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This article is a collaborative effort by Alexandru Filip, Jurica Novak, Magnus Tyreman, Ovidiu Tisler, and Bogdan Dimitriu.



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A competitiveness crisis between Europe and other major regions has been quietly unfolding for two decades, centered on a corporate and technology gap.

Unless tackled, this divide threatens to handicap Europe across many dimensions, including growth, inclusion, sustainability, and strategic autonomy (see sidebar: “Europe eclipsed in technology adoption”). The stakes are high: Europe could miss out on a potential corporate value add of €2 trillion to €4 trillion a year by 2040.¹ To put this into perspective, this is six times the amount that Europe needs to achieve net-zero emissions by 2050.²

The ongoing conflict in Ukraine has only exacerbated this strain, highlighting the need for economies to be resilient.³ Romania, a relatively recent EU member, shares many of the broader region’s technology problems, lagging on many indicators of business success. Sharing a border with Ukraine, Romania has also been particularly affected by the Russian invasion. While the country mounted a swift response to the Ukrainian refugee crisis, the conflict has brought to light strategic lacks in Romania’s food-security, energy, and defense systems.⁴ Not least, a disruption in oil and gas supplies from Russia threatens Romania’s economy.⁵

For the Romanian economy to build long-term resilience and weather current and future disruptions, it needs to catch up on ten key transversal technologies. Romania’s future growth and competitiveness across all sectors is at stake here—failure to deliver could jeopardize the country’s efforts to improve the lives of its citizens, who still experience low levels of inclusion and well-being relative to the EU average.

Long-held beliefs and trade-offs may need to be re-evaluated if Romanian companies are to keep abreast of other regions that are competing effectively in a world of technology disruption.

An integrated package of initiatives could create an environment that enables this—and will require leaders to show the same resolve and collaboration that they displayed in their response to the COVID-19 pandemic and the war in Ukraine. Some initiatives may need to happen on an EU level, which Romania could support, while others could readily be implemented on a national, bilateral, or multilateral level.

¹ “A new look at how corporations impact the economy and households,” McKinsey Global Institute, May 2021.

² McKinsey research finds that reaching net zero by 2050 would require \$9.2 trillion in annual average spending on physical assets, \$3.5 trillion more than today. For more information, see: *The net-zero transition: What it would cost, what it could bring*, McKinsey & Company, January 2022.

³ “War in Ukraine: Lives and livelihoods, lost and disrupted,” McKinsey & Company, March 17, 2022.

⁴ “UNHCR Romania: Ukraine refugee situation update,” ReliefWeb, July 12, 2022.

⁵ Iulian Ernst, “Romania’s dependency on Russian energy below EU-average but not insignificant,” *Romania-Insider*, March 29, 2022.

Europe eclipsed in technology adoption

In a McKinsey Global Institute report, *Securing Europe's future beyond energy: Addressing its corporate and technology gap* in September 2022, we compared the corporate and technological competitiveness of the EU-30 (that is, the 27 member states of the European Union plus Norway, Switzerland, and the United Kingdom) relative to the United States (US) and China.

We found that the EU-30 is being eclipsed on the industrial-scale adoption of technology. From 2000 to 2019, European firms improved their ranking in market capitalization vis-à-vis US firms in only three of 20-plus sectors: household and personal products, pharmaceuticals, and retail. Europe's largest companies lack the scale and strategic control of their US counterparts in most sectors. At the end of 2019, US companies had almost double the market-to-book ratios of their European counterparts and 30 percent higher levels of book equity.

Take the automotive sector as an example. Two of the world's top three auto manufacturers are European. As of 2018, five of the top ten premium cars sold in the US were European. However, US manufacturers account for close to 70 percent of all kilometers

driven by fully autonomous vehicles, mostly because of Europe's lag in AI innovation, development, regulation, and funding.⁶

Europe's recognized weakness in technology development presents a growing corporate-performance challenge. While in the past this was compensated for by competitive advantage and specialization in other sectors, this is no longer tenable. Technology now underpins all sectors via transversal technologies such as AI, biotechnology, and the cloud, which have application across sectors. The World Economic Forum estimates that 70 percent of new value created in the global economy over the next ten years will be digitally enabled, a shift accelerated by COVID-19.⁷ The fact that Europe did not keep pace with the US in the first digital technology wave, centered on the internet and software, means that it is now in a weakened position in these transversal technologies.

Europe will need to focus on leveraging transversal technologies to close its corporate and technology gap. Not doing so could put Europe at risk of missing out on half of its potential GDP growth until 2040, with significant proportions of value lost in growth, sustainability, and inclusion. And it is smaller economies like Romania, struggling to catch up to an already lagging European economy, that face the steepest struggle.

⁶ Erik Brattberg, Raluca Csernaton, and Venesa Rugova, *Europe and AI: Leading, lagging behind, or carving its own way?* Carnegie Endowment for International Peace, July 2020.

⁷ *Shaping the future of digital economy and new value creation*, World Economic Forum.



Sustainability, inclusion, and growth:

Where does Romania stand?

Improving the lives of Romanians over the long haul requires sustainability, inclusion, and growth: three factors that reinforce and impact one another.⁸ High growth runs the risk of undermining efforts to improve sustainability. However, growth strengthens confidence and creates a healthy investment climate for sustainability-related innovation, generating the new income streams needed to pay for the energy transition. Lagging growth could also undermine inclusion by limiting the pool of funds available to spend on social programs.

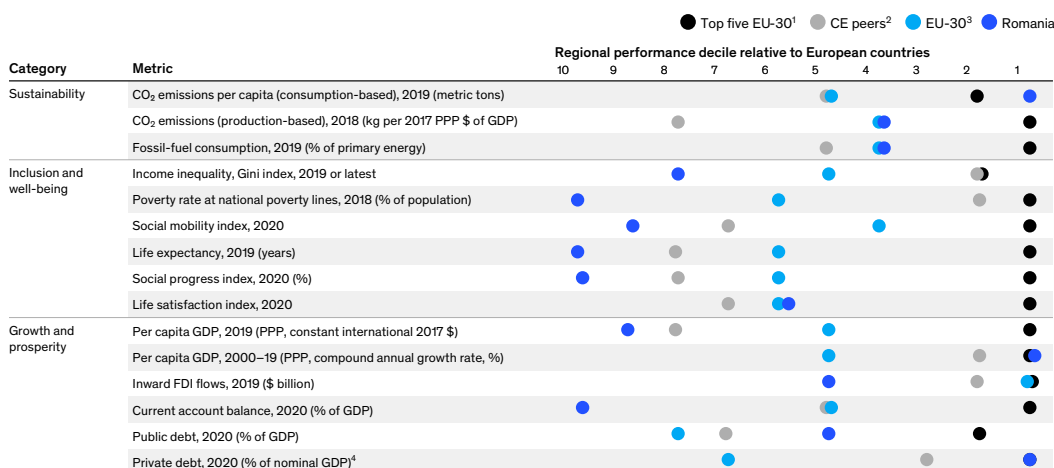
In these respects, how does Romania measure up against its European peers? Identifying Romania's relative strengths and weaknesses in

sustainability, inclusion and well-being, and growth and prosperity, could help the country to prioritize its actions, and identify where the application of transversal technology would be most effective (Exhibit 1). In our analysis, we assessed the 38 OECD countries on key metrics across sustainability, inclusion and well-being, and growth and prosperity and ordered them in deciles. Subsequently, we placed Romania in one of the deciles based on its performance across the same metrics (decile 1 being the best score, and decile 10 being the worst).

