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GLOBSEC Tatra Summit Insight Report 2021

Harnessing Disruption to Address Innovation and Skill Gaps in Central and Eastern Europe

2nd Edition
October 2021

STRATEGIC PARTNERS

institute for financial policy

MINISTRY
OF FINANCE
OF THE SLOVAK REPUBLIC

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Preface

"Never let a crisis go to waste." This famous quote by Sir Winston Churchill – which epitomises hope and using every challenge as an opportunity to better ourselves – remains a timeless guiding principle forever! In crisis have we been for some time now – on occasions, in agony – but as vaccines roll out, restrictions are lifted, and infections and deaths decline across Europe and the developed world, we see a glimmer of light at the end of the coronavirus pandemic tunnel: an optimism that the worst of the pandemic could be over.

Over the last fifteen years the European economy has been subjected to multiple intense crisis scenarios: from Lehman to sovereign debt, from migration to the Covid-19 pandemic, while the potentially far-reaching and irreversible fallouts of the climate crisis lurk upon us. Each of these crises has extended beyond the EU, and each has underscored its vulnerability, while Europe's global competitors have been gaining ground. We must be way more ambitious if we want to come out stronger from this crisis.

As I see it, the target is clear. Getting European competitiveness back on track is a necessary pre-condition for the much-coveted resilience of the European economy. The 2021 GLOBSEC Tatra Summit will deal with precisely these challenges: where to invest to strengthen Europe's competitiveness in the global context. Several ingredients are needed to advance towards such ambition:

- Increasing our innovation capacity requires massive investments in education and research. This includes the full range from kindergarten to universities, buttressed by life-long learning.
- Digitising our economy and our society is a must. Like it or not, digital transformation will be the key driver for our global positioning.
- The green transition is also a must if we want to win the race against climate change: we have the find the right balance between ecological needs and economical soundness.
- A well-functioning infrastructure from rail to road, from 5G (even 6G) to charging infrastructure for e-mobility are key prerequisite for regaining competitiveness.
- The social dimension of any successful recovery is of utmost importance: health infrastructure, new way of working, and affordable housing are just a few areas where especially the young need proper answers.

Importantly, how successful we are is not only in policymakers' hands, but rests on productively engaging the private sector, even as billions of euros are being poured to public budgets through various standing facilities. "Recovery Partnership" must be the name of the game, blending private and public money to increase the efficiency of public spending, and the quality of investment projects. Promotional banks or institution will have a key role in their implementation. Private money is urgently needed to close Europe's investment gaps at a global scale, and it should flow into exactly these investment priorities mentioned above, buttressed by sound and strong banks, budding capital markets, a predictable and stable regulatory system and reliable legal system to fight corruption.

The 2021 GLOBSEC Tatra Summit creates a single conversation juncture for such strategic discussion, creating a "Recovery Platform" for private and public players, and at the same time a space for the coordination of nationally designed recovery plans. The more global thinking of businesses can enrich the perspective of local policymakers. Countries' recovery paths would additionally benefit from cross-border cooperation in Central Europe, boosting the region's potential to become a major player within the EU and on a global scale.

Looking forward to seeing you at the 2021 GLOBSEC Tatra Summit,

Wilhelm Molterer

Chairman of the Board of Directors, GLOBSEC

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The principal author of the Report is Soňa Muzikárová, Chief Economist and Head of Economic Growth & Sustainability Programme at GLOBSEC.

Chapter 1 was advised by Iwona Maria Borowik, a Senior Innovation Economist at the World Bank Group and researched and co-authored with William Sommer, a graduate Economic Growth & Sustainability Programme research intern at GLOBSEC. Box 1 was co-authored with Anett Numa, Digital Transformation Adviser at e-Estonia. UiPath's Margareta Chesaru inputs on Romania's innovation environment is gratefully acknowledged.

Chapter 2 was co-authored with Dr Miroslav Beblavý, visiting lecturer at Sciences Po Paris and Scientific Coordinator at the European Expert Network on Economics of Education (EENEE). Research assistance was provided by Barbora Bačová, Research Assistant to Dr Beblavý.

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Executive Summary

As the past decade concluded, the new one began abruptly with an unprecedented and powerful shock to the global economy caused by the Covid-19 pandemic. Its arrival has reset the clock for the region of Central and Eastern Europe (CEE9), magnifying the shortcomings of its existing macroeconomic growth paradigm, faltering competitiveness, and the need to further improve economic resilience. It highlighted that rather than competing primarily on cost, the CEE9-region's forms of production should be morphed into knowledge-intense, technology-proficient, low-carbon, and all-over sustainable to advance the new, post-Covid social and economic contracts and deliver value to citizens, firms, and workers.

The 2021 edition of The Tatra Summit Insight Report continues to cater to the quest for a bold, strategic economic transformation. In the first two topical chapters it scrutinises two fundamental structural areas crucial for making the leap towards a new growth narrative: respective innovation environments in CEE9 (Chapter 1), and skill provision in Central Europe (Chapter 2). Chapter 3 then follows with research and policy insights based on GLOBSEC composite quantitative diagnostic tool, the CEE Strategic Transformation Index (STI), anchored at the Tatra Summit platform.

STI benchmarks CEE9 economies – Austria, Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, the Slovak Republic, and Slovenia – in relative terms, and within the broader context of selected control group of advanced European economies. It offers evidence-based policy insights into the region's past macro-resilience performance as well as forward-looking structural policy areas, including education, green and digital transitions, and innovation to help unlock its new growth paradigm. As such, it also serves as an evidence-basis to underpin the high-level policy dialogues of political elites, top-of-the-line policy experts and researchers, private sector leaders, academia and third sector frontrunners at the Tatra Summit platform, coming in as a handy macroeconomic policy compass for the region.

As per the 2021 index results, Austria defends its top performer standing, with an overall score of 63.9 points. The index value 63.9 is interpreted as being almost at a 2/3rd point between the worst and the best performer in the sample between 2010 and 2018, benchmarking each country and placing it on a scale between broad sample's bottom and top performer, while also making it comparable in time. Austria is followed by Slovenia (57.0), Czechia (56.0), Poland (51.9), Hungary (51.2), the Slovak Republic (47.8), Croatia (41.1), Romania (40.3) and Bulgaria (35.6). The index is further split into two main pillars, a more backward-looking element, Macroeconomic Performance & Resilience (Pillar 1) and a forward-oriented element, the Innovation Economy (Pillar 2). Each of these two pillars is further split into four thematic sub-indices, revealing country strengths and weaknesses at a more granular level.

Box 1. GLOBSEC CEE Strategic Transformation Index (STI) in Brief

- Caters to the need to formulate a new growth narrative and the underlying policy blueprint in CEE9
- Ideal timing to take the leap, as a part of post-pandemic transformation momentum
- GLOBSEC Tatra Summit as a platform amplifies and multiplies the index's impacts
- Support of strategic policy dialogue taking place at the GLOBSEC Tatra Summit
- Creates evidence-based pressure to act on policy weak points
- Enhances decision transparency, accountability, and integrity of policymaking
- Potentially boosts policy strategy-to-execution by providing a measurable basis for progress

The 2021 results are encouraging, as all CEE9 countries have posted gains towards the transformation frontier (Chapter 3). It is important to note that the 2021 index results refer to 2019 pre-pandemic information (t-2). Two notable points emerge from that, without having to dive deep into country-level or structural performance drivers. One, the pre-Covid19 CEE9's economic resilience, as defined in the report, fared well, compared to the control group of western-European and Nordic countries. And two, since the relative structural pain points as identified by the forthcoming analysis refer to pre-pandemic information, the need to expedite solutions has grown manifold since. Hence, albeit the year-on-year gains, bold and results-oriented policy action, like-minded alliances across borders, and prudent use of available rescue instruments will be needed to turn the walk towards the transformation frontier into a gallop.

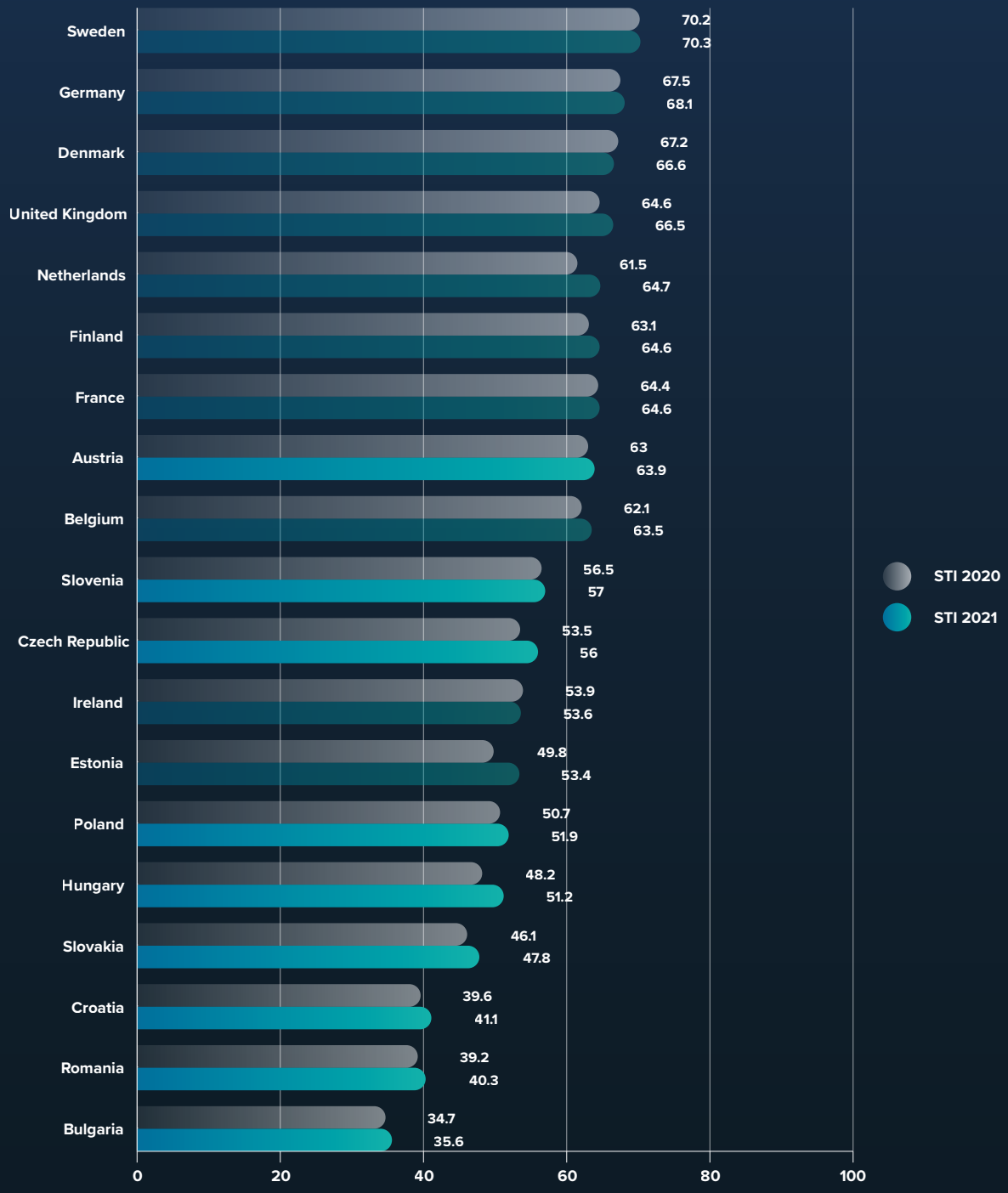
Since strategic economic transformation is a long-game, many of the challenges identified in the past report hold up, including CEE9's due progress on the education dossier, actionable and targeted policy approaches to move towards higher value-added domestic activities drawing on their core competencies and existing flagship industries, and the not-so-straight-forward quest to lay down innovation-conducive fundamentals. Even top performers need improvements in these policy arenas to close the gap vis-à-vis the control group of advanced European economies and to move closer to the 'distance to frontier' – the aggregate 'ideal' across all sub-indices of strategic economic transformation. Specific policy leads for each CEE9 country are drawn and presented in the Country Profiles section.

