found a positive correlation between public venture capital and private capital investment.[269] Historically, the total number and average annual budget of distinct equity entrepreneurial finance policies in Europe was on a par with those of the United States.[270] Yet the United States has invested largely in early-stage applied research projects in other financing schemes, notably though the US Defense Advanced Research Projects Agency (DARPA), which funded the research that created, for instance, the internet and the microchip.[271] Public support for venture projects and capital has started ramping up in Europe through the 2018 Venture EU megafund and a range of innovation programs, but these efforts still need to scale up to match current investment needs.

— **More active US stock market.** The United States has a more active stock market, and this enables and encourages US venture capital activity. Indeed, many European startups look to international investors for their late-stage funding rounds and go to the US market. Ninety-five percent of all deals of $250 million and above involve US or Asian investors.

— **Regulatory environment.** Across Europe (except for Sweden), current regulation has a high bar for pension funds to invest in illiquid alternative assets. Pension funds account for an annual average 8 percent of total venture capital fundraising in Europe, compared with 20 percent in the United States. European pension funds have $3 trillion in assets under management but less than 0.02 percent invested, so there is potential for any increase to have a large impact. Europe also lacks the large university endowments that commonly invest in new ventures in the United States. The lack of depth in capital markets has an impact on Europe's progress on the Bio Revolution. McKinsey's Biotech Innovation Index shows that Europe's main challenge is to transform its research powerhouses into newly funded biotechs.[272] This also reflects a lack of funding—early stage, total, IPOs, and mutual funds. Early-stage funding has been growing but is still materially below the levels in the United States and China, and the gap is widening. Total funding is lower for EU biotechs than for their US and Chinese counterparts, although Europe is catching up, with series E rounds and average value of large (more than $100 million) late-stage funding similar to those in both other regions. Similarly, the mean IPO size for EU biotechs was four to five times larger on US exchanges than on European exchanges. Investment funds in Europe are maturing, but they still lag behind those in the United States. The three largest biotech funds in the United States are twice as large as their European counterparts.

Regulatory environment and disruptive innovation

Despite an abundance of anecdotes about EU overregulation, from the curvature of bananas to flying empty planes to maintain airport slots, the Single Market has been an extremely successful driver of smarter regulation and competition, in particular product-market regulation. There, Europe scores higher on the OECD index than the United States and China, with a score of 1.4 versus 1.7 and 3.0 (where 0 is high and 6 is low), respectively. Also, against conventional wisdom, the degree of precaution in US and European risk regulation is similar.[273]

In some instances, however, the EU is more precautionary—and slower—in its approach than the United States.

[269] Mariana Mazzucato, *The entrepreneurial state: Debunking public vs. private sector myths*, Anthem Press, 2013; Jessica Bai et al., *The dance between government and private investors: Public entrepreneurial finance around the globe*, NBER working paper number 22844, May 2021.
[270] Includes only national programs and thus omits EU initiatives; Jessica Bai et al., *The dance between government and private investors: Public entrepreneurial finance around the globe*, NBER working paper number 22844, May 2021.
[271] Mariana Mazzucato, *The entrepreneurial state: Debunking public vs. private sector myths,* Anthem Press, 2013.
[272] *Innovation hotspots to drive the next act in Europe*, McKinsey & Company and Bio€uity Europe, May 2021.
[273] Jonathan B. Wiener et al., eds., *The reality of precaution: Comparing risk regulation in the US and Europe*, Routledge, 2014.

- **Autonomous vehicles.** Since 2018, China has established standards to authorize L4 test AVs to circulate. Beijing and Shenzhen have authorized L4 autonomous taxi services. In the United States, California approved circulation of test AVs. Waymo, based in Silicon Valley, is the leading L4 AV player by kilometers tested, with close to 55 percent of the global total. In Europe, regionwide common legislation on L4 AVs is absent. Germany and the United Kingdom are closest to putting legislation forward to allow L4 AVs only in very restricted test areas and under strict conditions.

- **Blockchain.** China was the first major region to take proactive steps toward blockchain regulation, with the aim of being the world leader. In 2016, its Ministry of Industry and Information Technology led the preparation of a legal policy research report on blockchain in finance. EU regulation is being planned but has not yet been ratified. In March 2022, the European Parliament decided to enter into negotiations with EU governments on the final shape of a bill formalizing new rules.[274] In the United States, the president issued an executive order in March 2022 that requires various government agencies to produce papers on a range of regulatory questions as a stepping-stone toward regulation.[275] Regulation needs to be smart to be effective. The US regulatory framework on cryptocurrencies has striven to find a balance between policy objectives such as financial stability and consumer protection and enabling innovation.

- **Biotech.** In 2015, the European Commission gave EU member states the ability to opt out of growing genetically modified food products; 19 out of the (then) 27 member states chose to ban them, while they are widespread in other countries.[276] Measured by land used, the leading producers are the United States, Brazil, Argentina, and Canada.[277] Approaches to the sharing of genomic data differ, too. The EU's General Data Protection Regulation (GDPR) has special provisions for the careful guarding of such data. The United States treats genomic data in the same way as health data.[278] The EU also takes a more precautionary approach than the United States to regulation of alien invasive species.[279] In turn, the EU was the first region in the world to define a policy and legal framework for the approval of biosimilar medicines; the first biosimilar was approved in 2006, nearly a decade before the first one was approved in the United States.[280]

- **Distributed infrastructure.** Europe's lagging position on adoption may reflect relatively tight regulation of data security and privacy in the region, among other factors, including decreasing the speed of integration of services, especially in banking and healthcare.[281] Europe's regulation may hinder companies' adoption of cloud and edge services as a significant part of their IT infrastructure. This may limit the ability of local players to scale quickly and to compete with market leaders.

- **Applied AI.** A European Digital Single Market has yet to be fully developed and Europe has chosen to have stronger rules to protect privacy, including the GDPR. In a 2020 survey conducted by the European Commission, firms in the EU said that a lack of internal data and insufficient access to public and private data sets stood in the way of their adoption of AI.[282] AI, machine learning, and deep learning tools such as recommendation engines and search algorithms need extensive data pools. The data issue therefore also has an impact on the future of programming.

274 "Cryptocurrencies in the EU: New rules to boost benefits and curb threats," European Parliament, March 15, 2022.
275 Katie Rogers and Ephrat Livni, "Biden takes step toward regulating cryptocurrencies," *New York Times*, March 9, 2022.
276 Andy Coghlan, "More than half of EU officially bans genetically modified crops," *New Scientist*, October 5, 2015.
277 *Biotech crop highlights in 2017*, International Service for the Acquisition of Agri-biotech Applications, Pocket K Number 16, October 2018, updated December 2019.
278 *The Bio Revolution: Innovations transforming economies, societies, and our lives*, McKinsey Global Institute, May 2020.
279 Ronit Justo-Hanani and Tamar Dayan, "Risk regulation and precaution in Europe and the United States: The case of bioinvasion," *Policy Sciences*, Volume 54, 2021.
280 *Biosimilars in the EU: Information guide for healthcare professionals*, European Medicines Agency and the European Commission, 2019.
281 *The top trends in tech: Technology deep dive: Cloud and edge computing*, McKinsey & Company, 2021.
282 Mia Hoffmann and Laura Nurski, "What is holding back artificial intelligence adoption in Europe?" *Policy Contribution,* issue number 24/21, Bruegel, November 2021.