⁸ 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 2022.

Exhibit 1

Romania is performing well in sustainability, has mixed results on growth and prosperity, and is mostly lagging on inclusion and well-being.



1. Top five European countries based on KPI performance.

2. Central and Eastern European peers includes Czechia, Hungary, Poland, Slovakia, and Slovenia.

3. Europe 30 (EU-30) includes the European Union plus Norway, Switzerland, and the United Kingdom.

4. Private debt is calculated as the sum of loans to the non-financial sector and households.

Source: CEIC; Eurostat; Gallup; OECD; Our world in data; Social progress organization; WEF; World Bank; McKinsey Global Institute analysis

Sustainability

Romania's record on sustainability is good: emissions per capita are low, below those of both its Central European (CE) peers and the five top-performing EU economies. Its fossil-fuel consumption is also lower than that of other CE countries, on par with the EU-30 average, and Romania has also pledged to phase out coal by 2032 and reach net-zero carbon emissions by 2050.⁹ Meeting the ambitious commitments will require a concrete plan, which has yet to be published.

Although Romania's sustainability picture is relatively healthy, this has not necessarily translated into more satisfying or financially abundant lives for its citizens. Indeed, Romania's strong sustainability could reflect a

more sluggish economic output than its EU peers.

Inclusion and well-being

Romania lags behind its CE peers, particularly when it comes to income equality, with a relatively high Gini index of around 34 percent in 2020 (compared to around 27 and 28 percent for Poland and Hungary, respectively), indicating high income inequality.¹⁰ In fact, Romania's in-work poverty rate is the highest in the EU, with one in three Romanians at risk of falling into poverty.¹¹

⁹ "Climate action: 2050 long-term strategy," European Commission.

¹⁰ "Living conditions in Europe—income distribution and income inequality," Eurostat, June 2022.

¹¹ *Inequalities in Romania*, World Vision Romania, June 2019.

80.4y

Europe life expectancy

74.2y

Romania life expectancy

As a region, Europe has the highest life expectancy at birth in the world: the EU-30 average is 80.4 years.¹² However, Romania performs relatively poorly, with an average life expectancy of 74.2 years.¹³ Unfortunately, a large portion of the deaths in Romania are preventable. Our analysis published in late 2021 showed that the main cause of death in the country is cardiovascular disease (57 percent of deaths), of which a large portion is preventable by raising awareness and encouraging lifestyle changes.¹⁴

When it comes to social mobility, which is computed by combining measures for health, education, technology, work, resilience, and quality of institutions, Romania had an index score of 63.1 in 2020—among the bottom five European countries (Denmark scored the highest, with 85.2) although still higher than most developing countries.¹⁵

Although Romania has a national plan to improve social inclusion and reduce poverty, some key actions have been delayed, such as boosting employment, reducing the early school drop-out rate, and improving national health programs.¹⁶

Growth and prosperity

Along with the five top-performing EU-30 countries, Romania's per-capita GDP has shown strong growth over the past two decades: at 6.7 percent in 2021, it was notably better than that of Europe overall or of the US, and slightly ahead of its CE peers.¹⁷ Private

debt in Romania was on par with the five top-performing EU economies in that year, at the height of the COVID-19 pandemic.

Along with other CE countries that are part of the EU, Romania has benefited from participating in the single market, with European direct investment and labor mobility contributing to rapid growth.¹⁸ Romania has been an EU member for 15 years, and Europe is the country's greatest investor and main strategic partner, contributing to 89.5 percent of Romania's total foreign direct investment (FDI) stocks.¹⁹ Romania has received €62 billion in EU funding, yet paid only €21 billion into the EU budget, making it a net beneficiary.²⁰

Romania is also expected to receive a total of €29.2 billion over the next five years through the EU-funded National Recovery and Resilience Plan (NRRP), which aims to enable investments in key areas for economic growth. Most of the funding (around 57 percent) will be allocated to the green transition, supporting the development of transport infrastructure, waste-management facilities, and improving the energy efficiency of buildings, while 21 percent will go toward digitization, enabling governmental cloud infrastructure, and eHealth systems, for example.²¹

Although data on Romania are limited, looking at CE peers, we see a large gap between company profits in this region and in the rest of Europe and the US (see sidebar "Europe eclipsed

¹² "Mortality and life expectancy statistics," Eurostat, April 29, 2022.

¹³ Ibid.

¹⁴ "How prioritizing health can be a prescription for Romania's prosperity," McKinsey, November 3, 2021.

¹⁵ *The Global Social Mobility Report 2020: equality, opportunity and a new economic imperative*, World Economic Forum, January 2020

¹⁶ *Inequalities in Romania*, World Vision Romania, June 2019.

¹⁷ "GDP per capita growth," World Bank, August 2022.

¹⁸ "EU direct investment positions, breakdown by country and economic activity (BPM6)," Eurostat, June 20, 2022.

¹⁹ Cristian Gherasim, "15 years on: How are Bulgaria and Romania doing in the EU?" EU Observer, January 25, 2022.

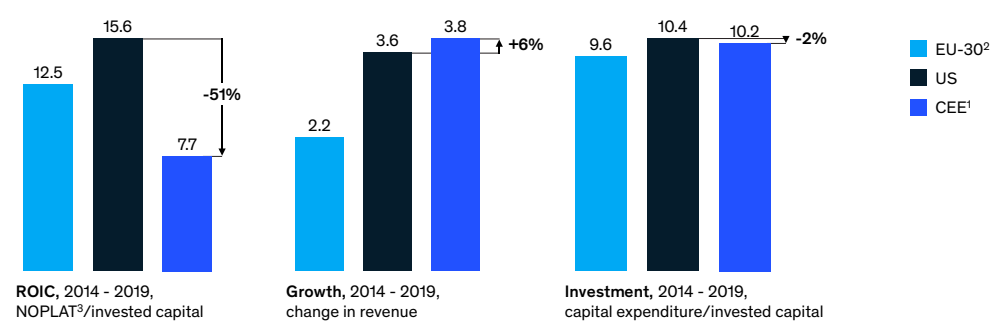
²⁰ Ibid.

²¹ Antoanela Ionita, "Romania is betting on the green transition in its post-COVID recovery plan," The Recursive, February 17, 2022.

in technology adoption”). Between 2014 and 2019, large CE companies were 51 percent (eight percentage points) less profitable by return on invested capital (ROIC) than those in the US, even as growth was six percent greater, potentially symptomatic of their home-economies’ lag in sustainability, inclusion and well-being, and growth and prosperity (Exhibit 2).