The Covid-19 pandemic is a game-changer at the global, regional, and local scales. And despite the losses it has incurred on our economies and societies, and the tragedies it has inflicted on human lives, perhaps this is a once-in-a-generation chance to catalyse a radical mindset shift and a more conscientious approaches to organisational change and policymaking. In a fast-paced, disrupted world where governments are one step behind, multistakeholder approaches to policy design yield better-suited solutions than classic top-down approaches. This means governments should use private sector's inputs to make policy and involve them in setting the rules where appropriate, but it also means letting companies go and exposing them to competition and market-forces to forge productivity-enhancing reallocations. All stakeholders are jointly responsible for contributing to a positive change. Like-minded alliances of key economic actors beyond political cycles can be effective and very important in defending strategic policy interests, carrying momentum of a strategic economic transformation, and preserving progress made on the transformation agenda.

CEE Strategic Transformation Index 2021

Global Rankings at a Glance

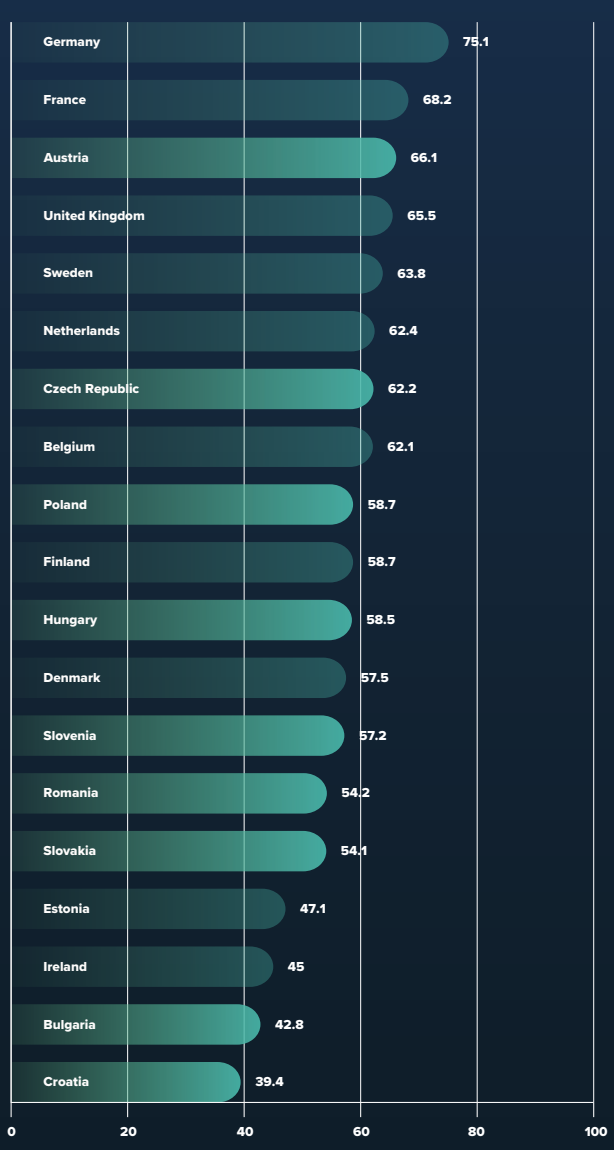
The GLOBSEC CEE Strategic Transformation Index 2021: Overall Ranking



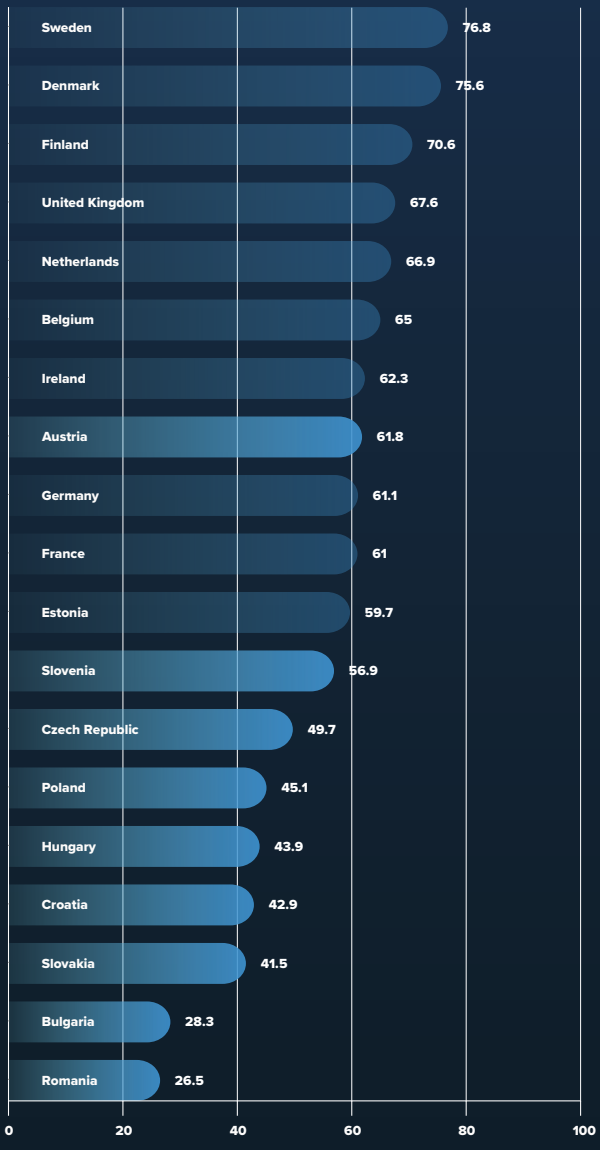
CEE Strategic Transformation Index 2021

Global Rankings at a Glance

Pillar 1. Economic Structure & Resilience (LHS)



Pillar 2. Innovation Economy (RHS)



1. The Tatra Summit 2021 Insight Report

Introduction: Europe Forged in Crisis

French diplomat Jean Monnet, an architect of the European Union (EU), once said "Europe will be forged in crises." He was not wrong.

The period after the 2008-2009 Great Financial Crisis (GFC) has seen remarkable progress in strengthening financial regulation and resilience, including by harmonising macroprudential rules with pointers how to adjust them during distress, analytical capabilities in place to instantly compare the soundness of Europe's systemic financial institutions and financial oversight readily mobilised. The foundations for banking union were laid to ensure that Europe's banking sector is stable and safe. The brisk and synchronised monetary, macroprudential and regulatory response to Covid-19 hinges on important improvements made in GFC's aftermath.

The 2011 Eurozone crisis catalysed permanent standing facilities to help European governments cope in times of sovereign financial distress. It yielded the European Stability Mechanism (ESM), which provides financial assistance to safeguard the financial stability of the euro area through its lending toolkit and the European Council paved way for banking union.

The pandemic forged a major paradigm shift, when it returned the Next Generation EU facility, with its centrepiece, the Recovery and Resilience Facility (RRF), featuring a common-European debt instrument. The €1.07 trillion, largest-ever budget alongside an additional €750 billion stimulus through the Next Generation EU facility represent a bigger financial outlay, measured as a percent of GDP, than the total aid granted by the U.S. to post-war Europe via the Marshall Plan.

Monnet's prediction has proved salient. This time, the pandemic is part of a triple-threat, combined with the pressing need to tackle climate change and meet the fourth industrial revolution upon us. The wheel of transformation is set in motion, while governments, firms, and citizens are faced with a challenge and an opportunity of an unparalleled scale.

Thankfully, the ambitions of the pandemic rescue plan extend well beyond returning Europe's economy to the pre-pandemic status-quo. Over 50% of budget outlays are earmarked for modernization programs such as research and development investments, decarbonization programs, and innovation initiatives. Spending rules for the €672.5 billion RRF mandates that 37% of funds be directed towards climate investments and reforms, and that at least 20% of funds are directed towards digitalisation, recognizing the urgency to tackle the triple-threat as a part of the pandemic recovery.

This investment in Europe's deep transformation could not be coming at a more critical time. Even pre-pandemic, the EU was struggling to remain competitive with the U.S. and major Asian economies in adopting and developing frontier technologies. While Europe retains some advantages in fields such as mobility and green technology, in many areas including AI, e-commerce, internet of things, and computing, the EU is barely in the race. Targeted and efficient allocation of the recovery funds, therefore, paired with national and unionwide policy reforms, will be crucial in resetting Europe's growth trajectory and improving the block's global competitiveness.

The plea is even more urgent for the region of Central and Eastern Europe (CEE9: Slovakia, Czechia, Hungary, Poland, Austria, Slovenia, Romania, Bulgaria), whose once-very effective growth paradigm has been trumped by the global megatrends such as digitalisation and growth greening, with which the region has lost stride.