Overall, the EU's score on the ability of the legal framework to adapt to digital business models—as compiled by the World Economic Forum—is below that of the United States (Exhibit 57).[283]

Labor market flexibility

The EU's score on the business friendliness of labor-market regulation is 20 percent lower than that of the United States and 35 percent below China's. This is important in a period of accelerated automation and technological disruption, which implies the need for very large-scale reskilling and labor reallocation across activities and firms. Labor market rules may benefit from being reviewed to ensure that they can support faster reallocation where appropriate. Flexicurity principles that protect workers and people rather than jobs, spearheaded by Denmark and now adopted in parts of Europe, are preferable to regulations centered on higher employment protection in the period of disruption ahead.

[283] *Global competitiveness report 2019*, World Economic Forum, October 2019.

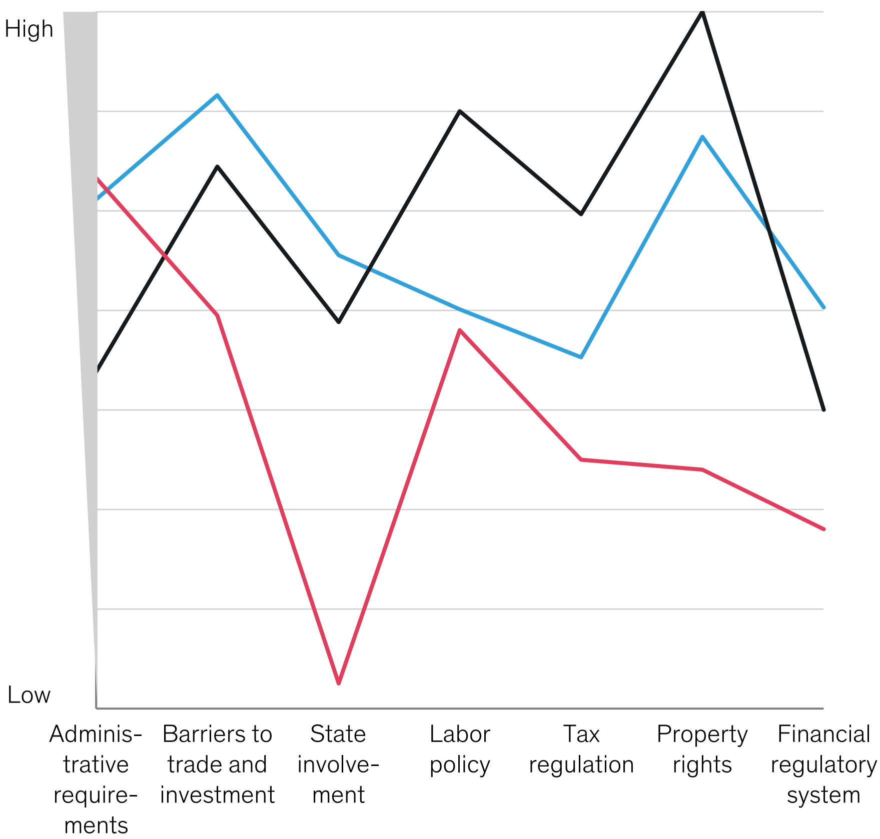
Exhibit 57

Europe leads on product-market regulation but lags on adaptability to digital business models.

European average · United States · China

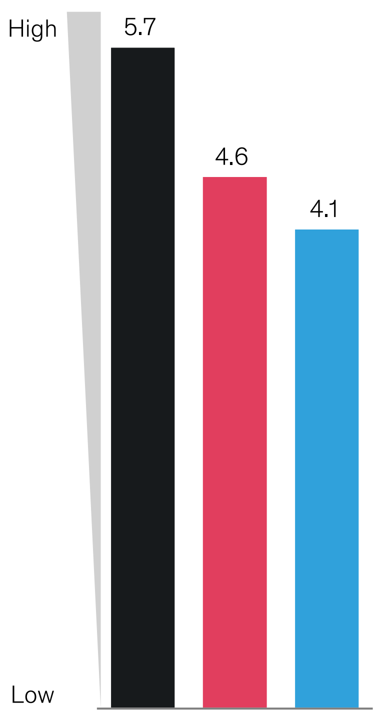
Europe is ahead of the United States on product-market regulation but behind on labor policy, tax, and property rights …

"Business friendliness" of regulatory domains



… and behind on adaptability to digital business models

Adaptability of the legal framework to new digital business models[1]



1. *Global competitiveness report 2019*, World Economic Forum, October 2019.

Source: OECD 2018; EIU 2020; World Economic Forum; McKinsey Global Institute analysis

Translation of university research into commercial applications

Despite the strength of Europe's education systems, including its robust science base, translation of scientific research into commercial opportunities is relatively slow in Europe.[284] The EU has less basic-school entrepreneurial education and training than either China or the United States, according to the Global Entrepreneurship Monitor. There are also many instances of effective collaboration between companies and academia in Europe. Nevertheless, there is less translation of university research into commercial applications and less entrepreneurism. One metric worth noting is that 12 percent of company founders in Europe have a PhD; it is 31 percent in the United States. EU startups tend to be run by academics with less industry experience than their US counterparts.[285] R&D in next-generation materials is lower in Europe than in other major regions, and there is less collaboration between universities and the private sector.

In the European biotech sector, as with other technologies, the translation of scientific research into commercial opportunities has tended to be slower and less extensive than in other major economies, partly reflecting the fact that much of the funding for academic research tends to be independent of how the research is applied in the market. Furthermore, academic regulations in Europe pertaining to academics taking equity stakes in companies, for instance, can be restrictive than in the United States.[286] To bridge this gap, tech transfer offices and technology licensing offices have been established at most top European research institutes and universities, but they remain small. According to the European Patent Office, more than half of them have ten or fewer employees, and only one to three employees who deal with patent commercialization.[287]

Public innovation procurement and basic R&D

$124b

public R&D investment in Europe in 2020 vs $144 billion in the United States and $55 billion in China

Basic research is the foundation for success in many horizontal industries. Europe still has strength here, but its position is weakening. In 2020, Europe invested $124 billion in public R&D, while China invested $55 billion and $144 billion was invested in the United States. Europe's investment is highly fragmented across member states.[288] Europe has relatively limited R&D funding from external sources such as state-funded private initiatives, examples being DARPA and the National Institutes of Health. Defense spending, so often a catalyst to broader innovation, has a role to play. The US government spends seven times more on defense R&D than Europe. Europe's public R&D spending stands at about 0.7 percent of GDP, on a par with the United States.