Exhibit 2
CEE peers have high-growth companies, with investment on par with the US but profitability lower than the US and Europe.
CEE, US, and Europe 30 (EU-30) scores for return on invested capital (ROIC), growth, and investment, weighted average, 2014–2019, %



1. Central and Eastern European countries includes Czechia, Hungary, Poland, Slovenia, and Slovakia (Croatia, Romania and Bulgaria did not have companies in the sample).

2. Europe 30 (EU-30) includes the European Union plus Norway, Switzerland, and the United Kingdom.

3. Net operating profit less adjusted taxes.

Note: Sample size of the country for ROIC, growth, and investment n=32. Financial companies excluded.

Source: “R&D investment scoreboard,” Eurostat 2020; McKinsey corporate performance analytics tool; McKinsey Global Institute analysis

Ten transversal technologies —“must-haves” for Romania







In each of these vital areas—sustainability, inclusion, and growth—adoption of transversal technologies could aid Romania to close its corporate and technology gap, while enhancing Europe’s competitiveness. With Romania behind its EU counterparts, such technology is no longer a “nice-to-have” but is a “must-have” if the country is to thrive. Several of these key technologies, such as Applied AI, have greater transversal capabilities than others and could impact all sectors in some way (Exhibit 3).

Romania’s technological position is mixed, with some positive developments in production and adoption. However, when compared with the top five performers in the EU, Romania lags in innovation, mainly due to a lack of capital for basic research.

A lack of capital could also hinder the production and adoption of these technologies, as the associated upfront costs could be too high to implement technologies in place of cheaper labor. For example, although process

Exhibit 3

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

Industrials (including auto and defense)	Chemicals and materials (including agriculture)	Transportation, energy, and infrastructure	Pharmaceuticals and healthcare	Consume and retail	Financial and professional services
					
Next-level automation					
Robotics, additive manufacturing, drones, digital twins	Virtual development modeling, 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 soldier	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 vehicles	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

automation is a focal technology for Romanian innovation, adoption is low due to a lack of financial resources, experienced personnel, IT readiness, and a legal framework, coupled with hesitancy toward the unfamiliar (Exhibit 4).²²

To assess Romania's position for each transversal technology, we compared its performance to that of the top five EU-27 and United Kingdom (UK) performers—the Romanian score is expressed as a fraction of the average score of their score.

²² Elena Vrabie, "From Bucharest to Cluj: how is AI adoption in Romania moving," The Recursive, September 23, 2021.

Exhibit 4
Romania is performing relatively well in technologies such as future of programming, trust architecture, and applied AI.
Romanian score as fraction of top five EU-27 + UK performers' average, multiple¹

Transversal technologies	Romania trailing ● <0.2 ● 0.2-0.5 ● Romania leading			
	Innovation ²	Production ³	Adoption ⁴	Average
Next-level process automation	● 0.30	0.09	● 0.19	0.19
Future of connectivity	0.00	● 0.18	● 0.42	0.20
Distributed infrastructure	● 0.01	n/a	● 0.19	0.10
Next-generation computing	● 0.12	n/a	n/a	0.12
Applied AI	● 0.15	● 0.45	● 0.33	0.31
Future of programming	● 0.41	● 0.49	● 0.03	0.31
Trust architecture	● 0.02	● 0.47	● 0.43	0.31
Bio revolution	● 0.05	● 0.01	n/a	0.03
Next-gen materials	0.00	n/a	● 0.08	0.04
Future of cleantech	● 0.09	● 0.09	● 0.36	0.18
Average	0.12	0.28	0.25	

1. For instance, if Romania issues 200,000 patents per year related to process automation vs 400,000 a year by the top five EU-27 + UK performers, the multiple is 0.5.
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: McKinsey Top Tech Trends; McKinsey Global Institute analysis

Our analysis looks at ten transversal technologies on which Romania's future performance and prosperity hinge.

1. Next-level process automation
Process automation can help companies turbocharge their operations by improving process efficiency and enhancing functionality. From collaborative robots in industry to virtual clinical trials in healthcare,

and military robots in defense, this technology can be widely applied across sectors.
Compared to the average for EU counterparts, Romania is ahead on innovation, but lagging on adoption

of next-level process automation. Process automation is a key focal technology for Romanian innovation, with companies such as UiPath leading the way in robotic process automation globally. Yet, with low adoption, Romania could be missing out on the benefits that process automation can bring.

2. Future of connectivity

Technologies like smart cities in industry, remote monitoring in healthcare, and smart branches in business services could be the future of connectivity. These technologies bring humans and technology closer, immersing users in an augmented reality with widespread applications to boost efficiency and productivity.

Although Romania's innovation and production of these technologies is low compared to that of the EU-30's top five performers, its adoption is high. Telehealth, for instance, saw a boost in adoption with the COVID-19 restrictions in Romania prompting remote consulting.²³ Both health practitioners and patients in Romania have relayed their willingness to use telehealth technology, which, coupled with high-speed internet, could be key to its successful adoption.²⁴

3. Distributed infrastructure

Distributed infrastructure is the umbrella term for object-oriented and other information technologies used by software architects, including edge and cloud computing. These make use of remote servers hosted on the internet (instead of local servers) to manage, store, and process data, and have broad applicability across sectors.

However, Romania is trailing significantly here, relative to the EU-30's top five economies, and ever more so on a global scale. The share of companies that used cloud computing services in Romania in 2021 was 14 percent, compared to 27 percent for CE countries and 41 percent for the EU.²⁵ Additionally, the share of Romanian companies with IT infrastructure in the cloud was 10 percent in 2021, compared to 20 percent for CE countries and 30 percent for the EU.

4. Next-generation computing

Next-generation computing (also called high-performance computing) uses technology based on quantum phenomena to process data. This allows for more complex calculations that improve productivity, with a range of uses across sectors, such as aerospace and defense, and energy and utilities.

Romania is behind on innovation relative to the EU-30's top five countries and lacks next-generation computing technology adoption and production. As this lack of production and adoption is widespread across the EU, Romania and other EU countries could be missing out on lucrative opportunities. The global next-generation computing market is forecast to grow at a CAGR of 19.4 percent from 2020 to 2030 to reach around \$782 billion by 2030.²⁶

5. Applied AI

As technology continues to transform the world, AI can have applications beyond customer-facing functions. Used across myriad sectors, including in smart power plants,

²³ Elena Vrabie, "The Romanian Healthtech industry takes off with a telemedicine momentum," *The Recursive*, April 9, 2021.

²⁴ Mira Florea et al., "Lights and shadows of the perception of the use of telemedicine by Romanian family doctors during the COVID-19 pandemic," *International Journal of General Medicine*, April 2021, Volume 2021, Number 14.

²⁵ "Cloud computing—statistics on the use by enterprises," Eurostat, June 22, 2022.

²⁶ *Next Generation Computing Market*, Allied Market Research, March 2022.

Annual investment in Romanian AI startups by 2025 could reach

€50M

autonomous vehicles, and precision agriculture, Applied AI is showing signs of advancement in Romania, where innovation is poised to catch up with production and adoption.