The 2021 vintage of the GLOBSEC CEE Strategic Transformation Index is a testament to this and based on 47 individual data series under-scores the region's structural weak spots. In most region's economies, governments are overdue to enable an innovation ecosystem with conducive policy-setting and conditions that have been proved to work. Skills provision to buttress the transition to innovation-fuelled growth, and towards green and digital transition remain severely behind-the-curve.

Drawing on the Index results, the 2021 GLOBSEC Tatra Summit Insight Report highlights these pain points with detailed research and policy insights focusing on the building blocks upon which a potential streamlined innovation strategy for CEE9 can be predicated *(Chapter 1)*; and, how to reskill bottom-up in the absence of a top-down

reform, as well as how can the two approaches be synergic *(Chapter 2)*.

On top of the uneasy feat to go smart, innovative, and green, the Covid-19 shock has provoked questions – including big questions as regards to Europe's economic and financial architecture – that cannot go unanswered for much longer because of their importance to rapid and robust post-Covid recovery. Just to name a few, they concern *(i)* will policymakers be able to push through the previously unpalatable structural reforms in addition to the investment projects under the RRF; *(ii)* how and when to phase out the indiscriminate fiscal support that ensued in Covid-19's wake, for greater productivity and resilience (i.e. what to do about jobs and firms with business models designed for the 'old world': bricks and mortar shopping outlets, fossil fuel companies, banks with near-obsolete branches, etc.); *(iii)* how to reform the current EU fiscal rulebook in the face of their suspension when Covid-19 hit, ballooning debts, and rising inflation on the horizon; *(iv)* what is policy-makers' and regulators' role in rolling out and incentivising green and digital transitions (e.g. central banks' in motivating green finance or going cashless); and *(v)* how to tie all these moving parts the European architecture, so that it is future-proof in the milieu of the impending transformation waves, and makes sense for EU citizens, firms and other key actors?

GLOBSEC Tatra Summit's 10th anniversary takes place on a bedrock of a galvanizing cocktail of macro-financial issues, narratives and questions that will direct and define our joint future, health, and prosperity for decades to come. We hope you enjoy the 2021 Insight Report and find the high-level strategic discussions at the 2021 GLOBSEC Tatra Summit platform valuable!

Yours sincerely,

Soňa Muzikářová

Chief Economist & Head of Economic Growth & Sustainability Programme, GLOBSEC

Chapter 1.
Harnessing Disruption to Forge Innovation-led Growth in CEE9

By Soňa Muzikárová and William Sommer.

The 2021 STI suggests sub-index (H.) *Capacity to Innovate* to be one of the relative weakest structural areas in the CEE9-region. But an inclusive economic recovery – future-proof and one that is fit to face the challenges of the post-Covid era – rests on a growth paradigm that is smart and sustainable. **As leaders convene for the 10th Tatra Summit to shape a post-pandemic future of Europe, with a special focus on the CEE-region, most agree that the plea is not to return to the manufacturing-reliant growth model but the need to rethink pre-pandemic growth strategies.** The choices made by decision-makers, business leaders, and employees today will shape societies for decades to come. At this critical crossroads, leaders are to consciously, proactively, and urgently lay down enabling conditions for innovation-led growth paradigm. **This chapter is to serve as a factual basis to that end, and a background brief for the innovation-focused discussions at the Tatra Summit platform.** It deliberates why now is the right time to take the leap *(Section I)*, what the EU-led efforts have looked like in the past *(Section II)*, surveys the current status quo in each CEE9 country *(Section III)*, and based on the findings identifies potential policy areas for a common regional CEE9-approach *(Section IV)*.

CEE9 Growth Reset: Seizing the Potential of Covid-19 for Innovation

History teaches us that shocks precede transformation. The challenge presented by the pandemic – immense as it has been – is exacerbated by the climate crisis and technological revolution. This is high-noon for a material change in the way the CEE9-growth is powered, which should be underlined by a mindset shift at the levels of policymaking and business. CEE9-economies must gear up for the global economy of tomorrow to become more resilient and competitive.

The deep transformation ahead is a high-stake challenge but also a remarkable opportunity. The Recovery and Resilience Facility (RRF) under the EU Next Generation pandemic response package is one significant tool focused on the double challenge emanating from environmental degradation on the one hand, and on the need to keep up the pace with technological advances on the other – to invest in change and push forward a previously unpalatable structural reform. There are other, additional important standing facilities in the EU toolkit.

The ambitions of the rescue plan extend well beyond returning Europe's economy to the pre-pandemic status-quo. Over 50% of budget outlays are earmarked for modernization programs such as R&D investments, decarbonization programs, and innovation initiatives. Spending rules for the €672.5 billion Recovery and Resilience Facility (RRF), the centrepiece of the Next Generation EU, mandate that 37% of funds be directed towards climate investments and reforms, and that at least 20% of funds are directed towards digitalisation.

This investment in Europe's innovation economy could not be coming at a more critical time. Even before the pandemic, the EU was struggling to remain competitive with the U.S. and major Asian economies in adopting and developing frontier technologies, while the CEE9-region (except Austria) has by-an-large reached the frontier of its development policy, failing to transition to a high-income bracket due to rising costs and declining competitiveness[1]. While Europe retains some advantages in fields such as mobility and green technology, in many areas including AI, e-commerce, internet of things, and computing, the EU is barely in the race. Targeted and efficient allocation of recovery funds, paired with national and unionwide policy reforms, will therefore be crucial in resetting Europe's innovation trajectory and improving the block's global competitiveness.

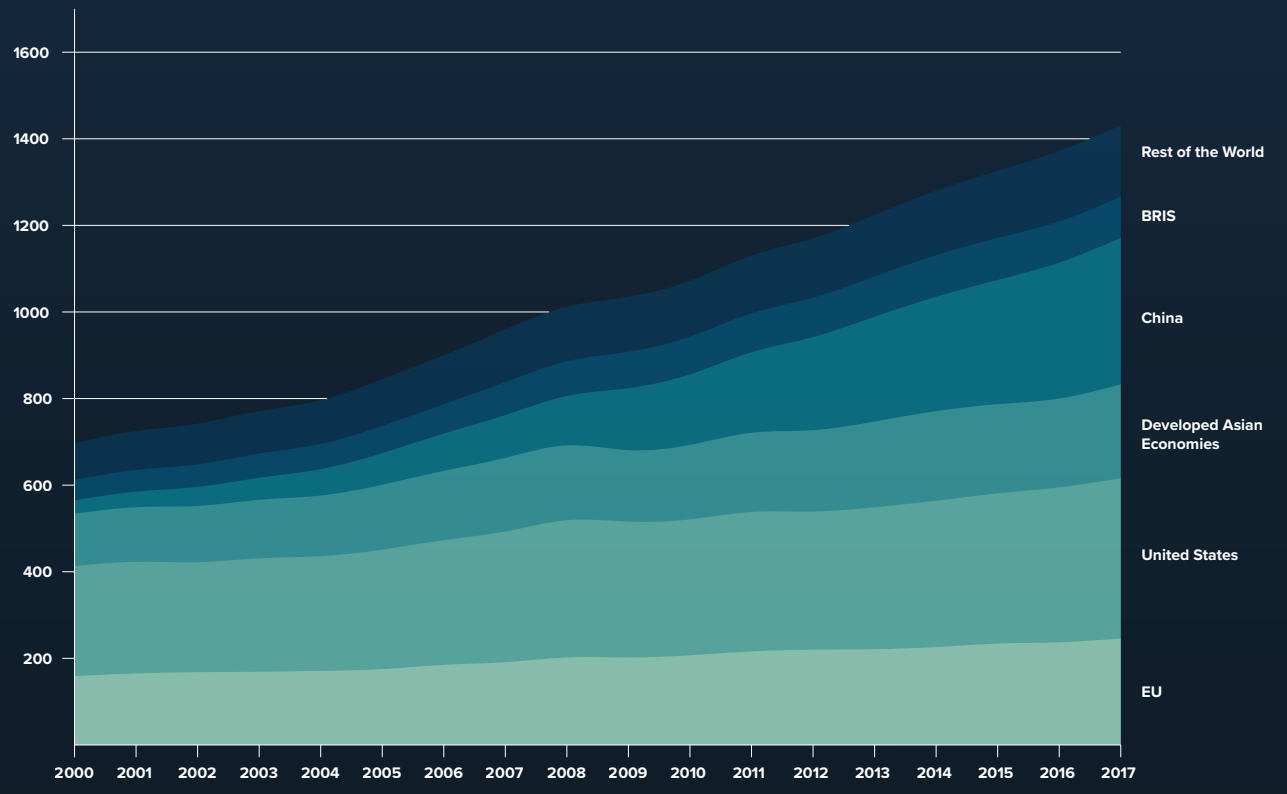
1 A more-detailed discussion of the middle-income trap in the context of CEE9 is presented in the 2020 edition of the GLOBSEC Tatra Summit Insight Report, available at: https://www.globsec.org/wp-content/uploads/2020/10/Tatra-Summit-Insight-Report-2020.pdf

Past EU-led Efforts

The EU has announced significant plans to spur innovation in the region well before the pandemic set. In 2011 the EU (EU) launched a flagship initiative under its "Europe 2020" strategy known as the "Innovation Union". The Innovation Union served as a framework to: *"improve conditions and access to finance for research and innovation, [and] to ensure that innovative ideas can be turned into products and services that create growth and jobs"* [2]. The plan lamented Europe's technological and entrepreneurial weakness compared to its peers, notably, the United States and Japan, as well as China's growing innovation capacity. It noted Europe's anaemic investment in research and development, weak capital markets, and fragmented regulatory framework and economic environment, as significant impediments to European innovation. Moreover, in achieving Innovation Union goals, the framers of the plan recognised that significant investments and reforms would be required. Specific targets included R&D investment equal to 3% of GDP or greater in all member states, greater reliance on the private sector for developing next generation technology, and increased spending on Information and Communication Technology (ICT)[3].

With the expiration of the Europe 2020 strategy last year, and a new "Horizon Europe" innovation strategy coming into effect in April 2021, buoyed by the €672.5 billion Recovery and Resilience Facility, **many of the challenges described in the 2011 Innovation Union strategy remain today, and in some cases, have become more dire.** R&D spending in the EU only increased by 0.2% between 2010 and 2019 to 2.18% of GDP, well behind the R&D spending of innovation leaders such as South Korea (4.53%), Japan (3.26%) and the United States (2.83%)[4]. Moreover, research investment in Europe is significantly more dependent on public spending than in other peer economies. In Europe, the public sector is responsible for approximately 33% of R&D spending, compared to 15% in Japan, 20% in China, 10% in Israel, 25% in the United Kingdom, and 30% in the U. S[5].