Moreover, Europe's academic research ecosystem is challenged by the increasing migration of its human capital to the United States and Japan, for instance. Among several factors explaining this phenomenon, the appeal for outside-EU academic institutions is the superior financial rewards. Average salaries of EU researchers were 37 percent lower than those in the United States.[289] Beyond remuneration, other factors behind the brain drain from Europe to other geographies include short-term fixed contracts for researchers early in their careers and attractive migration policies.[290]

---

284 *Valorisation of scientific results: Patent commercialisation scoreboard: European universities and public research organisations,* European Patent Office, November 2020.
285 *The Quantum Technology Monitor*, McKinsey & Company, September 2021.
286 Jamie Smyth, "Finance, culture, talent: Why Europe struggles to commercialise its biotech expertise," *Financial Times*, March 21, 2022.
287 *Valorisation of scientific results: Patent commercialisation scoreboard: European universities and public research organisations,* European Patent Office, November 2020.
288 Hector Hernandez Guevara et al., *The 2019 EU Industrial R&D Investment Scoreboard*, European Commission, December 18, 2019.
289 Michele Grigolo, "Shifting from academic 'brain drain' to 'brain gain' in Europe," *European Political Science*, volume 9, number 1, 2009.
290 Jawaria Khan, "European academic brain drain: A meta-synthesis," *European Journal of Education*, John Wiley & Sons Ltd, 2021.

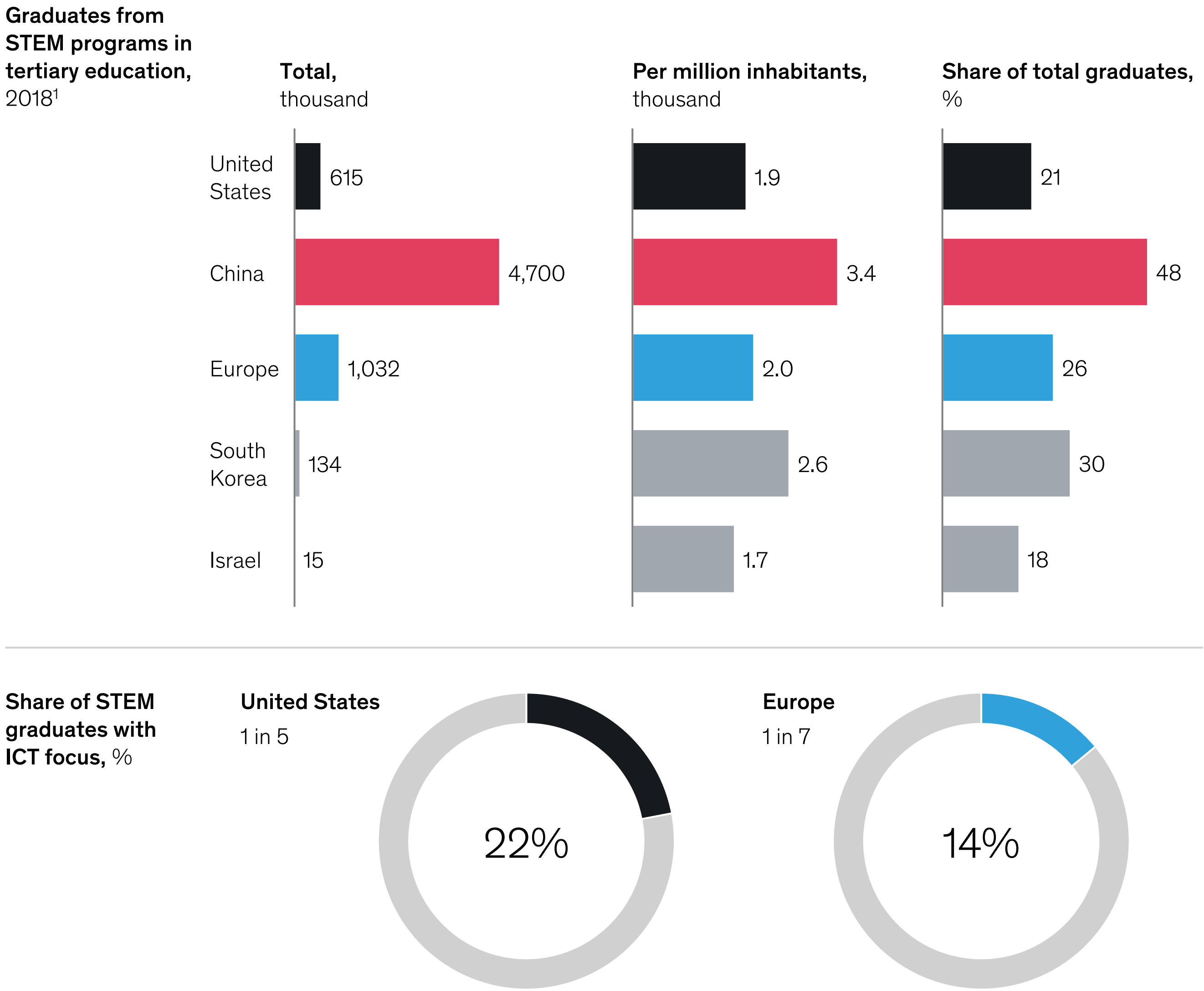
The environment for attracting tech and entrepreneurial talent

Europe's ability to attract the right talent to innovate is constrained by several factors, including the fact that it has fewer successful scale-up companies that offer high pay, a lack of stock options that act as an incentive for people with high skills as well as difficulties in using them, and immigration policies that do not focus on attracting outside tech talent and entrepreneurs.

Europe has about the same number of STEM graduates as the United States as a share of their respective populations—0.20 percent versus 0.19 percent. However, China has 0.34 percent of the total population (2016 figures) (Exhibit 58).

Exhibit 58

China has the highest rate of STEM graduates, with Europe second in absolute numbers.



1. International Standard Classification of Education, 2011, level 6–8.
2. Latest available data for China limited to 2016.

Source: OECD; National Science Board, United States; World Economic Forum; McKinsey Global Institute analysis

35%

of immigrant inventors go to Europe vs 60% to the United States

Moreover, Europe is not attracting the world's immigrant inventors, drawing about 35 percent while the United States' figure is 60 percent.[291] A contributory factor is Europe's more limited use of skills-based immigration—the number of highly skilled workers given EU "blue cards" in 2018 was nearly 80 percent lower than the number of people given employment-based immigrant visas each year in the United States.