Romania's level of innovation is relatively embryonic compared with the top five EU-30 performers. While it has been the second-largest publisher of AI research in the region over the past two decades—after Poland—its actual spending on investments lags behind that of EU counterparts.²⁷ However, with the inclusion of AI in the objectives of the Authority for the Digitalization of Romania (which carries out and coordinates the implementation of public policies and strategies around the digital transformation), annual investments in Romanian AI startups could reach almost €50 million by 2025.²⁸

Romania is ahead in terms of production and adoption, with over 50 startups in the field of agritech alone. Several of these have garnered attention, including FieldBook AgriApps (FBAA), a software innovation that allows enhanced-quality, precision agriculture; AgroCity, which helps farmers to gather and analyze data from sensors, bringing down costs while boosting productivity; and StartAgro, which uses cutting-edge technology to build greenhouses that utilize geothermal and solar energy.

6. Future of programming

The future of programming is expected to trend towards a no-code or low-code development environment with increasingly automated processes, such as Software 2.0. This could boost the efficiency and speed of programming development across sectors, with the most focus in the automation, machine learning, and AI industries.

Romania is making headway here, with a solid performance in innovation and production, but a softer showing in technology take-up. The country has given rise to leading innovators in AI, such as DRUID AI—an end-to-end platform for AI-driven conversational business applications.

7. Trust architecture

Trust architecture involves a set of cybersecurity paradigms that focuses on protecting resources (such as assets, workflows, services, network accounts, etcetera). Trust principles can be used to plan industrial and enterprise infrastructure and workflows, with a broad range of applications from cybersecurity in defense to smart sourcing in consumer and retail.

Romania shows signs of promise here, with strong production and adoption. The country performs relatively well against the EU-30's top-five performers, with homegrown company Bitdefender consistently ranked among top global cybersecurity players. Romania has also given rise to novel security solutions, like Typing DNA, which assigns a biometric "fingerprint" to a person's typing style for reinforced security.

8. Bio revolution

Advances in biological science coupled with the development of computing, automation, and AI are supporting fresh innovation. This bio revolution could significantly impact economies and lives, from health, agriculture, and consumer goods to energy and materials.

The biotech industry is nascent in Romania, with some innovation but very little production or adoption relative to the EU-30's top five countries. Romanian innovative players are slowly emerging, such as Rayscape, whose

²⁷ Country rankings, *Scimago Journal & Country Rank*, August 2022.

²⁸ Claudiu Vrinceanu, "Why Romania must tap into artificial intelligence," *Business Review*, April 17, 2020.

software solution uses a recognition algorithm to help radiologists detect lung nodules, and Lumen, a research startup that aims to empower the blind.

9. Next-generation materials

Next-generation materials with novel properties can increase functionality and reduce costs throughout manufacturing, with potential for major energy, carbon, and economic benefits. However, breakthroughs in materials science and engineering are needed to enable these new capabilities.

Romania has much potential here. Demand for these materials exists, but innovation and output are lacking—creating an opportunity to kickstart the sector. While Poland is the regional leader in materials-science research, contributing around 49 percent of R&D output in the region, Romania has the world's leading companies in construction-material production.²⁹ The 50 largest manufacturers of construction materials in Romania saw a cumulative turnover of about €2.35 billion and a net profit of around €365 million in 2020.³⁰ Romania is also home to the largest polymer processor in eastern Europe, Teraplast, and the largest European players in construction, like Saint Gobain and Heidelberg Cement.

10. Future of cleantech

Cleantech can contribute to a cleaner, more sustainable world. The use of sensors, gateways, embedded radios, and cellular routers can optimize process efficiencies by removing the need for natural resources and manual monitoring. Renewable energy systems and sustainable products and services are some examples of cleantech, with a wide range of industrial uses.

Innovation and production have not kept pace with adoption. Romania has few cleantech patents compared to CE peers: for example, from 2012 to 2021, Romania produced only five patents in environmental technologies, compared to 86 from Poland.³¹ This offers opportunities for local developers, and Romania's cleantech market is starting to gain traction as platforms like bonapp.eco (that aims to reduce food waste) and EcoTree (that digitalizes recycling) take off. Further, Romanian automotive company, Dacia, started producing its own electric vehicle—the Dacia Spring—joining in on the global trend of electrification.³²

²⁹ "High-performing places in the materials world," *Nature Index*, July 5, 2021.

³⁰ Andreea Guțu, "Top foreigners dominate the local construction materials market. The Germans and the Swiss, the biggest producers present in Romania, with businesses worth billions of lei," *Profit Insider*, December 23, 2021.

³¹ European patent applications, European Patent Office, September 22, 2022.

³² Antoanela Ionita, "Is Romania's cleantech market finally starting to shape up?" May 11, 2021.



The time to act is now:

Ramping up Romanian technological capabilities and competitiveness

As we have seen, Romania, like most of Europe, is being outperformed by non-European competitors in industrial-scale technology adoption. The country's lack of scale in transversal technologies jeopardizes its position in nearly all sectors, including current strongholds like trade, manufacturing, transportation, construction, and ITC.

In addition, the economic slowdown of 2021, coupled with Russia's invasion of Ukraine in 2022, has dampened Romania's economic activity. Although Romania produces most of its gas, it imports almost 20 percent, relying on the Russian pipeline through Ukraine.³³ An expected GDP growth of 2.6 percent in 2022 and 3.6 percent in 2023 would

³³ Nicoleta Banila, "Russian war on Ukraine to negatively affect Romania's economy—EC," SeeNews, May 23, 2022.

mainly be supported by investments from EU funds like the Recovery and Resilience Fund.³⁴ Meanwhile, exports and imports will likely grow at a slower pace due to supply-chain shortages. For instance, one of the world's biggest exporters of wheat and corn, Romania's Constanta port, is unlikely to maintain its volumes without concerted support from the EU.³⁵

Despite these challenges, Romania has substantial strengths, including a booming digital economy and a strong automotive sector, bountiful natural resources, a growing renewable sector, agricultural potential, and EU membership.

Digital economy

Romania has traditionally been a key outsourcing destination for digital technology but is now home to many emerging start-ups in the digital sphere. For example, Romanian blockchain platform, Elrond, has made apps such as the cryptocurrency eGold (EGLD) available to millions of its users, allowing Romania to participate in the global cryptocurrency wave. Further, Romania has produced emerging regional champions like Superbet, an online gaming and sports betting company, and eMAG, an online retail platform.

With innovation by local champions, Romania's IT market is expected to be a key contributor to the country's GDP in the medium to long term.³⁶

Romania's strong IT market is fueled by its established IT education program. Romania has 49 public universities and eight private ones, with more than 500,000 students enrolled each year.³⁷ Although falling in last place in the EU with respect to the percentage of citizens aged between 25 and 34 with a completed higher education (25 percent in Romania compared to the EU average of 41 percent), Romania leads when it comes to the number of certified IT specialists.³⁸ The country produces around 8,500 IT graduates and 1,500 telecommunications graduates each year, and many others have shifted their careers to work for an IT company, given the higher-than-average salaries.