Figure 1. Evolution of world expenditure on R&D in real terms, 2000-2017



Sources: Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat, OECD, UNESCO.

2 European Commission. (2010, October 6, p.1). Turning Europe into a true Innovation Union. [Press release]. https://ec.europa.eu/commission/presscorner/api/files/document/print/fr/memo_10_473/MEMO_10_473_EN.pdf

3 European Commission. (2010). Turning Europe into a true Innovation Union.

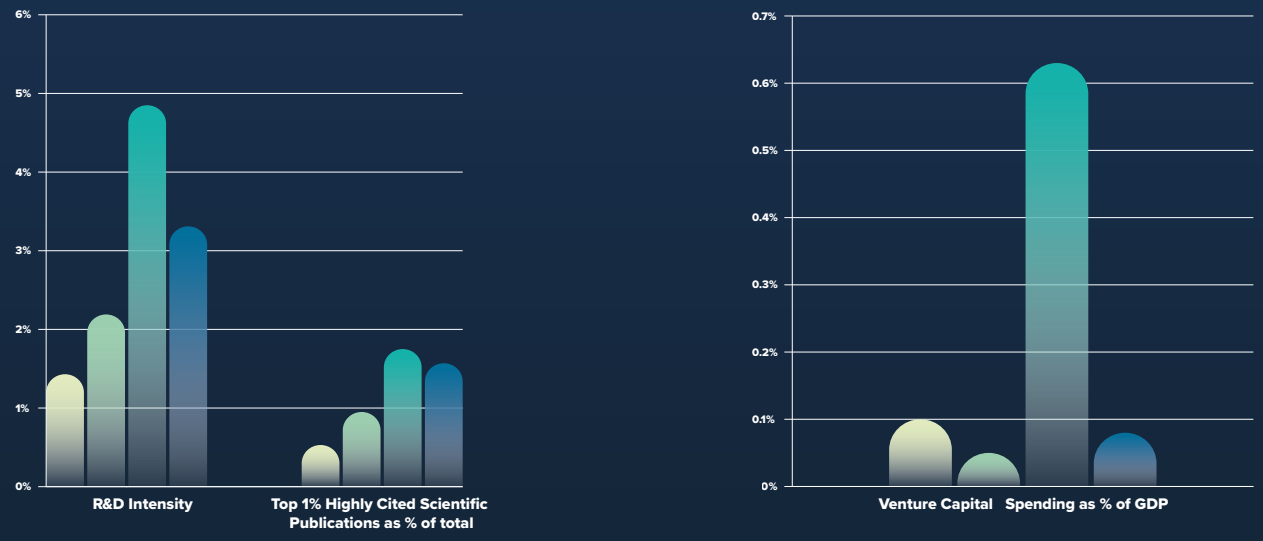
4 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe. Publications Office, LU. https://ec.europa.eu/info/sites/info/files/srip/2020/ec_rtd_srip-2020-report.pdf

5 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

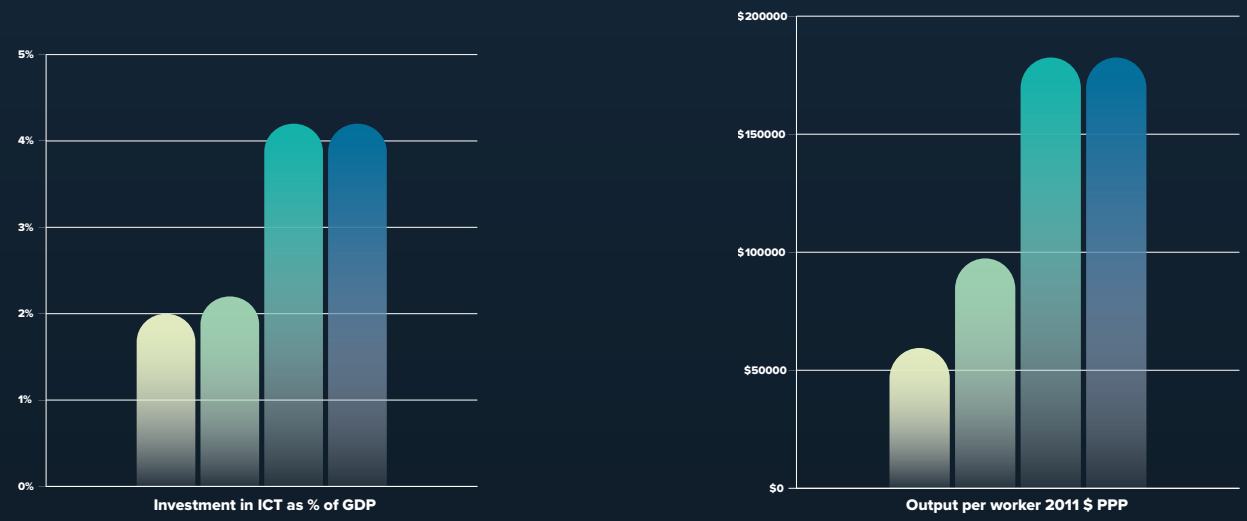
Thus, not only is Europe underinvesting in R&D compared to peer nations, but much of the research is being steered toward public institutions, which are less likely to immediately apply technological breakthroughs to productive endeavours. These weaknesses contribute to the current dynamic where of the world's 15 largest technology companies, not one is European, and where Europe is a laggard in most high-tech and frontier industries[6].

Europe is still struggling with technology adoption and digitalisation. In the EU 37% of companies still have not adopted any form of digital technology, compared to 27% in the U.S.[7] The failure of European firms to implement business technology systems is particularly worrying given

Figure 2. Snapshot of EU's Key Innovation Metrics Vis-à-vis the World



Source: European Commission (LHS); OECD (RHS).
Notes: LHS chart refers to 1% highly cited scientific publications as a % of total (2018, World: Switzerland, Europe: Netherlands)
RHS chart refers to Venture Capital Spending as % of GDP (2018, World: US, EU, Sweden)



Source: European Commission (LHS); OECD (RHS).
Notes: Investment in ICT as % of GDP (2017, missing BulgariaCroatia and Romania, World & EU: Netherlands)
Output per worker 2011 $ PPP (2018, productivity, World & EU: Ireland)

6 Bughin, J., Windhagen, E., Smit, S., Mischke, J., Sjatil, P.E., & Gurich, B. (2019). Innovation in Europe: Changing the game to regain a competitive edge. McKinsey & Company. https://www.mckinsey.com/~/media/mckinsey/featured%20insights/innovation/reviving%20innovation%20in%20europe/mgi-innovation-in-europe-discussion-paper-oct2019-vf.pdf

7 European Investment Bank. (2020). Who is prepared for the new digital age? : Evidence from the EIB investment survey. Publications Office, LU. https://op.europa.eu/en/publication-detail/-/publication/d3b8f418-99b7-11ea-aac4-01aa75ed71a1/language-en

than studies by the European Investment Bank indicate that digital firms tend to grow faster and hire more employees than their non-digital counterparts[8]. These problems are compounded by weak investment in digital infrastructure by the public sector. While public investment in high-speed broadband and connectivity has increased in recent years, a lack of sufficient digital infrastructure is still viewed as an impediment to investment for 16% of EU companies, compared to 5% of companies in the U. S[9].

Underpinning these shortcomings is underwhelming venture capital investment – the key to unlocking finance for growing promising firms – which lies at the core of promoting innovation. In 2019 venture capital (VC) investment in the U.S. was over fifteen times greater than in the EU[10]. Moreover, in South Korea VC lending was almost 33% of that in the EU, while VC lending was virtually equivalent in Israel and the EU, which is particularly striking given that the GDP of Israel is only 2% that of the EU[11].

Well-functioning capital markets are an important channel for allocating capital to firms with the greatest potential for productivity gains thanks to the roll-out of innovative processes and the commercialization of new technologies[12]. But European capital markets remain fragmented and shallow. In aggregate, the stock market capitalization of Europe was 52% of GDP in 2018, barely higher than Israel (50%), and significantly lower than Korea (82%), Japan (107%) and the United States (148%)[13]. The gap in capital access is even starker among start-ups. Ultimately, EU companies are significantly more dependent upon domestic bank loans for financing than firms in peer economies, disadvantaging high-risk ventures in relative terms. While bank loans may suffice for technology adoption, they are typically not a suitable option for innovation (i.e., R&D commercialization or entrepreneurship)[14].

Many of these trends are related to the continent's business and policy landscape. On the one hand, European nations share a relatively rigid and inflexible business environment, which does not create sufficient conditions for creative destruction. This pertains to both firms and labour markets. European labour markets are, on average, more than twenty times less flexible than the US labour market, based on the composite OECD's 2019 Strictness of employment protection – individual and collective dismissals (regular contracts) indicator[15]. Recent data on firm bankruptcies are a case in point: while in 2020 bankruptcy rates in the US remained broadly unchanged in annual terms, decrease in bankruptcies has been observed across most Member States owing to the government supporting measures during the Covid-19 crisis[16]. **At the same time, other regulation is highly variant among EU countries,** including but not limited to financial markets regulation, creating barriers to entry, and achieving scale[17]. So, while American, Chinese, and Japanese companies can rapidly reach hundreds of millions of domestic customers, European countries must contend with a kaleidoscope of national identities, languages, laws, and taxes, limiting the growth of both frontier start-ups and international champions alike. Although over 36% of formally funded start-ups are founded in Europe, 14% of unicorns come from the continent[18]. The EU also has a disproportionately low number of large companies, which represents a significant challenge given that large companies are responsible for most of the global R&D spending[19]. Indeed, approximately ⅔ of worldwide private R&D spending is carried out by only 250 companies, the majority of which are headquartered in the U.S., Japan, and China[20].

While the EU remains one of the world's largest and wealthiest economies, the continued prosperity and dynamism of Europe depends on addressing these weaknesses. Europe must adopt and develop frontier technologies such as green tech and AI, scale national and continental industry champions, incubate innovative firms that produce next-generation systems and goods, compete with peer nations in R&D spending, commercialization, and labour productivity, and consolidate its fragmented markets. Given a declining population, the increasingly dominant market-share of American and Asian companies, and the rapid growth occurring in emerging economies, Europe faces the risk of permanently falling behind and ceding its position as a major economic power. Europe can

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benefit from innovation through increased productivity and spending power, and thus economic growth[21]. Moreover, it will produce significant benefits that improve the lives of Europeans, such as higher life expectancy, a cleaner environment, and an improved standard of living[22]. It is therefore crucial that current European innovation facilities such as Horizon 2021 and the RRF be deployed effectively – focusing on the development of sustainable European competencies which will enable the EU to remain technologically and economically competitive in the long run.