Risk-averse mindset

Academic literature and surveys suggest that EU firms and individuals are more risk averse in business than their counterparts in the United States. A 2021 McKinsey executive survey on the future of growth found that European firms were more risk averse than their US counterparts on four out of five aspects of risk aversion.[292] The World Economic Forum found that European firms underperform their US counterparts on embracing disruptive ideas and that they have a weaker appetite for entrepreneurial risk than in either the United States or China.[293]

The World Economic Forum also found that Europeans have less of an appetite for entrepreneurial risk than individuals in the United States or China. A European Central Bank report found that risk aversion in investment decisions is more prevalent in the eurozone than in the United States, where the share of households holding risky assets is more than double the share in the eurozone.[294] In a similar vein, a Flash Eurobarometer survey conducted with Gallup in 2009 found that US respondents were more likely to prefer competition and taking risks than their European or Chinese counterparts.[295] In the United States, 16 percent of adults are entrepreneurs; in Europe, the share is only 6 percent. In the United States, 39 percent of media portrayals of entrepreneurs is positive; in Germany, that applies to only 10 percent of such coverage.

Turning to how risk aversion may be affecting Europe's position in transversal technologies, take next-generation computing as an example. Quantum technologies are deep tech, requiring specialized investors who support technologies whose technical risk is higher than their market risk. The United States outweighs the top 100 deep-tech investors in numbers and size of available budgets for emerging opportunities.[296] Given that predicted disruptions across industries through quantum computing may be almost a decade out, investors willing to support long-haul innovations with risk are required. The EU's Horizon has created a fund solely for deep tech, some venture capital players believe public funding may come with more restrictions for startups than traditional venture capital investments.

European players may also be less encouraged to take risks. Europe offers less "skin in the game" incentives such as stock option plans. Six times more employees in the United States have access to different forms of participation ownership than in the EU.[297] One study of publicly listed companies in the United Kingdom between 2000 and 2012 found that when CEOs have more equity, their companies are more likely to perform better.[298]

---

[291] Carsten Fink and Ernest Miguelez, *Measuring the international mobility of inventors: A new database*, Economic Research working paper number 8, World Intellectual Property Organization, 2013.
[292] *Getting tangible about intangibles: The future of growth and productivity?* McKinsey Global Institute, June 2021.
[293] *The global competitiveness report 2019*, World Economic Forum, 2019.
[294] *Risky assets in Europe and the US: Risk vulnerability, risk aversion and economic environment*, European Central Bank, 2019.
[295] Anna Manchin, "Entrepreneur mindset more common in U.S. than in EU, China," Gallup, October 12, 2010.
[296] *The Quantum Technology Monitor*, McKinsey & Company, September 2021.
[297] Martin J. Conyon et al., *The executive compensation controversy: A transatlantic analysis*, Cornell University Institute for Compensation Studies, January 2011.
[298] Hend Alregab, "Does CEO pay enhance a firm's performance? An empirical investigation of UK listed companies," *Proceedings of the Eighth Saudi Students Conference in the UK,* 2016.

Digital infrastructure

Europe lags behind both the United States and China on digital infrastructure, and this may have a negative impact on the productivity of firms.[299] In the United States, 92 percent of the population had access to ultra-high-speed (100 megabits) broadband in 2019. China is almost on a par with the United States with a 90 percent share; Europe is at 67 percent. Between 2012 and 2018, investment in telecommunications infrastructure was $4,955 per household in the United States, compared with $1,610 in Europe (comparative data for China are not available). In the fourth quarter of 2019, the United States had 64 5G base stations (low- and midband) per million people, China 86, and the EU eight. In the case of cloud, even within Europe US-based companies have 66 percent of the market, and European cloud providers control only 16 percent. Taking another metric, economies' dependence on satellites for navigation, imaging, and telecommunications is increasing. In 2021, the United States had 3,891 satellites in orbit, the EU 505, and China 490.[300] Due to Europe's legacy devices and systems, capital-intensive upgrades may be needed to utilize the full potential of next-level automation, enabling all devices, sensors, and machines to work as a unified system.[301]

Europe faces several challenges to address if it is to progress on innovation and scaling. Many of these have long been recognized by decision makers in the region, and the EU, the United Kingdom, and others have been acting to address them and enable companies to build scale in key technologies. In the final chapter of this report, our attention turns to what decision makers in the public and private sectors might also consider to vault the region forward—and catch up with others.

[299] Meta Ayu Kurniawati, "ICT infrastructure, innovation development and economic growth: A comparative evidence between two decades in OECD countries," *International Journal of Social Economics*, volume 48, number 1, December 2020.

[300] EU numbers include satellites from Eumetstat, ESA, and Eutelsat. US numbers include satellites from Orbcomm and O3b Networks.

[301] *The top trends in tech*, McKinsey Digital, 2021.

Europe faces several challenges that stand in the way of progressing on innovation and scaling. Many of these have long been recognized by decision makers in the region, and the EU, the United Kingdom, and others have been acting to overcome them and enable companies to build scale in key technologies.

6. Achieving scale, speed, and a level playing field

In a winner-takes-most world, European decision makers and companies will need to go after competitiveness and growth. The diagnostic offered in this report thus far suggests that European decision makers may now need to consider new stances and fresh trade-offs in order to propel corporate and tech performance forward with more scale and speed. As noted, Europe has many strengths that it can leverage, including high-quality education systems producing a large pool of STEM talent. Europe is also the most open and connected large economy, with the most sophisticated industrial fabric and supply chains. Moreover, there are signs of positive momentum on which to build, including indications that new company formation and venture capital investment are starting to pick up, and the fact that the continent has launched a flurry of initiatives designed to up Europe's game on technology and innovation.