However, Romania does face a "brain drain" due to talented Romanians moving abroad for work or study, leaving Romania with the second-largest talent shortage in the world, after India.³⁹ The talent shortage is at a 16-year high as three-quarters of employers report difficulty in sourcing the required talent.⁴⁰ With almost 40,000 young Romanians studying abroad, the economic cost of migration for Romania could reach €700 billion.⁴¹

Automotive industry

Romania's automotive industry is well established, having operated for more than 80 years.⁴² Contributing to 26

³⁴ Nicoleta Banila, "Russian war on Ukraine to negatively affect Romania's economy—EC," SeeNews, May 23, 2022.

³⁵ Vadim Ghirda, "Romanian port struggles to handle flow of Ukrainian grain," AP News, June 24, 2022.

³⁶ "Romania country commercial guide," International Trade Administration.

³⁷ *A guide on IT outsourcing to Romania*, Evozon, January 2019.

³⁸ "Eurostat: Romania, in the last place in the EU in terms of the percentage of citizens aged between 25 and 34 with complete higher education," G4Media, June 25, 2021; "Romania country commercial guide," International Trade Administration.

³⁹ Carmen Radu, "Romania's talent shortage second largest in the world after India," Economedia, September 17, 2021.

⁴⁰ *Romania's 2022 talent shortage*, ManpowerGroup, 2022.

⁴¹ "The Great Escape" of young Romanians who go to study abroad," Digi24, August 28, 2022; Andrei Buruiana, "The economic cost of migration for Romania is estimated at over 700 billion euros," Project-E, November 23, 2021.

⁴² Direct automotive manufacturing jobs in the EU, by country, ACEA, April 1, 2022.

percent of Romania's exports, it is a key industry in the economy.⁴³ As one of Romania's top ten exporting industries, the automotive industry accounts for more than 14 percent of the country's GDP, and employs almost 180,000 Romanians.⁴⁴ Romania is the sixth largest producer of passenger cars in the EU, producing 420,755 of them in 2021.⁴⁵ With its domestic automobile brand, Dacia, and regional manufacturing plants for international brands like Renault and Ford, Romania is an important player on the global stage.

However, Romania's automotive industry faces many challenges: poor transport infrastructure, an under-skilled labor force, rising energy prices, and a global lack of electronic components and critical raw materials. This is compounded by political factors like the US-China trade row, Brexit, the conflict in Ukraine, and stringent emission targets.⁴⁶ These global and local challenges have significantly impacted Romania's automotive sector, with Dacia and Ford producing only half of their monthly production capacity in September 2021.⁴⁷

Natural resources

Romania has large reserves of timber, petroleum, natural

gas, iron ore, coal, and salt, and facilities for hydropower. These reserves support Romania's strong automotive industry and enable Romania to be largely energy self-reliant. But a lack of investment is preventing Romania from benefiting from its natural resources. Sustainable management of the resources is also needed.

Romania also has a strong agriculture, producing 10 percent of the EU's grain and oilseed.⁴⁸ Around one-fifth of Romanians are employed in agricultural activities, compared to an average of 4 percent for the EU. Yet despite Romania's large agricultural potential, the country remains a net food importer, importing meat, dairy, horticulture, feed ingredients, and beverages. The low level of agricultural productivity is attributed to the prevalence of subsistence farms (the average farm size is 4.4 hectares, considerably smaller than the EU average of 15 hectares) and their low level of technologization.⁴⁹

EU membership

Romania benefits greatly from being part of the most open and connected large economy in the world, with the most sophisticated supply chains.⁵⁰ However, many changes may be required to make

⁴³ "The impact of the international auto market's evolution in Romania," China CEE Institute, November 2019.

⁴⁴ Daniel Workman, "Romania's Top 10 Exports," World's Top Exports, July 20, 2022; "The automotive industry in Romania," SMMT, August 2, 2021; "The impact of the international auto market's evolution in Romania," China CEE Institute, November 2019.

⁴⁵ Adrian N Ionescu, "Romania, the sixth largest producer of passenger cars in the EU in 2021, over Italy or Sweden," CursDeGuvernare, April 6, 2022.

⁴⁶ *Inflation report*, National Bank of Romania, November 2019; "Economy Minister Spataru: 'We are looking for solutions to support the Romanian automotive industry in this difficult period'," The Diplomat, April 5, 2022.

⁴⁷ "The automotive industry at the tipping-point: sustainable, intelligent, and user-centric mobility at a cost," Romania-Insider, November 4, 2021; "Economy Minister Spataru: 'We are looking for solutions to support the Romanian automotive industry in this difficult period'," The Diplomat, April 5, 2022.

⁴⁸ "Romania—country commercial guide: agricultural products," International Trade Administration, July 27, 2022.

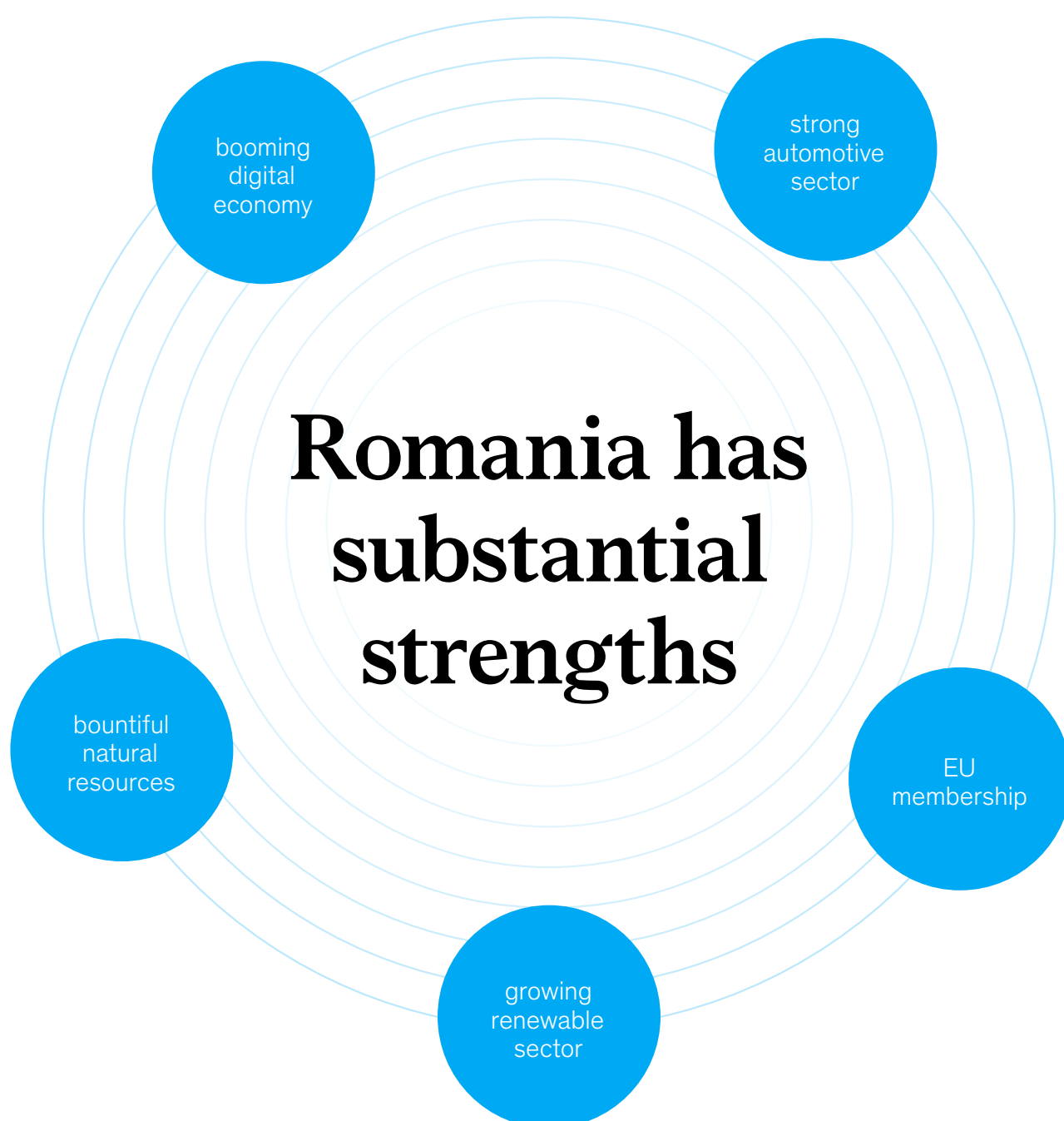
⁴⁹ Ibid.