Fortunately, the EU yet retains significant advantages which should be leveraged and strengthened in achieving next-generation innovation goals. The continent remains dominant in the high-tech manufacturing sector, particularly in automotive, and has consistently been a first mover in public sector digitalisation and technology governance[23]. Moreover, Europe is well positioned to lead the global transition to a "green" economy[24], and is expected to be a significant beneficiary of emerging technologies such as AI and automation[25]. Europe's public investment in R&D also tends to be higher than in other advanced economies[26].

Although government spending is not a replacement for private capital, it has the potential to seed innovation funds and support critical basic research. When the EU acts in unison, the world listens. For example, the bloc has positioned itself as the global leader in technology regulation, giving rise to the "Brussels Effect" whereby the EU, by virtue of its market size, can compel companies to modify practices and products to remain compliant with EU regulation[27]. The General Data Protection Regulation (GDPR), a data protection and privacy law, represents one such achievement, which has influenced policymaking and product design abroad. Those who portend Europe's inevitable technological and economic decline ignore these strengths at their peril. Europe retains considerable resources and weight, which if applied productively, could yet spur its technological renaissance.

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CEE9 Innovation Performance by Country

***Austria* has effectively leveraged government policy and financing to further its innovation goals and remains a bright spot among CEE9-countries.** Its strengths range from R&D, manufacturing, to green development. Innovation is driven by its high R&D intensity, which at 3.17% of GDP[28], is the second highest in the EU after Sweden. Since 1998, R&D expenditures as a share of GDP have grown from 1.10% to 3.19%, making Austria one of only four countries which has achieved the 3% of GDP target for R&D spending set by the EU[29]. The country also shows marked strength in green economic development: over 33% of its primary energy consumption comes from renewable sources[30]. Further strengths include manufacturing, which benefits greatly from Austria's leadership in R&D spending[31], as well as public administration and SME digitalisation[32]. Patent applications from Austria are among the highest in the world[33], buttressing its leadership in medium/high-tech manufacturing. Over 65% of Austria's already markedly high R&D investment is channelled toward the manufacturing sector[34], contributing to approximately $4.5 billion in annual investment to Innovation 4.0 technologies, amounting to nearly 1% of annual GDP[35]. Austria's remarkable rise to R&D powerhouse is largely a testament to the country's robust and targeted innovation policy. The 2011-2020 Austrian Research and Innovation Strategy, for example, is accredited by the OECD for mobilizing and maintaining government support for innovation, coordinating national research strategies, and ensuring policy continuity[36]. The establishment of the Austrian Research Promotion Agency (FFG) constitutes another innovation policy success. The FFG is a unique Government agency providing €1billion in funding annually to support Austrian industrial R&D[37]. The program funds over 200 new marketable products and 100 start-ups each year, with over 70% of funding going toward manufacturing, ICT, mobility, and green development. FFG predicts that for each euro of funding distributed, partner companies receive 10 euros in revenue. As a result, Austria's high-tech products make up 13.8% of exports in 2019, behind only Czechia and Hungary among CEE9 countries[38]. Another notable factor of Austria's economy is the relative dynamism and health of its SMEs. SMEs in sectors outside the financial sector in Austria represent 62% of total value added in the economy, compared to an EU average of 56%[39]. Per the European Commission: "Annual SME productivity in Austria, measured as value added per person employed, amounts to €62,700. This is considerably higher than the EU average of €44,600". Part of this dynamic can be explained by the relatively high rate of innovation and digital adoption among Austrian SMEs. Indeed, while high speed broadband coverage, adoption of cloud technologies and big data, and e-commerce sales remain markedly low in Austria[40], SMEs represent a relative bright spot for digitalisation. Austrian SMEs are more likely to train their employees in ICT technologies, invest in R&D, and introduce product innovations than other EU peers[41]. Adoption of digital marketing strategies, ERP/CRM platforms, RFID tech, and e-invoicing, among other indicators, is also considerably higher in Austria among SMEs than in other EU countries[42]. These high technology adoption rates are partially the result of robust national policy. Programs such as "KMU Digital" and the "Digital Innovation Hubs" program, provide consulting services, training, and funding to SMEs to facilitate the adoption of modern technologies. Despite leadership in some areas, there is a substantial gap to be closed vis-a-vis EU innovation leaders. Adoption of digital technologies is below the European average among large companies and

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41 European Commission. (2019). 2019 SBA Fact Sheet Austria.

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households. While in certain areas of business digitalisation such as ERP system use, Austria is a leader, the country stumbles in adoption of digital services such as high-speed broadband connectivity and cloud computing. Moreover, despite being a leader in R&D development, Austria's focus on industry has left the country trailing in other critical fields such as artificial intelligence[43]. Shallow capital markets stymie entrepreneurship. A relatively weak start-up ecosystem acts as a drag on producing high-growth companies. The OECD attributes these shortcomings to a paucity of risk capital (angel investors, VC, etc.)[44]. At 0.08% of GDP, private equity investment in Austria is low, well below the EU average of 0.5%, as well as European leaders such as the Netherlands and Sweden where PE is over 0.8% of GDP[45].

As the lowest scorer on the GLOBSEC Strategic Transformation Index, *Bulgaria* faces fundamental economic, political, and social challenges which inhibit the development of a robust innovation economy. Although Bulgaria may not be a leader in any major innovation field, the government has acknowledged the importance of growing its innovation sector. In the country's "Innovation Strategy for Smart Specialisation 2014-2020", the government has declared to advance from "modest innovator" status to becoming a "moderate innovator" during this period[46]. While Bulgaria stumbled in achieving plan innovation goals, the country shows some promise in ICT and cybersecurity. Bulgaria's outsourced IT industry has grown rapidly in recently years and has become the country's largest services export (excluding tourism and travel), accounting for over $1 billion in revenue in 2019[47]. The Capital region of the country has established itself as a regional tech hub. Sofia alone has produced over 2,000 entrepreneurial ventures, including international names such as Nexo, Gtmhub, Dronamics, and Telerik, and in 2019 over €20 million was invested in Sofia-based start-ups[48]. These disruptors are anchored by coworking spaces such as Campus X and Puzl, as well as the State-backed Sofia Tech Park, in which over €50 million have been invested[49]. While the tech industry remains small by European standards, Bulgaria has positioned itself as a leader in several key frontier technologies including augmented reality, cybersecurity, and autonomous vehicles[50]. It is also worth noting that Bulgaria is a continental leader in ICT sector gender equality, with over 27% of ICT employees being women, compared to the EU average of 16%[51]. Sasha Bezuhanova, founder of the Bulgarian Centre for Women in Technology Trends, notes that there is an immense shortage of engineers in Bulgaria, and that gender equality in the STEM sector is the most obvious solution to reducing this deficit[52].

As the only country in CEE9 with manufacturing value-added lower than the EU average[53], the more services-dominated *Croatia* is one of the greenest in the region, with budding innovation-culture geared towards services. Croatian companies were more likely to report implementation of innovative practices or processes in their business than any country in the CEE9 other than Austria[54]. Croatian innovation pathways therefore diverge considerably from its CEE9 peers, with a significantly greater emphasis on sustainable business and digital services. At 11% of GDP, tourism is more integral to the Croatian economy than any other country in Europe other than Spain[55]. Croatia is also among the European countries most at risk of extreme weather events and climate disaster[56], making it more vulnerable given the economy's dependence upon maintaining a pristine natural environment. In response to these challenges Croatia has been aggressive in pursuing an active climate policy and transitioning toward a circular economy. In 2020 the Croatian Government merged the Ministry of Economy, Entrepreneurship and Trade, with the Ministry of Environmental Protection and Energy to create a joint Ministry of Economy and Sustainable Development. The remit of the agency is to: "carr[y] out the tasks related to the competitiveness of the Croatian economy, instruments and measures of economic policy, industrial policy and the policy of applying innovations and new technologies, as well as activities related to the protection and preservation of the environment and nature, waste management and environmental impact assessment, climate change mitigation and adaptation,

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water management and energy."[57] The relationship between government and business has been a key driver of Croatia's green economy. Over 63% of SMEs in Croatia reported receiving public support for implementing resource-efficiency actions, and 36% of Croatian SMEs reported receiving government support in producing green products[58]. Existing government programs incentivise the use of renewable energy by businesses, and finance green certification initiatives. Among the many beneficiaries of these incentives is Croatia's e-mobility sector. Companies such as Rimac, an electric vehicle upstart, and Hrvatska elektroprivreda, the national electric utility, have been aggressively promoting the adoption of electric vehicles, and have made significant investments in promoting the technology in Croatia, making the country a regional e-mobility hub.

Greenhouse gas emissions per capita are the fourth lowest in Europe after Liechtenstein, Sweden, and Malta[59], driven by the country's relatively low use of coal in energy production[60]. Its rate of municipal waste recycling increased 800% between 2004-2017[61]. While Croatia may lack the manufacturing capabilities of its CEE9 peers, Croatia's growth has not come at the expense of the nation's environmental capital. In other sectors, Croatia's record is more mixed: Croatian businesses have made modest progress in digitising in recent years[62],while the government has made a concerted effort to increase national competitiveness through national R&D vouchers, and training and certification programs, among other policies[63].The country also graduates almost 50% more ICT specialists than the European average[64]. At 0.97% of GDP, Croatian R&D intensity is among the lowest in Europe and below the CEE9 average[65]. Industry in the country is largely limited to agroforestry, food processing and metals, with little medium or high-tech manufacturing[66]. While the country contains some factories in the mobility space, particularly in shipbuilding, this sector is considerably smaller than in neighbouring CEE9 countries[67]. Moreover, Croatia's proportionally large service industry has not made up for deficiencies in manufacturing and technology. Indeed, exports of knowledge-intensive services are the lowest in Europe[68]. While risk capital in the country remains relatively scarce, Croatia's start-up scene has seen growth in recent years. The first Croatian Venture Capital Firm, South Central Ventures, was founded in 2015, and today retains approximately €40 million under management. In 2019 private investments in Croatia reached €94 million – 0.174% of GDP[69]. Although relatively insignificant by global and European standards, 2019 risk capital expenditures in Croatia exceeded Poland, Hungary, Austria, Greece, Czechia, Bulgaria, and Slovenia measured as a percentage of GDP[70]. Given the country's limited industrial infrastructure, continued investment in frontier technologies will be critical to future economic growth.