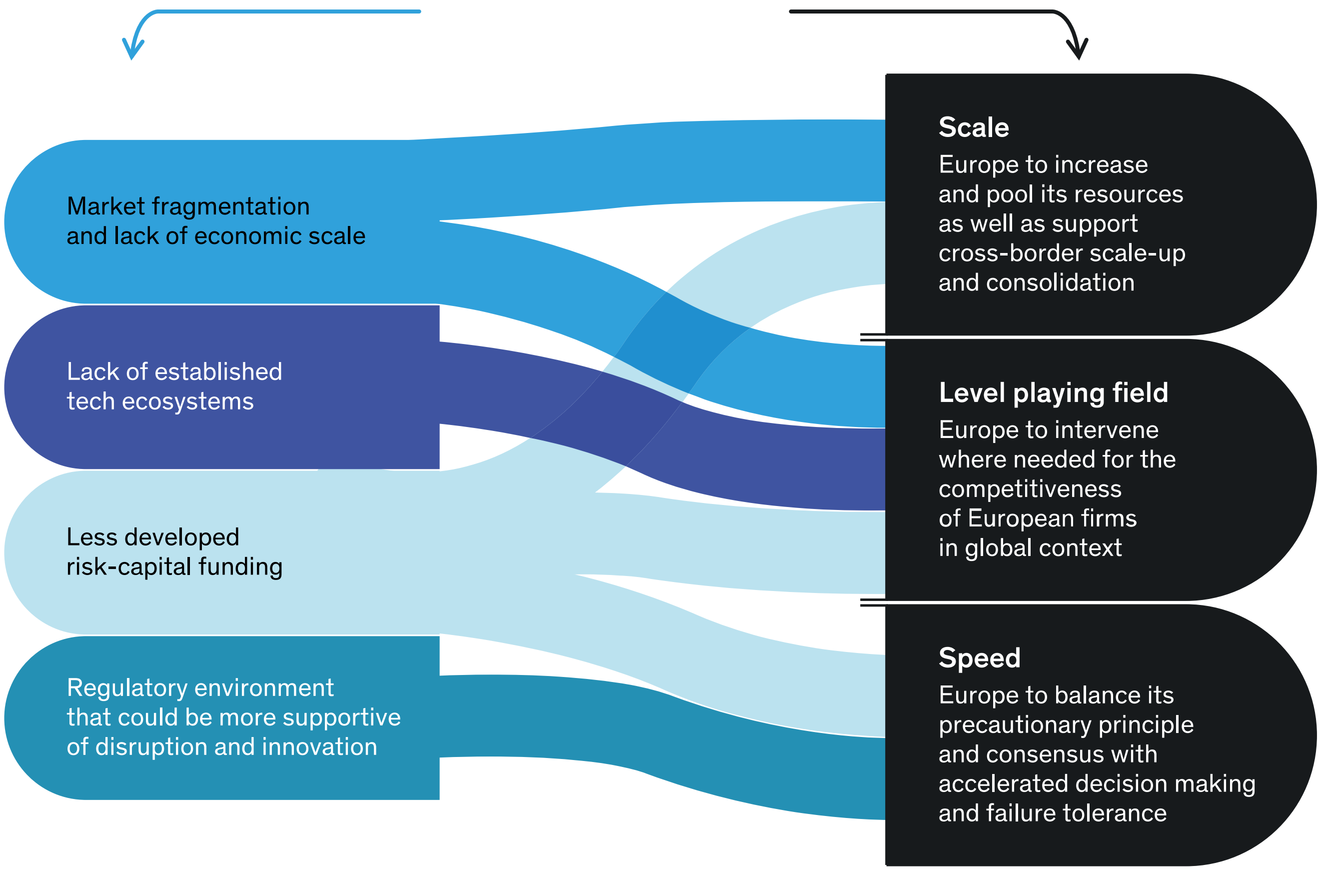
As winner-takes-most dynamics spread, Europe needs to play at greater scale and speed, and level the playing field for its firms.

As the sources of competition and growth shift toward disruptive innovation and intangibles, a winner-takes-most dynamic emerges in which scale, speed, and established tech ecosystems are increasingly vital. A changing geopolitical landscape complicates and deepens the challenge.

In this context, the challenges discussed in the previous chapter put Europe at a disadvantage (Exhibit 59). Four challenges stand out and mutually reinforce one another: market fragmentation and lack of economic scale; smaller and less established technology ecosystems and firms; less developed risk-capital and scale-up funding; and a complex and slow regulatory environment that could be more supportive of disruption and innovation. Other impediments seem to be consequences more than root causes of those four. Take entrepreneurial talent as an example. If Europe were to address its scale, venture capital, and ecosystems gaps and its regulatory approach, there is a high probability that entrepreneurs would seek and find opportunities in Europe rather than elsewhere.

Exhibit 59

Four standout challenges can be addressed through policies in three areas.



Source: McKinsey Global Institute analysis

These challenges are well known among Europe's leaders, and there is a keen appreciation for what needs to be done at the institutional level. Many initiatives are being designed and launched. In the EU, the €95 billion Horizon Europe program, the Smart Specialization initiative, and the Important Projects of Common European Interest framework are but a few recent examples.[302]

Yet if Europe wants to address its corporate performance gap and avoid a potential slow-motion crisis unfolding over the years ahead, it could usefully consider one question: does the collective total of all the initiatives under way and planned not only match the scale and impact of what leading regions are doing but exceed it, and therefore enable catch-up from today's weaker position?

The implication is not that Europe simply copies the recipes used by other regions, but that it ensures that it enables its firms to compete at scale and speed and on a more level playing field.

To help European firms to compete, Europe could reevaluate trade-offs on 11 policy and regulatory initiatives

We identify 11 initiatives as a thought starter that could form part of an integrated package to change the rules of the game for European firms, overcoming current handicaps. They would enable firms to build scale and attract scale-up funding, operate at higher speed and with greater degrees of freedom, and level the playing field with other regions and established firms. Many of those have been the topic of long-running debates and suggested trade-offs, yet this diagnostic suggests revisiting the current stance on them. We invite comments and collaboration to advance these initial ideas.

Scale and scale-up funding
In transversal technologies where scale of markets, firms, and investment matters, Europe could increase and pool its resources as well as support cross-border scale-up and consolidation. European decision makers are bringing forward many initiatives aimed at enabling corporations to build scale in key tech areas. Some of the most prominent are the following:

— **Horizon Europe.** This is the main European research funding program of €95 billion from 2021 to 2027, or €14 billion a year. The previous program (Horizon 2020) had €80 billion in funding. For comparison, the annual federal R&D budget of the United States for 2021 was $165 billion, or more than ten times larger.

— **Important Projects of Common European Interest (IPCEI).** This framework allows for a combination of private funding, EU funds, and national funding (above the normal limits for state aid) for major cross-border infrastructure or innovation projects. For instance, the Battery IPCEI pooled about €3 billion of public funding plus more than €9 billion of private funding. As of 2022, only three innovation IPCEIs are in place—two covering the battery value chain, one covering microelectronics—but several more are being proposed on health, hydrogen, cloud computing, and semiconductors. This framework has been criticized for lack of broad-based participation by small and medium-size enterprises and small member states. Only France, Germany, Italy, and Sweden have participated in more than two IPCEIs.

[302] See *Horizon Europe*, European Commission; *What Is Smart Specialisation?* European Commission; *Important projects of common European interest (IPCE)*, European Commission; and Thierry Breton, "How a European Chips Act will put Europe back in the tech race," European Commission, September 15, 2021.

— **Chips Act.** This legislation aims to mobilize €43 billion of public and private investment with the objective of having a 20 percent market share for Europe by 2030; only a small share is committed public funding. This initiative will promote R&D and production of chips in Europe with the aim of achieving meaningful scale. The US CHIPS and Science Act has a funding envelope of $52 billion, all public money.

— **Scale-up Europe.** President Emmanuel Macron of France launched this initiative in 2021 in collaboration with the European Commission and other member states. The aim is for Europe to become home to ten tech giants, each valued at more than €100 billion, by 2030.[303] The initiative centers on three areas of action: (1) funding the final stages of development of scale-ups to support the emergence of world-class businesses of the future with deep ties in Europe; (2) making Europe a magnet for tech talent; and (3) fostering the development of world-class European breakthrough innovation companies.

— **Fund of funds.** One major announcement in 2022 was the creation of a pan-European fund of funds dedicated to late-stage funding and scale-ups, with €3.5 billion of total initial funding.

— **JEDI (Joint European Disruptive Initiative).** This nonprofit private effort to create a European DARPA has received informal approval from France and Germany and has an initial budget of €50 million to €100 million—much lower than its US counterpart, which had a budget of about $3.5 billion in 2021.