⁵⁰ Gross exports have accounted for 11 percent of Europe's GDP over the past five years; in the US, the share is 7 to 8 percent. 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.

sure that Romania remains resilient and competitive against a backdrop of shifting geopolitics and a growing “winner-takes-most” dynamic. Romania has been sensitive to the fluctuating oil prices resulting from the war in Ukraine,

especially in the large refining industry that depends on oil imports.⁵¹

⁵¹ “Sustaining a green and sustainable recovery in the face of increased uncertainty,” European Semester Spring Package, European Commission, May 23, 2022.



Addressing challenges through policy

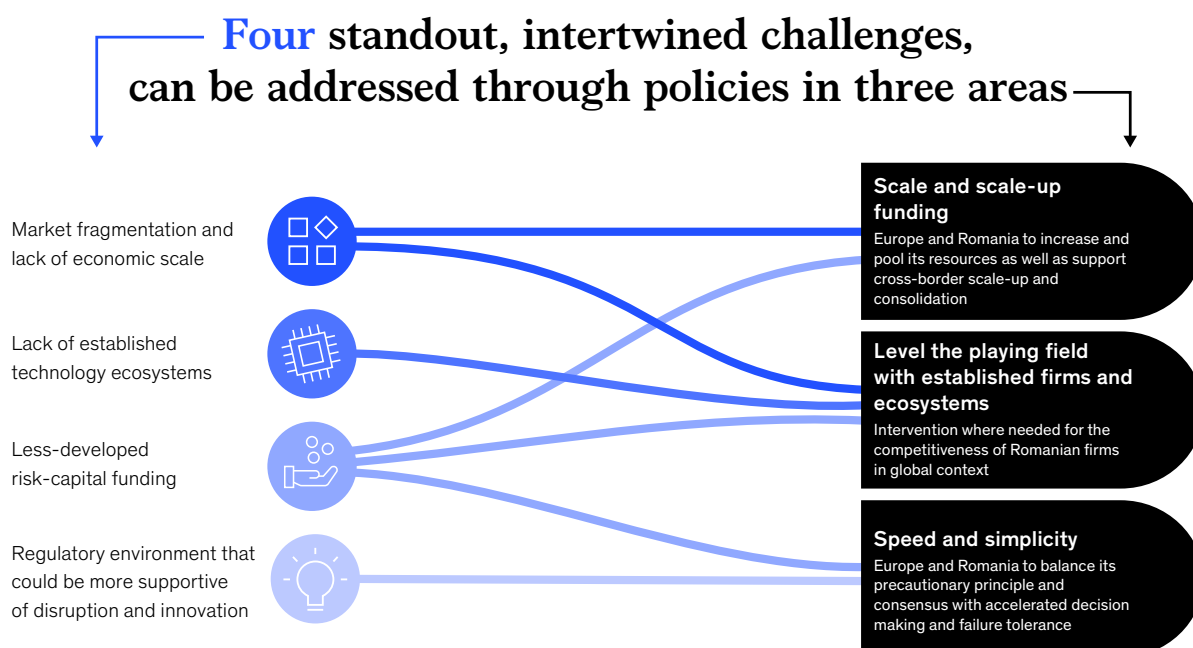
As the sources of competition—and growth—shift toward disruptive innovation and intangibles, scale, speed, and established technology ecosystems are increasingly vital to level the playing field. In this context, Romania faces four mutually reinforcing challenges: market fragmentation and lack of economic scale; less-developed risk-capital and scale-up funding; a complex and slow regulatory environment; and smaller and less-established technology ecosystems and firms (Exhibit 5).

Europe shares these problems when competing against China and the US, and the problems are amplified in Romania. To rebound faster from the current crisis, Romania requires more competitive markets and

stronger human capital than its EU peers. Competition is key to unlocking opportunities and creating jobs, yet a lack of quality education in some of Romania's regions hinders the country's productive potential and broadens the inequality gap.⁵²

⁵² Donato de Rosa and Alexandria Valerio, "To advance, Romania needs more competitive markets and stronger human capital," World Bank, May 12, 2020.

Exhibit 5



As a relative latecomer to the EU, Romania will have to match and even exceed the scale and impact of what others are doing to enable its firms to compete.

It cannot merely copy the method used by other countries; it will rather have to re-evaluate trade-offs in policy and regulatory initiatives, at both regional and national levels (see sidebar “EU-wide initiatives”).

EU-wide initiatives

Many necessary changes are at the EU level. Romanian leaders could support three bloc-wide initiatives, forming part of an integrated package. These would enable Romanian companies to operate at higher speed and with greater freedom, build scale and attract scale-up funding, and level the playing field with other countries and established firms.

1. **Raise awareness of transversal technologies and the importance of competitiveness for Romania and the EU.** An example is France's two-day ministerial conference on digital sovereignty in February 2022—part of the Scale-Up Europe initiative, which aims to make Europe home to ten technology giants each valued at more than €100 billion by 2030.⁵³ Romania has committed to the initiative, with both capital and talent. In fact, Romania has been a key player in initiatives to increase Europe's technological competitiveness. For example, since 2021, Romania has hosted the European Cybersecurity Industrial Technology and Research Competence Centre, which works with a network of national coordination centers

to fund cybersecurity research projects, increase Europe's cybersecurity competitiveness, and build a robust cybersecurity community.⁵⁴ Romania also hosts the Cybercrime Program Office of the Council of Europe (C-PROC), which helps countries to strengthen their legal systems to respond to cybercrime challenges.⁵⁵ Romania could continue to play a supporting role to such initiatives to accelerate Europe's technological competitiveness and bolster Romania's own position.