At 23.1 % of GDP, manufacturing intensity is higher in *Czechia* than in any other CEE9 country and is the second highest in the EU after Ireland[71]. While the country is not a remarkable innovator overall, it has made significant strides in its critical manufacturing sectors and has led the CEE9 in adopting business technologies. Moreover, the country has a high degree of inertia in closing competency gaps with more developed European countries. While the Czech R&D spending is slightly below the EU average, the rate at which R&D spending has grown in Czechia, at 4.7%, is more than triple the EU average[72]. High-tech manufacturing and digitalisation demonstrate similar trends. Recent research indicates that Czechia is better prepared to adopt Industry 4.0 technologies CEE9-peers[73]. Given its slowing labour productivity and increasing wages, adoption of IoT platforms and automation will be critical to its growth prospects and escaping the middle-income trap[74]. A 2018 study by the Banque de France found that Czechia had a higher rate of ICT capital investment than any other country studied (including the

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U.S., Germany, Austria, Israel, Japan, the UK) [75]. Similar investment is being made in automation and robotization. While current robot density in Czech manufacturing is only somewhat higher than in peer states, the country's stock of robots is growing rapidly[76]. It has championed mobility research, directing over 20% of national R&D spending toward mobility, and establishing a Mobility Innovation Hub via public-private partnership[77]. As a result of these investments, it has seen a renaissance in its dominant automotive industry, as well as high-tech manufacturing. A study by the Polish Economic Institute found that Czechia's automotive sector was more developed than its central European peers, in terms of productivity of labour, gross output and net exports[78]. Czechia is also an EU leader in producing high-growth high-tech (HT) and medium-high-tech (MHT) manufacturing firms[79]. It is one of only five European countries to see employment increase in the high-tech manufacturing sector, and among these countries it has experienced the largest growth[80]. Czechia has also made sustained progress in digitising its business sector, with strength in e-commerce. Czech companies are significantly more likely to sell products and share information online than their European peers. They also sell products across borders at twice the rate of the EU average[81]. As a result of these competencies, Czechia's digital economy is larger, as a percentage of its GDP, than many large Western economies[82]. ICT is also a significant national strength, with the third highest investment in the sector in Europe as a percentage of GDP[83]. However, in areas such as e-government and connectivity Czechia is a relative laggard. High speed broadband is scarce, while the number of Czechs who have engaged with the government online is 16% below the EU average[84]. Czechia seeks to further develop these competencies through its 2019-2030 Innovation Strategy[85]. The Czech authorities envision R&D expenditures to grow to 2.5% of GDP by 2025, and 3% of GDP by 2030, with increases in funding coming from both the private and public sectors[86]. The program also envisions the development of a national funding mechanism for Czech start-ups, establishing technology training programs, massive expansion of digital infrastructure and innovation hubs, and significant investment in frontier technologies[87]. Policy tools include increased state funding, tax incentives, long-term public-private research partnerships. If deployed effectively alongside the RRF, these policies could be transformational for Czechia, jumpstarting the Czech innovation economy. However, the growth has come at an environmental cost and continues to be a heavy greenhouse gas emitter. Approximately 35% of the country's primary energy is supplied by coal, one of the highest rates in Europe. Czechia's only substantial source of emissions free power generation is its aging base of nuclear power plants. Generation from wind and solar is negligible. Even in green mobility, Czechia is lagging. The country only began producing electric vehicles at scale last year, and is far behind current industry leaders such as Germany and the U.S. In the coming years, the Czechia's challenge will be to retain its strong growth while moving away from fossil fuels and polluting industries.

In many ways *Hungary* exemplifies the economic and technology challenges faced by the CEE9, as well as the opportunities available to the region if it invests in their core competencies. The country has produced numerous industry-leading technology firms which have successfully scaled internationally, including Prezi, LogMeIn and NNG. It has been a regional leader in adopting next-generation manufacturing and automation technology[88]. However, these successes are overshadowed by systemic challenges which threaten Hungary's ability to compete internationally. Business churn, R&D expenditure, digitisation labour productivity growth, and human capital lag behind the CEE9 average[89]. Its economy is highly reliant upon manufacturing, accounting for approximately 19% of GDP in 2018[90]. The automotive sector is particularly important, with over 600 local companies generating almost 21% of total national exports and employing

75 Cette, G., Lopez, J., Presidente, G., & Spiezia, V. (2018). Measuring "Indirect" Investments in ICT in OECD Countries. Working Paper, (686). Banque de France. https://www.banque-france.fr/sites/default/files/medias/documents/wp-686.pdf

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77 Mobility. Czech Invest. (n.d.) https://www.czechinvest.org/en/Key-sectors/Mobility

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80 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

81 European Commission. (2020). The Digital Economy and Society Index (DESI).

82 Novak, J., Marciniak, T., Svoboda, T., Karakolev, T., Purta, M., & Valachovicova, I. (2020). Digital Challengers in the Next Normal: Czechia and Slovakia in the CEE context. McKinsey & Company. https://www.mckinsey.com/cz/~/media/mckinsey/locations/europeandmiddleeast/czechrepublic/ourwork/mckinseyreportdigitalchallengersinthenext normal.pdf

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89 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.; Novak, J., Jánoskuti, L., Havas, A., Purta, M., Marciniak, T., Ignatowicz, K., Rozenbaum, K., & Yearwood, K. 2018). Rise of the Digital Challengers: How digitization can become the next growth engine for Central and Eastern Europe: Perspective on Hungary.

90 World Bank. (2021). Manufacturing value added (% of GDP).

100,000 people[91]. Electronics, food processing, and pharmaceuticals are also prevalent. Within the automotive sector Hungary has acted as a regional model for factory automation. Daimler and SK Innovation have announced significant investments in electric vehicle and battery plants in Hungary, among some of the largest EV projects in Europe[92]. Other facets of the Industry 4.0 framework – use of frontier technologies such as AI, internet of things, and 3-D printing – lag behind compared to peer countries[93]. Transition to the green economy has been slow, with renewables as a percentage of total energy consumption declining from 16% to 12.5% between 2013 and 2019[94]. Compounding these shortcomings, Hungary's spend on R&D is low at 1.53% of GDP and is threatened by significant budget cuts to public R&D spending as well as reliance on foreign multinationals to finance domestic R&D[95]. Its digitalisation and high-tech track-record is mixed. Hungary has seen success in small software companies with big ideas that develop their products and scale. Authorities have stressed the importance of indigenous start-ups, in 2016 implementing a national Digital Start-up Strategy backed by the formation of a new government centre for monitoring, coordinating, and studying start-up activity at home, tax incentives for "small early-stage enterprises", and increased investor protections and incentives, among other initiatives[96]. The ICT sector is dynamic, representing 6% of national GDP in 2018, and employing over 4% of the labour market, a higher degree of importance than in any other CEE9 economy[97]. Digitalisation has lagged among legacy industries. In its 2019 assessment of Hungary's industry digitalisation plan the auditors noted that: "half of its population does not possess the basic digital skills"[98]. SME take-up is particularly poor. In 2017 Hungarian companies shared less information online than those in any other country, while use of e-billing, RFID, cloud systems and international online shopping lagged far behind the European average[99]. Most troubling, Hungary was one of the five worst performers in Europe among every measure of Government digitalisation tracked by the European Commission[100]. Further challenges include labour shortages, low STEM graduation rates, high emigration, and relative undercapitalization[101]. While automotive innovation and the ICT sector represent bright spots, Hungary's economy is dominated by SMEs and microbusinesses which have not adapted to the modern, digital economy. Hungary's greatest challenge will be simultaneously expanding its nascent start-up and green automotive ecosystem, while shoring up innovation in manufacturing and services, which represent the bulk of Hungarian economic output.

Despite being dominated by the automotive industry – representing 13.9% of GDP and 27% of exports[102] and being the global leader in car production per capita[103] – and with clearly defined core competencies, *the Slovak Republic* remains under-developed on mobility R&D. Only 40% of companies operating in Slovakia conducted any R&D domestically, of which majority is for internal company use, not being dispersed throughout the ecosystem[104]. Between 1993-2015 Slovakia had the second fastest annual GDP growth among CEE9 countries[105], driven by low value-added downstream activities[106]. While Slovakia has placed at a lower spectrum of the European value chains, continuing investment of large automakers, such as Jaguar Land Rover and Volkswagen, and production orientated towards upgraded, top-end SUV models has enhanced its value-added in selected industries over time. Several large domestic firms, such as Matador, which are integrated in value chains make significant leaps to that end, moving upwards and generating a sizeable value-added. The problem is that this is not the case for a substantial chunk of the Slovak economy, only for a few superstar firms. As Slovakia faces both a declining population and slowing productivity growth, reinvigorating its economy will require a blanket movement up the global value chain toward skill-based industry, with a particular focus

91 Wik Consult, Valdani Vicari, & Associati Economics and Policy. (2019). Monitoring Progress in National Initiatives on Digitalizing Industry: Country Report - Hungary. European Commission. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_hungary_-_final_2019_0D30BE02-9661-9403-6F972D2CCBB689B0_61210.pdf

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93 Szabo, S., & European Commission, & Directorate General for Economic and Financial Affairs. (2020). Transition to Industry 4.0 in the Visegrád countries.

94 Eurostat. (2021). Share of energy from renewable sources. [Data file]. https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_ren/default/table?lang=en

95 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

96 Government of Hungary. (2016). Digital Startup Strategy of Hungary. Digital Welfare Program (DJP). https://digitalisjoletprogram.hu/files/89/ea/89eac5ce5f74178f3f527945f7edd08f.pdf

97 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

98 Wik Consult, Valdani Vicari, & Associati Economics and Policy. (2019). Monitoring Progress in National Initiatives on Digitalizing Industry: Country Report - Hungary. European Commission.

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102 Szabo, S., & European Commission, & Directorate General for Economic and Financial Affairs. (2020). Transition to Industry 4.0 in the Visegrád countries.