Europe could further consider the following initiatives:

1. Develop a European corporate rule book or 28th regime for high-growth firms. Companies scaling up in Europe cite a lack of regulatory harmonization as the second most important barrier to growth. European startups must contend with the fact that Europe is not a single market but a collection of countries with their own languages, cultures, regulations, and governments; customer behavior varies, and distribution and marketing are more challenging. The fragmented European value pool means that the region's startups need to deal with cross-border complexity earlier in their journey, and many use the US market to scale before returning to other parts of Europe. About 70 percent of European unicorns have established a global or partly global geographic footprint to reach unicorn status, compared with 50 percent of US unicorns.[304] Within the Single Market, the streamlining of regulation has been progressing, but full harmonization of standards for taxes (including VAT or employee stock options), regulation, labor rules, and administrative processes would be all but impossible in short time frames. Europe could therefore develop an additional 28th regime (a pan-European regulatory entity alongside the 27 EU member states and affiliated countries) as a common standard on top of national ones and allow high-growth firms that opt in and comply to operate in all European countries.

[303] "Scale-up Europe spurs collective action to accelerate European tech," French Presidency of the Council of the European Union, February 7, 2022.
[304] "Europe's start-up ecosystem: Heating up, but still facing challenges," McKinsey & Company, October 2020.

2. Facilitate and encourage cross-border consolidation, including completing the Single Market, revisiting antitrust rules, and removing political obstacles. More scale also requires more cross-border consolidation of existing large firms—not only to create more global leaders but also to support the development of ecosystems of innovative B2B suppliers around them. Completing the Single Market could help. A recent survey of all European Roundtable of Industrialists members found that the completion rate of the Single Market is 75 percent.[305] More integration is needed in energy, particularly renewables and hydrogen, including for instance harmonizing taxation, removing infrastructure bottlenecks, and improving cross-border grid capacity. For instance, BASF cannot fully use its own offshore wind energy because of grid bottlenecks and lacking interconnectors and surcharges on renewable energy. Finance is another area for attention. Work still needs to be done on accelerating progress toward a capital markets union and banking union. In digital, establishing common data standards to ease data sharing across the EU member states and developing a common EU framework for the IoT, AI, and the deployment of 6G are next steps. The CEO of Deutsche Telecom, for instance, has expressed regret that there is no European electronic identity (eID) scheme. Today, 14 member states offer national eID schemes, but users face obstacles when trying to access public services in another EU country; the rest do not use eID. Private eID wallets compete, and each one struggles to gain critical mass, leaving the lion's share of the market to tech giants. The respective frameworks and proposals are in place, but the work now needs to be implemented.[306] European decision makers should consider removing political barriers to consolidation of what are often considered "national champions." Finally, more consolidation would mean revisiting concentration rules in individual member states for M&A in sectors where competition is truly global. The aim is not to raise concentration or reduce competition. Quite the contrary, the motivation is to move from fragmented national competition (as is, arguably, the case today in sectors like banking) to truly European and global competition (as is already largely the case in, for instance, automotive).

Europe's later-stage growth funding

~1/10

of US total

3. Build European basic research and scale-up capital, including a "European DARPA," venture capital structures, and changes to pension institutions. Europe's later-stage growth funding is only about one-tenth that of the United States. The average amount for series D and E rounds raised by European startups is about $1 billion; the average amount in the United States is between $10 billion and $15 billion.[307] Moreover, organizations like DARPA, the Advanced Research Projects Agency–Energy (ARPA-E), and the National Institutes of Health provide several billions of dollars to hundreds of R&D programs for breakthrough technologies. Europe could consider building equivalent institutions, for instance further developing JEDI. In the United Kingdom, legislation creating a new Advanced Research and Invention Agency, with £800 million of funding over four years, was going through Parliament in spring 2022.[308] Europe could also reduce restrictions and capital requirements to enable asset managers and pension funds to invest more in alternative asset classes like venture capital and private equity. As discussed in Chapter 5, European pension funds find it difficult to invest in illiquid, alternative assets because of regulatory restrictions, which could be addressed. Europe could go one step further and build pension institutions that can operate at the scale and level of sophistication of global leaders.[309] Finally, it could do more to crowd in private venture capital, building on the initiative of the Venture Capital Funds-of-Funds under the auspices of VentureEU to create a public venture capital fund.[310] Venture capital funding is about one-third of the US level. The United States has double

305 "Economic confidence among Europe's industrial leaders cools as supply chain issues, inflation cloud the horizon," ERT, November 24, 2021.
306 *European industrial strategy*, European Commission; and *Business journey on the Single Market: Practical obstacles and barriers*, European Commission, March 2020.
307 "Europe's start-up ecosystem: Heating up, but still facing challenges," McKinsey & Company, October 2020.
308 John Thornhill, "Britain's ARPA is an ideological pet project that might yet succeed," *Financial Times*, February 18, 2022.
309 In 2020, European financial providers spent 0.6 percent of the total assets under management—about $31 trillion—on venture capital investment. In North America, 1.4 percent of $54 trillion assets under management was dedicated to venture capital in that year. See *A year of disruption in the private markets: McKinsey Global Private Markets Annual Review 2021*, McKinsey & Company, April 2021; and Pooneh Baghai, Kevin Cho, Ju-Hon Kwek, and Philipp Koch, *Crossing the horizon: North American asset management in the 2020s*, McKinsey & Company, October 2021.
310 Under VentureEU, the EU is providing cornerstone investment of €410 million in independently managed venture capital funds of funds.

Europe's angel funding and about triple its early- and late-stage funding, largely reflecting a lower volume of deals rather than ticket sizes.

4. Pool more public procurement and R&D support among a coalition of the willing, including in defense and healthcare. Europe has strengths in basic research. It is home to 43 percent of the world's top 100 life sciences universities and 26 percent of the top 100 for computer science.[311] Within the EU, there is considerable integration of scientific research with a web of collaborations across the region through the European Research Council. Moreover, the EU earmarks funds to help less prosperous countries within Europe to build up their research infrastructure.[312] Yet, as noted in chapter 5, there is still a brain drain to other countries and regions. Moreover, Europe pools only 0.2 percent of its total public procurement at the European level, compared with 45 percent at the federal level in the United States. In particular, the United States spends four times the combined budget of European states on defense and space, although it is noteworthy that in February 2022, Germany announced €100 billion of additional spending in 2022 to modernize the military in response to Russia's invasion of Ukraine; this funding is a national initiative and not an example of pooled public procurement.[313] Similarly, the US federal government spends four times more on public R&D than is spent at the EU level. For instance, in the case of semiconductors, European states have in the past devoted only a few billion dollars in investment in a fragmented way, but in a welcome move in February 2022, the EU announced new EU-level funding of nearly €50 billion by 2030, much closer to US funding of $52 billion.[314] Moving to joint procurement in innovation-related areas, from defense to healthcare to education technology, would allow for larger bets, permit a more regional focus, and help build an environment for scaling up leading European firms in those areas. The most obvious example is defense. However, innovation and pre-commercial procurement in other large-spending areas like medical and educational technology and supplies, or construction systems and materials, could be pooled. Joint procurement of broader healthcare or education services could also dramatically reshape those sectors, but this would require major reforms. Pre-commercial procurement and procurement of innovative solutions instruments exist but are not used at scale. At the same time, European leaders could consider increasing compensation schemes for lagging regions.