2. **Take the lead, or join other member states, in implementing EU-wide initiatives.** Romania has played an important role in co-leading initiatives in the European parliament, with Romanian representatives acting as a link between the Bucharest technology hub and European institutions. For instance, Romanian representatives initiated the Battery Alliance and the Platform of Carboniferous Regions in Transition to better understand what's at stake as Europe transitions from coal to clean energy sources for low-emission electricity production.⁵⁶ Further, Romanian Euro-elects coordinated the Common Agricultural Policy reform, which aims to unify the agricultural market in the EU to ensure common

prices and a preference for internal products over imports. Romania also managed the regional fund portfolio between 2014 and 2020, where it made a strong impact on the recovery of the Union economy. Romania could continue to play a leading role in implementing initiatives by bringing Romanian talent and expertise to the global stage.

3. **Provide political support for the adoption of such initiatives in EU bodies and institutions. Initiatives are more likely to succeed with political support that's human-centric and sustainable.** In the decade of digital transformation, the European Commission has proposed a digital compass that evolves around infrastructures, business, government, and skills, to empower businesses and people.⁵⁷ It aims to accelerate and support the launch of cross-country projects to advance Europe's digital transformation by 2030. Romania could benefit from being involved in such large-scale projects that cannot be developed by a single member state.

⁵³ Scale-up Europe brings together more than 30 start-up and scale-up founders, investors, researchers, and corporations. The aim is for Europe to become home to ten tech giants, each valued at more than €100 billion, by 2030; "Scale-up Europe spurs collective action to accelerate European tech," French Presidency of the Council of the European Union, February 2022.

⁵⁴ "Romania—country commercial guide," International Trade Administration.

⁵⁵ "Bucharest to host EU's new cybersecurity center," Romania-Insider, December 10, 2020.

⁵⁶ Vlad Epurescu, "Who are the Romanian MEPs who can make the books in Brussels and Strasbourg? What advantages do they have and to what extent can they be relevant in Bucharest as well?" Adevărul, June 16, 2019.

⁵⁷ "Europe's digital decade: digital targets for 2030," European Commission, 2021.

There are also numerous actions Romania can take, alone, bi-laterally or multi-laterally, to scale up technologies, become more agile, and level the playing field.

Scale and scale-up funding

Decision makers in Europe and Romania are aware of the need to close the technology gap and as such have implemented initiatives to enable corporates to build scale in key technology areas. Romania could consider the following initiatives to increase and pool its resources and support cross-border scale-up and consolidation:

Open more funds for risk capital.

The capital raised by Romanian start-ups more than tripled last year, from around €30 million in 2020 to €115 million in 2021.⁵⁸ However, this is a fraction of the €19.7 billion in venture capital (VC) raised for technology start-ups in Germany, and the €279 billion raised by US start-ups.⁵⁹ Romania could reduce its restrictions and capital requirements to enable asset managers and pension funds to invest more in alternative asset classes like VC and private equity. Going one step further, it could build pension institutions that operate at the scale and sophistication of global leaders.⁶⁰ Romania could also build on the Venture Capital Funds-of-Funds initiative (supported by VentureEU) to produce a public-venture capital fund.⁶¹ Here, Romanian crowd-

funding platforms that are specialized in technology startups, like Seedblink, could be used.⁶² Yet unlocking this finance hinges on the creation of an ecosystem of angel investors, as well as an innovative policy for venture capital funds. On top of this, co-investment schemes and tax incentives could be applied in the latter phase to support early-phase companies.⁶³

Establish joint public procurement and public investment in R&D with other EU members.

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 US. Moving to joint procurement in innovation-related areas, from defense to healthcare to education technology, would allow for larger bets and more regional focus, and would build an environment for scaling up leading Romanian firms. For example, countries pooled their orders for medical supplies during COVID-19, which was supported by legal frameworks. Romanian leaders could also consider increasing compensation schemes for lagging regions.

⁵⁸ *Romanian Venture Report 2021*, Howtowebe, 2022.

⁵⁹ Miriam Partington, "Germany tech in review: the key moments of 2021," Sifted, December 27, 2021; Priyamvada Mathur, "Six charts that show 2021's record year for US venture capital," PitchBook, January 19, 2022.

⁶⁰ 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; see also: Pooneh Baghai, Kevin Cho, Ju-Hon Kwek, and Philipp Koch, "Crossing the horizon: North American asset management in the 2020s," McKinsey & Company, October 6, 2021.

⁶¹ Under VentureEU, the EU is providing cornerstone investment of €410 million in independently managed venture capital funds-of-funds.

⁶² *Start-ups, scale-ups and entrepreneurship in Romania*, European Commission, October 2017.

⁶³ Ibid.

Increase tax breaks and subsidies to ensure higher scale and speed of adoption.

Romania offers a 150 percent tax deduction for qualifying R&D expenditure: creative and original research that fills gaps in scientific and technological knowledge.⁶⁴ This includes applied research to develop or improve existing or new materials, products, processes, systems, and services. Since Romania introduced the R&D tax break in 2016, the private sector's contribution to R&D expenditure has grown from 38 to 54 percent.⁶⁵ Romania could further increase tax deductions in certain industries, such as renewables, to attract funding and support their development. Alongside this, the Romanian government could support the opening of Romanian companies' subsidiaries in foreign markets through several measures, such as by providing legislative and logistical support or low interest financing programs for access to other markets (as demonstrated by Poland and the Netherlands).⁶⁶ Romanian state initiatives, like the Support Scheme, could further help Romania increase subsidies for the renewables sector.

Stimulate early demand for new technologies by having the government act as an early adopter.
Collaboration between the private

and government sectors could be key to unlocking opportunities and supporting economic recovery.

Government has a unique role as both provider and customer in the private market and could leverage this to plug into market gaps and support their scaling. An example is the IT sector: although Romania has established a telecommunications infrastructure that offers fast and affordable network access, its digital public services are underdeveloped.⁶⁷ The pandemic prompted authorities to introduce new technologies and encourage their use, but public services' digital availability and quality are below those of private ones. Romania could also look to other countries that have made strides here. Estonia, for example, has one of the world's most digitized populations.⁶⁸ The country's advanced financial technology and electronic ID-systems support broad societal uses—from 99 percent of financial transactions to voting.⁶⁹ In the United Kingdom, the Government Digital Service is testing a sweep of future technologies for various purposes, including machine learning to improve education, and autonomous robots in defense.⁷⁰ For Romania, further collaboration with the IT sector could solidify e-government solutions while supporting the development of new technologies.

⁶⁴ *Romania: Survey of global investment and innovation incentives*, Deloitte, October 2020.

⁶⁵ "GERD by source of funds," Eurostat, March 15, 2022.

⁶⁶ Mihai-Alexandru Cristea, "More unicorns born in Romania? Solutions to better promote tech founders," *Business Review*, March 16, 2021.

⁶⁷ Kamil Calus, "Digitisation in Romania accelerates during the pandemic," *Centre for Eastern Studies (OSW)*, September 22, 2021.

⁶⁸ Kristjan Puu, "Why Estonia's technology companies are worth twice its national budget," *BDO Global*, January 10, 2022.

⁶⁹ *Ibid.*

⁷⁰ Marcus Shephard, "Future technology in government," *Institute for Government*, May 21, 2019.

Level the playing field with established firms and ecosystems

Romania could level the playing field by considering where state intervention may be needed for Romanian firms to remain competitive in a global context. Romania could do the following:

Increase resources for low-income students.