103 Slovakia – Market Intelligence: Automotive Market. (2020, August 13). International Trade and Administration. https://www.trade.gov/market-intelligence/slovakia-automotive-market-2020

104 PricewaterhouseCoopers. (2019). Automotive Supplier Survey 2019. https://www.pwc.com/sk/en/odvetvia/automobilovy-priemysel/assets/Automotive%20Supplier%20Survey%202019.pdf

105 World Bank. (2021). GDP growth (% annual). https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=SK

106 OECD. (2019). Slovak Republic Economic Snapshot. https://www.oecd.org/economy/slovak-republic-economic-snapshot/

on Industry 4.0 technologies such as automation[107]. Multi-faceted challenges will need to be overcome to that end. At 0.84% of GDP, R&D investment is among the lowest in the EU[108]. In measures of education[109], labour productivity[110], digitalisation[111], business technology and e-government[112], Slovakia ranks below the EU-average and possesses few indigenous advantages for closing its innovation gap with the rest of the EU. Recognizing these weaknesses, public and private sector institutions have put forth foundational programs for spurring domestic innovation and modernization. Ambitious government initiatives backed by the EU such as the "2030 Digital Transformation Strategy for Slovakia" and "The Action Plan for Smart Industry" represent ambitious plans to upgrade digital infrastructure and adoption, improve education outcomes, and implement Industry 4.0 technologies, among other goals[113]. Public-private alliances further promote the establishment of an innovation environment. Examples include the Slovak Alliance for Internet Economy (SAPIE) which has supported education, networking, and policy initiatives to foster the Slovak innovation economy[114]. Slovak Investment Holding (SIH) has successfully stepped in as a provider of a returnable growth capital for small and medium-sized enterprises (SMEs) in the absence of a functioning capital market, in liaison with private entities, such as Zero Gravity Capital, Vision Ventures and Crowdberry. While Slovakia's start-up scene remains small by regional standards, risk capital investors such as Neulogy and Eterus Capital, as well as a constellation of successful incubators and tech firms, have managed to thrive and expand, providing the foundation for a broader innovation ecosystem. Slovakia is among the most challenged economies within the EU given current demographics, economic conditions, industry competencies, and capital investments but existing projections indicate that the rapid adoption of next-generation technologies such as automation and business technology would restore economic growth and substantially narrow its productivity gap vis-a-vis Europe[115].

107 OECD. (2019). Slovak Republic Economic Snapshot. https://www.oecd.org/economy/slovak-republic-economic-snapshot/

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114 About us. The Slovak Alliance for Internet Economy (SAPIE). (n.d.). https://sapie.sk/about#page-section-5e3c156a12b6646eca78f5b8

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Spotlight: Lessons from Estonia's Digital Miracle

By Anett Numa and Soňa Muzikárová.

Estonia's fascinating transformation to e-Estonia begins – like in case of most other CEE9 countries – **at the bedrock of a centrally-planned economy, saddled by decades of under-development.** Estimates of its GDP growth compared to neighbouring Finland during the 20th century indicate that – while the two countries had similar levels of economic development in 1960 – by 1988 the average Fin produced 4.6 times more economic output than the average Estonian[116]. Exacerbating these circumstances, Estonia was among the most affected by the post-breakup recession given its dependence on Russia for virtually all trade and industry inputs[117]. In 1992, GDP fell by as much as 21.2%, while inflation exceeded 1,000%[118]. Thus, in 1993, the first year for which reliable data is available, Estonian GDP per capita was just 36% the European average[119].

Today, Estonia provides a blueprint for making digitalisation work for everyone, regardless of the starting point. Since adopting free-market capitalism and democracy and accessing the EU along with a cluster of its regional peers in 2004, Estonia has evolved into one of the most dynamic and technologically integrated economies in Europe, converging with average European levels of welfare faster than any CEE9 country[120], and emerging as a global leader in digital innovation. The country's success in transitioning from a centrally planned economy to an innovation powerhouse provides important lessons for CEE9 nations which have struggled to achieve their full economic potential.

Estonia's first generation of democratically elected governments implemented a series of novel reforms which set it on the path toward developing a world-class innovation economy. On the macroeconomic policy-side, the government pursued an aggressive transition strategy consisting of capital account and trade liberalization, low-touch governance, low taxes, and institutional reforms[121]. These policies are credited with stabilizing the Estonian economy and attracting significant FDI, creating the base conditions for the country's surge of innovative activity. However, the critical ingredient in Estonia's innovation revolution was its approach to 'leapfrogging' existing technology, rather than upgrading legacy Soviet-era systems, or adopting last-generation Western infrastructure[122].

Given Estonia's post-Soviet standing of a leading electronics component producer, this 'leap-frogging' strategy ran somewhat counter to conventional wisdom. The Estonian electronics component sector employed over 26000 workers[123], and was responsible for producing much of the hardware used in the Soviet Space Program[124]. Moreover, in the first years of economic transition, the country was offered substantial technological aid, such as legacy telecommunications infrastructure from Finland[125].

But there was a recognition at the highest levels of Estonia's government that the country did not have the resources to invest in expensive Western infrastructure, nor could it afford to become dependent upon antiquated

116 Erixon, F. (2008). The Baltic Tiger: The Political Economy of Estonia's Transition from Plan to Market. European Centre for International Political Economy. https://ecipe.org/wp-content/uploads/2014/12/the-baltic-tiger.pdf

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121 Lumiste, R., Pefferly, R., & Purju, A. (1970, January 1). Estonia's economic development: Trends, Practices, and Sources. Working Paper, (25). World Bank Group. http://hdl.handle.net/10986/28035 ; Kattel, R. & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand. UCL Institute for Innovation and Public Purpose Working Paper Series (IIPP WP 2018-09). https://www.ucl.ac.uk/bartlett/public-purpose/wp2018-09

122 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.

123 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.

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125 Margetts, H., & Naumann, A. (2016). Government as a Platform: What can Estonia Show the World? Oxford Internet Institute, University of Oxford. https://www.politics.ox.ac.uk/materials/publications/16061/government-as-a-platform.pdf ; The Economist. (2013, July 13).

systems[126]. Rather, **government agencies were encouraged to pursue simple, distributed, open-source technical solutions, which could easily be connected to the broader digital system**[127]. Specific directives were scarce, and it was not until the late nineties that meaningful policy was introduced regarding the design of these digitised government systems. It was during this period that the two pillars of Estonia's modern digital ecosystem were implemented: X-Road and e-Id.

X-Road is the secure platform through which the IT systems of various government agencies share and exchange information[128]. X-Road provides a single-entry point for data/information amassed by each government agency (within its mandate), while none of this data are duplicated[129]. For example, while education and health data are stored by schools and hospitals respectively, data from both systems can be accessed via X-Road for authorised institutions. Citizen personal data security and transparency is secured through a data tracker, which provides full disclosure about which government or private institutions have been accessing personal data. The system is so effective, Estonians need not copy basic personal information when filling out a driver's license application or opening a bank account. The system has become widespread and major private institutions in Estonia and abroad have piggybacked onto the platform[130].

Estonia's second digitisation pillar – e-Id – is a mandatory digital identification used to access and input data within the Estonian digital ecosystem and in the nutshell **enables general use of digital services**[131]. Its adoption was largely facilitated through public partnership with banks, which saw electronic identification as an efficient means by which to implement emerging e-banking technologies[132]. Banks coordinated with the government to roll out the e-Id platform, while also financing IT education programs, such as Tiger Leap and Look@World to raise digital literacy. Tiger Leap, in particular, was supported by the country's two largest banks and two largest telecoms companies and is credited with training over 100,000 Estonians in ICT technology, roughly 10% of the adult population at the time[133].

In tandem, Estonia's unique key and network system has revolutionised e-governance. In 2005 Estonia became the first country to allow online voting in government elections. Applying for loans, paying fines, and establishing a corporation, among countless other bureaucratic chores, can all be done online[134]. The next step for the service design is developing proactive government services by providing the highest quality and user experience of public e-services. So-called invisible and cross-authority event-based services are being developed to make public services as efficient and user-friendly as possible.

With the foundations of what would become e-Estonia, the stage was set for a boom in private digital development. The architects of Estonia's e-government applications began exploring opportunities in the private sector, while a generation of young Estonians, trained by Tiger Leap, pursued bold new ideas empowered by Estonia's relatively high-quality digital infrastructure[135]. Small tech start-ups quickly spread throughout Estonia, leveraging X-Road to efficiently incorporate their companies and integrate with the existing digital network. The $2.6 billion acquisition of Estonian start-up Skype by E-Bay in 2005 put Estonia on the map for institutional investors and provided the seed capital for a series of other investments in notable tech companies. Indeed, members of the "Skype Mafia" a collection of Skype founders and high-level employees from the early 2000s, are heavily involved in Estonian tech leaders such as Wise, Topia, Pipedrive, and Veriff[136]. Today Estonia has the highest numbers of unicorns per capita in Europe. Between 2014-2019 over €1 billion was raised by Estonian venture capital firms, with €120 million being invested back into Estonian companies during this same period[137]. As a percentage of GDP, private equity investments are higher in Estonia than any other country in Europe,

126 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.
127 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.
128 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.
129 OECD. (2019). Digital Opportunities for Better Agricultural Policies. OECD. https://doi.org/10.1787/571a0812-en
130 Heller, N. (2017, December 11). Estonia, the Digital Republic. The New Yorker. https://www.newyorker.com/magazine/2017/12/18/estonia-the-digital-republic
131 OECD. (2019). Digital Opportunities for Better Agricultural Policies.
132 Kattel, R., & Mergel, I. (2018,). Estonia's digital transformation: Mission mystique and the hiding hand.; OECD. (2019). Digital Opportunities for Better Agricultural Policies.
133 Vassil, K. (2015). Estonian e-Government Ecosystem: Foundation, Applications, Outcomes. University of Tartu.
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135 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.
136 Turp-Balazs, C. (2020, April 15). Why Skype remains key to Estonia's digital success. Emerging Europe. https://emerging-europe.com/business/why-skype-remains-key-to-estonias-digital-success/
137 Galvelė, L. (2020). Baltics Private Equity and Venture Capital Market overview 2010-2019. Deloitte Central Europe. https://www2.deloitte.com/content/dam/Deloitte/lv/Documents/about-deloitte/Baltic_Private_Equity_survey_results.pdf

representing almost three-fold the GDP contribution of risk capital markets in the UK, the Netherlands and Sweden[138].