5. Increase development and crisis support to European regions in need. EU structural funds and the Recovery and Resilience Facility are widely respected. Yet US intrastate fiscal transfers are four times greater than transfers within the EU. Enhanced support for economically less developed parts of Europe could help them reach their full potential and usefully extend and consolidate the inner market—so long as effective governance could be put in place, both locally and at the European level. This would include both monetary transfers and support for economic development.

311 *World University Rankings 2021*, Times Higher Education, 2021.
312 "What Europe is getting right about research," *Nature*, May 22, 2019.
313 Birgit Jennen, Alexander Michael Pearson, and Arne Delfs, "Germany to boost military spending in latest historic shift," Bloomberg, February 27, 2022.
314 Michel Cabirol, "Semiconductors: Europe's mega plan of almost 50 billion to reduce its dependence," *La Tribune*, February 4, 2022.

Speed and simplicity

Europe could balance its precautionary principle and consensus among member states with accelerated decision making and failure tolerance. European regulators have shown that they can become more agile. In response to the need for a rapid reaction to the pandemic, the European Medicines Agency significantly sped up its authorization for COVID-19 vaccines from anywhere between one and two years to only six months. This speed could now be applied to a broad range of innovation-related areas, along with the following measures:

6. Rebalance the regulatory approach from a precautionary consumer-protection imperative to one that balances costs and benefits of rapid experimentation and disruptive innovation. In certain breakthrough technologies, Europe could choose to ease requirements for consumer protection, currently grounded in the precautionary principle, to allow faster research on, and rollout of, new disruptive innovation, with the aim of achieving better outcomes for citizens rather than minimizing risks. For instance, EU regulation of data privacy and autonomous mobility may encourage activities in areas like AI and autonomous vehicles, respectively, to move to other regions—and thus for the rules to be made elsewhere. Furthermore, it could also ensure that regulation is consistently outcome oriented rather than restriction based. Data privacy and consumer protection should continue to rank high on Europe's priority list, but they should be thought of in a way that allows more experimentation and innovation. Coul d Europe, for instance, become a front-runner in the secure exchange and ownership of data—learning from the good and bad of the "India stack" (biometric payment, health data, and so on, which are stored safely and with standardized application programming interfaces to access and share)? Or could Europe build on the EU Data Governance Act, which has rules for data intermediaries and data sharing, particularly in the case of public data? Smart thinking can always be applied to regulation to boost speed. For instance, the European Commission has proposed new legislation on batteries and waste batteries that will, for the first time, govern the entire battery life cycle; put in place mandatory requirements for sustainability, including, for instance, minimum recycled content and end-of-life management; and introduce due diligence obligations on the sourcing of raw materials.[315]

7. Develop fast-track regulatory approval and decision-making processes. In disruptive innovation, speed matters. Yet Europe tends to move more slowly than other regions, from lengthy consensus-based decision making to slower administrative processes, such as patenting being half as fast as in the United States. European regulators could take an accelerated approach similar to the one that unfolded in the case of COVID-19 vaccines to tech-enabled sectors in which it aims to lead, even if that means occasional failures, setbacks, and adjustments. This could be particularly powerful when paired with a common corporate rule book. The EU could consider ways to adjust governance to enable more speed, particularly in light of the possible accessions in coming years of more countries into the union. One aspect of this could be cross-industry corporate agenda-setting governance.

[315] *A new EU regulatory framework for batteries*, European Parliament, March 2022.

8. Embrace faster labor reallocation and reskilling. As disruptions spread, more workers will need to change occupation or activities. For rapid technology adoption, labor markets will need to be sufficiently flexible. One advantage for Europe in moving swiftly in response to changes in labor markets is the strength of its higher education system and its robust pool of skills. However, labor market rules will now need to be amended to support faster reallocation. Flexicurity principles that protect workers and people rather than jobs, spearheaded by Denmark and now adopted in other parts of Europe, are preferable to regulations centered on higher employment protection that slow down labor reallocation in the period of disruption ahead.

Level playing field with established firms and ecosystems

Where might state intervention be needed for the competitiveness of European firms in a global context? Europe has long promoted competition and has recently taken strong measures on digital gatekeepers. It could also do the following:

9. Ensure a level playing field for smaller firms around natural digital monopolies. The EU has already put in place a digital strategy that includes the Digital Markets Act and the Digital Services Act to ensure that large online platforms that act as gatekeepers in digital markets behave fairly. The Digital Markets Act is an EU regulation to govern natural digital monopolies; the EU legislated on service unbundling in rail, power, and telecommunications in a similar way. The act provides for major social media messaging services to interoperate with other messengers, for instance, and for third-party app stores and payment methods to be imposed on iOS and Android. The act includes sanctions in the case of noncompliance, such as fines of up to 10 percent of worldwide turnover. For instance, WhatsApp would be required to interoperate with other messengers; third-party app stores and payment methods would be imposed on iOS and Android. The initiative is a step toward service unbundling in "natural digital monopolies" as previously seen in rail, power, and telecoms. The act includes sanctions in case of noncompliance; for instance, fines of up to 10 percent of worldwide turnover. Europe could consider further stepping up action that allows smaller firms to innovate around and on top of those gatekeepers rather than being pushed out or swallowed. This could include a continued strong stance and faster action on service unbundling, but also open or regulated access to platform services and data.

10. Initiate a debate about how to protect nascent technology-savvy firms before they face the full force of global-scale competitors. European innovators need more time to scale in a more fragmented market, and they have lower valuations than their US counterparts, making them easy targets. Giving them time to grow could help maximize the innovative power of smaller firms and build capabilities in Europe. A number of national initiatives originated in this spirit. For instance, the competition authority in the Netherlands fined Apple, alleging that it was not offering app creators any alternatives to using its in-house payment systems (with 30 percent commissions). Germany's competition authority has been given more powers to act on abusive practices and target companies that dominate a particular market. In a similar vein, the United Kingdom is setting up a tech watchdog focused on market dominance.[316] In addition, other regions have gone as far as mandating local operations and capability transfer of global firms. Great care will be needed, because cross-border competition and takeovers are also a great source of international learning, scaling, and funding.

[316] Javier Espinoza, "How Big Tech lost the antitrust battle with Europe," *Financial Times*, March 21, 2022.