Each unemployed person who drops out of school costs the Romanian state around €18,000 in their lifetime.⁷¹ Coupled with unrealized gains from income tax, the state loses as much as €272,000 over this period. Furthermore, Romania's education system has long been underfunded: the average government expenditure on education in the EU was 5 percent of GDP in 2020, but only 3.7 percent in Romania.⁷² Although Romanian public universities receive almost 63,000 fully paid study grants for first-year students, only around 2,000 are dedicated to students from rural areas.⁷³ Increasing resources for low-income students could enable their social mobility, ensuring the state's expenditure goes toward economic development.

Nurture and retain talent in science, technology, engineering, and mathematics (STEM).

Europe has the second-highest number of STEM graduates of any region in the world, but ramped-up

skills development could position companies and workers to be even more competitive in a technology-driven world. Romania's growth potential lies here—a third of the country's graduates were in STEM fields in 2020, and Romania has the second-largest share of people ages 25 to 64 working in these fields in the EU (after Ireland).⁷⁴ The number of STEM graduates in Romania has grown by 10 percent from 2015 to 2020, likely driven by the attractive salaries and tax incentives in the IT industry.⁷⁵ Additionally, Romanian programmers earn 25 percent more than their Eastern European counterparts, attracting foreign talent to the local IT sector, which is bolstered by Romania's digital nomad visa.⁷⁶ Overall, Romanian decision makers could consider greater coordination, increased budgets, and more visibility to attract, develop, and retain STEM and entrepreneurial talent, including talent from abroad. The tax-incentive recipe that proved successful in the IT industry could be replicated by the government in other critical STEM fields to increase talent density in strategic sectors. In addition, the recent commitment to a new European Tech Talent service desk, in collaboration with the European Startup Nations Alliance, is another example of what can be done.⁷⁷ Romania could further

+10%

Romanian programmers earn more than their Eastern European counterparts

⁷¹ *The cost of education: Investment, efficiency, impact*, Deloitte, August 2021.

⁷² "Total general government expenditure on education, 2020," Eurostat, February 28, 2022.

⁷³ "Number of places—study grants (first year) financed from the state budget for university undergraduate studies, in the form of full-time education, from state higher education institutions, for the 2018–2019 academic year," Romanian Ministry of Education.

⁷⁴ "HRSTO by occupation, age 25–64, 2021," Eurostat.

⁷⁵ Carmen Radu, "IT salary map. How much does a programmer in Romania earn compared to the neighbors and where are the highest salaries in the sector?" Economedica, July 15, 2022.

⁷⁶ Ibid; "Romania launches digital nomad visa," SchengenVisa, January 30, 2022.

⁷⁷ *Scale-up Europe spurs collective action to accelerate European tech*, French Presidency of the Council of the European Union, February 2022.

attract foreign talent by introducing tax reductions for digital nomads (like Greece), or by shifting immigration policies to a points-based one, as used by Australia.⁷⁸

Double down on funding education in the sector and supporting technological transformation.

The education system may require reform to grasp this opportunity, as it is less established than its EU counterparts. While a minority of Romanian students excel, almost 40 percent of 15-year-olds have not mastered basic skills according to PISA 2015, and almost 20 percent leave school before completing their higher secondary education.⁷⁹ Romania could enhance its evaluation and assessment system to give every student a chance to reach their full potential, by setting higher aspirations for teaching and learning with greater support for students and teachers. For example, Romania could design its examinations to assess a broader set of skills.

Implement direct measures on wealth redistribution.

Romania has fairly high levels of income inequality when compared with the top five performers in the EU-30, and a sluggish social-mobility index, while the public sector plays a smaller role in the economy than the EU peers (that is, the share of public spending in GDP). To combat this, the government could introduce measures such as an inheritance tax (a tax on estates, including the property, money, and possessions of the deceased), or an increased marginal tax (the highest tax rate that can be applied to a portion of one's income) that could then be used to fund social mobility interventions (such as offering more fully-paid study grants to students

from disadvantaged backgrounds). It could further strengthen activation policies to encourage the unemployed to boost their job searches by providing benefits to those who participate in programs. Romania could also increase collaboration around grassroots support to develop innovative solutions in resource-poor neighborhoods with the help of local governments and communities. Overall, more of the country's GDP could be allocated to creating accessible, quality education, supporting the health system, and to rural areas.⁸⁰

⁷⁸ "Portugal introduces new campaign to attract digital nomads from Britain," SchengenVisa, August 12, 2022; Rosalind Smith, "What are countries doing to attract international talent?" Mauve Group website.

⁷⁹ *Romania 2017*, OECD, May 3, 2017.

⁸⁰ *Inequalities in Romania*, World Vision Romania, June 2019.

Speed and simplicity

Speed will be vital in Romania's journey toward closing technology gaps. COVID-19 showed that regulators in Europe and elsewhere can become more agile—this speed could now be applied to a broad range of innovation-related areas:

Develop fast-track regulatory approval and decision-making processes.

In disruptive innovation, speed matters, yet countries in Europe tend to move relatively slowly, with lengthy consensus-based decision making and slower administrative processes (patenting, for example, is half as fast as in the US). Regulators could take an accelerated approach to tech-enabled sectors, even if that means occasional setbacks and adjustments. This could be particularly powerful when paired with a common corporate rulebook. For example, Romania could increase the speed at which medicines approved by the European Medicines Agency (EMA) become available to the public: the country currently has one of the longest time-to-availability in the region (775 days, relative to European counterparts, where evaluation takes up to 210 days).⁸¹

Incentivize companies to invest in employee training and reskilling.

For rapid technology adoption, labor markets will need to be flexible. As disruptions spread, more workers will need to change occupations or activities. Labor market rules will likely need to be amended to support faster reallocation. Through Romania's National Strategy for Employment, the government could implement education and vocational-training programs to develop skills for an adaptable and resilient workforce. To incentivize

companies to train employees and develop their professional competencies, Romania could offer tax credit, subsidies, grants, and vouchers. For example, Finland offers a tax allowance whereby it deducts employee training expenses from the company's income tax.⁸² It's a win-win scenario for both company and country.

Rebalance the regulatory approach to one that weighs the benefits of rapid experimentation and disruptive innovation.

Within the bounds of regulations set by the EU, Romania can make certain improvements. EU regulation—of, for example, data privacy or autonomous mobility—may encourage activities to move to other regions. However, in certain breakthrough technologies, Europe could choose to ease consumer-protection requirements to allow faster research on, and roll-out of, disruptive innovation, with the aim of achieving better outcomes for citizens rather than minimizing risks. It could also ensure that regulation is consistently outcome-oriented rather than restriction-based.

As the Ukraine war looks set to continue, and geopolitical and technological shifts disrupt the status quo, Romania can kickstart collaborations between its private and public sectors, and with other EU member states, to make the trade-offs needed for technology and competitiveness. This could be key to Romania keeping up with global rivals and propelling economic growth and investment, while supporting social progress.

⁸¹ *Applying for EU marketing authorization*, European Medicines Agency, 2015.

⁸² "Employee Training Incentive Program (E-TIP) tax credit," New York State, January 19, 2022.

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