11. Double down on talent as Europe's prime success factor in future markets. Europe has the second-highest number of STEM graduates of any region in the world, but the region could ramp up skills development, thereby positioning companies and workers to be competitive in an increasingly technology-driven world. Europe is also losing out to the United States on attracting immigrant inventors. About 35 percent of the world's immigrant inventors migrate to Europe, but about 60 percent go to the United States.[317] Numerous European countries already have programs to attract talent, including through skill-based immigration systems and talent visas (for example, the United Kingdom recently announced a High Potential Individual visa). Yet the number of highly skilled workers who secured EU blue cards in 2018 was nearly 80 percent lower than the number of people given employment-based immigrant visas each year in the United States.[318] European decision makers could consider greater coordination, increased budgets, and more visibility to attract, develop, and retain STEM and entrepreneurial talent. The recent commitment to a new European Tech Talent service desk in collaboration with the European Startup Nations Alliance is an example of what can be done.[319]

Whether or not the competitive arena improves, corporate leaders and owners need to step up their game to take risks and compete

Even if policy and regulation were to create a more enabling environment in which European firms can compete, they, too, need to step up, developing scale and agility in order to grow and succeed—not only today on the national and regional levels, but globally and for decades to come. Nonexecutive boards have a strong role to play as they define ambitions, strategies, and guardrails. Hedging will not be enough to succeed. Private leaders can usefully take a range of actions, of which we highlight the following three examples:

— *Set stretch long-term targets and adjust incentives. In the current environment of disruptions, corporations need to set their sights beyond their incumbent business, develop a vision for global leadership ten to 20 years out, and take risks and deploy capital and R&D investment commensurate with that vision.* European companies and their boards could also consider adjusting executive and employee compensation to better align with those visions and the risk-taking needed. Today, only about 5 percent of the private-sector workforce in Europe has some kind of employee ownership, compared with about 20 percent in the United States.[320] The largest European tech companies have already taken this approach.

— *Leverage programmatic M&A and alliances to acquire the scale and capabilities needed.[321] This would extend to cross-border European and global consolidation, including—painfully—sell-side M&A where global leadership is out of reach.* It would also include using vertical and capability-based acquisitions to ramp up the development of innovation strengths and ecosystems, for instance using corporate venture capital. This is the approach taken by German pharmaceutical company Boehringer Ingelheim, whose corporate venture capital arm has investment capacity of €250 million, enabling the group to access new therapies, including cancer treatments.[322] Companies should also be proactive in seeking and developing cross-sector alliances to accelerate the development of transversal technologies, as Total and PSA are doing on battery manufacturing.[323] Companies and entrepreneurs can also seek to set up new disrupters.

[317] Carsten Fink and Ernest Miguelez, *Measuring the international mobility of inventors: A new database*, economic research working paper number 8, World Intellectual Property Organization, May 2013.
[318] In 2018, about 30,400 EU blue cards were issued, around 90 percent of which were in Germany. Annually, the United States issues about 140,000 employment-based immigrant visas.
[319] "Scale-up Europe spurs collective action to accelerate European tech," French Presidency of the Council of the European Union, February 7, 2022.
[320] National Center for Employee Ownership in the United States; European Federation of Employee Share Ownership.
[321] "How one approach to M&A is more likely to create value than all others," *McKinsey Quarterly*, October 13, 2021.
[322] Leah Hodgson, "Europe's most active corporate VCs target pandemic-proof startups," PitchBook, February 2021.
[323] "PSA and Total create 'Automotive Cells Company', a joint venture dedicated to the manufacture of batteries in Europe," Saft, September 3, 2020.

— *Invest in innovation and technology governance and capabilities at scale and pace. Companies will need to implement agile and more customer-centric innovation governance able to deal with higher-risk, long-term projects.* They will need to find—or reallocate—funds on a larger scale and target them more toward long-term innovation and business development than used to be the case. And they will need to build skills. Siemens, for instance, enabled 380,000 employees in 200 countries to upskill and reskill in digital capabilities in 2021 through a dedicated learning platform.[324]

European countries have been leaders on sustainability and inclusion. They are now concerned with the security of supply chains, energy, food, and defense. How much should the region also worry about its corporate and technology gap, which is jeopardizing future growth and strategic autonomy—and when? Can the momentum of common action triggered by war in Ukraine now also provide the impetus to consider the trade-offs needed for technology and competitiveness that have long felt difficult?

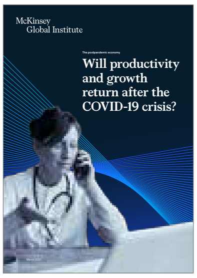
More work will likely be needed to determine how to tackle Europe's gaps in corporate performance and innovation in detail and in practice, technology by technology and sector by sector, building resilience into the European model for the long term.

[324] Prajeet Nair, "Siemens to deploy Infosys digital learning platform to upskill and reskill employees," TechCircle, March 13, 2020.

Related MGI and McKinsey research

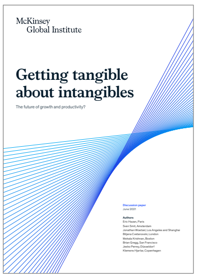
The net-zero transition: What it would cost, what it could bring (January 2022)

Governments and companies worldwide are pledging to achieve net-zero emissions of greenhouse gases. The report looks at the economic transformation that the transition would entail, estimating the changes in demand, capital spending, costs, and jobs, to 250, for sectors that produce about 85 percent of overall emissions and assessing economic shifts for 69 countries.



Will productivity and growth return after the COVID-19 crisis? (March 2021)

Bold innovation by some firms under the pressure of the pandemic could deliver a productivity dividend, but that depends on corporate action broadening and robust demand. The research finds that there is potential to accelerate annual productivity growth by about one percentage point in the period to 2024.

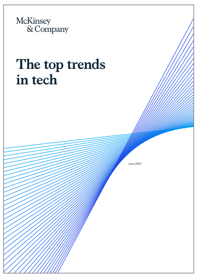


Getting tangible about intangibles: The future of growth and productivity? (June 2021)

Companies that master the deployment of intangibles investment will be well positioned to outperform their peers. The research uses sector-level data and a survey of more than 860 executives that reveal that "top growers" invest 2.6 times more in intangibles than low growers.

The future of work in Europe: Automation, workforce transitions, and the future geography of employment (June 2020)

Beyond COVID-19, automation, migration, and shrinking labor supply are shifting the geography of employment. A detailed analysis of 1,095 local labor markets across Europe examines profound trends that have been playing out on the continent in recent years and will continue to do so in the future.



The top trends in tech (June 2021)

Which technologies have the most momentum in an accelerating world? McKinsey Digital identified the trends that matter most.

Innovation in Europe: Changing the game to regain a competitive edge (October 2019)

A century ago, Europe was a global powerhouse of innovation, but it has started to lose its edge. Despite some notable exceptions, many innovative companies are found elsewhere. Five paths could help the continent regain its competitive edge.

McKinsey Global Institute
September 2022

Designed by the McKinsey Global Institute

www.mckinsey.com/mgi

@McKinsey_MGI
@McKinseyGlobalInstitute
@McKinseyGlobalInstitute

Subscribe to MGI's podcast, *Forward Thinking*:
mck.co/forwardthinking

Cover image: Sinelab