Estonia harnessed its distinctive approach, relative advantages, and unique circumstance to rapidly lay down and develop its digital infrastructure and industry from scratch. Realizing that the state cannot afford the bureaucracy of a developed democracy, Estonia's 'leapfrog' innovation strategy was self-reliant and distinctive for a small, homogenous country lacking in significant legacy infrastructure: unlike many CEE9 peers, it turned a handicap into an advantage. Despite this notable success, its pace of digital adoption and innovation is not universally exemplary[139], penetration of business-oriented technologies is average compared to other EU countries[140], while citizen satisfaction with healthcare and education services remain low by OECD standards, despite the advances afforded by X-Roads[141]. Nevertheless, Estonia offers several key lessons that may be emulated by governments and private enterprises worldwide:

- **While Estonia's economic policy has been notably free market, its digital policy has been considerably more interventionist.** Kattel and Mergel of UCL and the University of Konstanz describe a "hiding hand" at play in Estonia, writing that:
- *"...policy-makers sometimes take on tasks they think they can solve without realizing all the challenges and risks involved— and this may result in unexpected learning and creativity. The success of Estonia's e-government has much to do with [this] principle of the hiding hand: naivety and optimism propelled initial 'crazy ideas' in the early 1990s to become ingrained in ICT policy, enabling the creation of multiple highly cooperative and overlapping networks that span public–private boundaries."*[142]
- **The backbone of Estonia's digital infrastructure was not a product of free-markets and maverick private enterprise, but rather an organic collaboration between major corporate interests and the government.** In establishing X-Roads and e-id as efficient, public use tools, which could be leveraged by the private sector, the government provided nascent Estonian tech start-ups with significant competitive advantages over peers.
- **Technology is second to process.** In an interview with the Economist, Toomas Hendrik Ilves, former president of Estonia, noted that the success of e-Estonia had less to do with abandoning legacy technology than "legacy thinking."[143] While oftentimes governments will digitalise by simply copying paper forms online, Ilves argues that this approach is wasteful. Tax forms should be pre-filled with the abundance of data available to governments, so that citizens need only scan the information to ensure it is correct before submitting. The principle that data should only be entered once into the government system, similarly, eschews legacy thinking. While during the Post-Soviet transition years Estonia could not afford state-of-the-art technologies implemented by Western consultants, government agencies were able to apply simple, decentralised, and open-sourced platforms to construct the most advanced e-government ecosystem in Europe, if not the world. The Estonian case reinforces arguments that risk capital and innovation will struggle to flourish without minimally favourable market conditions, while highlighting the positive role policy can play in facilitating private investment.

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140 European Commission. (2020). The Digital Economy and Society Index (DESI).

141 Kattel, R., & Mergel, I. (2018). Estonia's digital transformation: Mission mystique and the hiding hand.; OECD. (2019). Government at a Glance 2019. OECD. https://doi.org/10.1787/8ccf5c38-en

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***Slovenia* has consistently ranked among the most innovative in the CEE9-region, buttressed by a robust medium/high tech export sector, driven by automotive, pharmaceuticals, and ICT, as well as a flourishing eco-innovation industry and an engaged public sector.** To defend its status, Slovenia will need to double-down its efforts in adopting digital technologies and financing R&D, modernise established export industries, and further develop capital markets. In mobile broadband use and 5G implementation Slovenia is laggard, while internet use is below the EU-average[144]. In several medium/high-tech export sectors, Slovenia punches well above its weight. The Slovenian automotive sector, for example, accounts for 10% of GDP and 12.5% of exports, and is strengthened by its relatively solid labour productivity[145]. Industry revenues are also over 10%[146] of GDP, and the industry accounts for 13.6% of national export. Slovenian pharmaceutical champions Lek and Krka are global producers of generic drugs, while R&D in the sector is the third highest in the world as a percentage of GDP at 0.45%[147]. In recent years ICT manufacturing and services have also become major component of Slovenia's economy, cumulatively generating €4.4 billion in 2019, an annualised growth rate of 6.9% over the previous year[148]. The economy is increasingly transitioning toward high-skill sectors. Between 2000-2016 Slovenian employment growth in knowledge-intensive services and medium-tech manufacturing was the second highest in the EU[149]. Moreover, at 1.95% of GDP Slovenia's R&D intensity falls somewhat below the EU average, the proportion of R&D financed by the private sector in Slovenia is the highest in the EU at 70%[150].These industry strengths are in part predicated upon the high degree of educational attainment and government support in Slovenia. Tertiary education rates in Slovenia are among the highest in Europe[151], while a business-friendly environment and abundant government initiatives have made Slovenia one of the most appealing markets in the CEE9 for innovative investment and entrepreneurship[152]. The cost of starting up a business, borrowing money, and resolving insolvency is well below the European average, while state aid and access to public financial support for entrepreneurs is considerably higher[153]. The Slovenia Enterprise Fund provides hundreds-of-millions of euros in direct aid to domestic innovative ventures, while the SPIRIT business development agency provides significant consulting, training, and marketing services for Slovenian entrepreneurs[154]. Given that the value-added of SMEs is 10% greater than the EU average, supporting and promoting high-growth, high-skill start-ups will be critical to Slovenia's future prosperity. PPPs between its Ministry of Economic Development and Technology and Startup: Slovenia, have supported the development of dozens of Slovenian tech start-ups, making Slovenia a regional hub for IT and blockchain innovation[155]. Slovenia has also been among the strongest eco-innovators in the CEE9. While overall R&D intensity in Slovenia is low by European standards, R&D investment and early-stage funding of green technology investment is approximately equivalent to the EU average, and well above the majority of its CEE9 peers[156]. While Slovenia's eco-industry exports and revenues may fall below the EU average, the sector employs 2.13% of Slovenians, 50% more than the EU average[157]. Policy strategies such as the 2018 "The Roadmap for Slovenia's Transition to a Circular Economy" and "the Strategy of the Sustainable Growth of Slovenian Tourism for 2017-2021" have also been attributed with stimulating the development of a "circular economy" in areas such as tourism, agriculture, agroforestry, and manufacturing[158]. The country has made great strides in increasing recycling rates[159] and renewable energy use[160], ranking well above the EU and CEE9 average in both metrics, and continues to be a model of sustainable development in the CEE9.

As the largest CEE9 economy, *Poland* is critical to the economic development of the region. Despite dramatic improvements in prosperity over the last 30 years, it is behind the curve in terms of capacity to innovate, while facing acute risks of economic slowdown[161]. Buttressing its prosperity has been its relatively well-diversified economy. Unlike peers, Poland has not differentiated

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145 Key 2019 Automotive Figures. Invest Slovenia. (n.d.) https://www.investslovenia.org/industries/automotive

146 Key 2019 Chemicals & Pharmaceutical Figures. Invest Slovenia. (n.d.) https://www.investslovenia.org/industries/chemicals-and-pharmaceuticals

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itself as a specialist in any particular manufacturing discipline, which is an asset when industry-specific shocks hit. Poland's less developed manufacturing sector is not compensated by a robust services or IT ecosystem. Polish competencies in agriculture, mining, and low-tech manufacturing have certainly contributed to Poland's impressive growth over the last thirty years. However, further growth beyond middle-income country status will depend upon a successful transition to innovative industries. Poland has a large innovation-gap to close: its R&D intensity stands at 1.21% of GDP[162], and digital performance is subdued[163]. To some extent, this dynamic can be explained by the relative importance of low-innovation industry (construction, mining, and agriculture) but even sector-specific R&D investment, across all industry classes, is lower the EU-average[164]. A recent World Bank study found that: "[a]lmost 1 in 4 enterprises in Poland considered undertaking innovative activities but chose not to due to high barriers."[165] According to various assessments, Polish patents do not have significant business suitability[166]. Increasing R&D expenditures and channelling research toward applied uses represent steps to be pursued to kickstart innovation.

In recent years, authorities have taken steps to modernise its economy and invest in emerging technologies and industries. As the largest recipient of EU funds, it has blended this financial support with national funds to finance dozens of national innovation programs[167]. Between 2014-2020 over €21 was distributed to private enterprises through various facilities designed to spur investment in innovative technologies[168]. National programs include everything from special investment tax credits created by the 2018 Investment Zone Act[169], to direct financing through the Polish Development Fund and the National Centre for Research and Development[170]. These incentives and grants have been widely disbursed, supporting established industries such as mobility and IT, and seeding nascent frontier enterprises in AI and biotechnology[171]. A windfall of government funding; however, does not make up for systemic deficiencies, and many programs have been downsized or wound down due to lack of uptake[172]. Moreover, developing the Polish green economy is overdue. The country has some of the worst air quality in the EU, with 29 of the 100 smoggiest cities on the continent[173]. Its GHG emissions per euro of GDP are the third highest in Europe[174].

Despite starting from a low base when it joined the EU in 2007, Romania has made progress on the innovation front. Measures of R&D intensity[175] , digital economy[176], entrepreneurship[177], and knowledge-based manufacturing[178] remain among the lowest in Europe but it has developed competencies in outsourced IT and software development[179], and STEM graduates are on the rise[180]. Over 100,000 IT engineers currently work in Romania[181], providing technical services for clients around the world, and contributing to the country's digital economy, which at 6.9% of GDP matches the European average[182]. Romania's digital importance is expected to grow. Recent studies indicate that Romania's tech sector has grown at an annualised rate of 10% in recent years, as compared to 6.2% on average in the rest of the EU[183]. But for innovation to flourish in Romania, it must take considerable steps to improve basic market conditions. Bucharest and Cluj have emerged as regional

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163 European Commission. (2020). Science, Research, and Innovation Performance of the EU 2020: A fair, green and digital Europe.

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177 European Commission. (2019). 2019 SBA Fact Sheet Romania. https://ec.europa.eu/docsroom/documents/38662/attachments/24/translations/en/renditions/native

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180 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

181 Ecosystems: Romania. Startup Europe Networks. (n.d.)

182 Novak, J., Spiridon, D., Purta, M., Marciniak, T., Ignatowicz, K., Rozenbaum, K., & Yearwood, K. (2018). Rise of the Digital Challengers: How digitization can become the next growth engine for Central and Eastern Europe: Perspective on Romania. McKinsey & Company. https://digitalchallengers.mckinsey.com/files/Rise-of-Digital-Challengers_Perspective-on-Romania.pdf

183 Novak, J., Spiridon, D., Purta, M., Marciniak, T., Ignatowicz, K., Rozenbaum, K., & Yearwood, K. (2018). Rise of the Digital Challengers: How digitization can become the next growth engine for Central and Eastern Europe: Perspective on Romania. McKinsey & Company.

hubs for digital innovation, hosting both international technology giants such as Microsoft and Oracle, as well as homegrown unicorns and disruptors including UiPath, a leading enterprise automation software company, and Bitdefender, a cybersecurity firm[184]. Bucharest will also be the new home of the European Cybersecurity Competence Centre, a new European cyber research hub[185]. While Romania's cyber ecosystem is still small by global standards, it is a heavyweight among CEE9-countries, drawing in more risk investment than peers. Investors are drawn to the country's relatively large and well-educated population, IT roots, and EU membership. Despite the coronavirus pandemic, interest in the country's tech sector continues to grow. Venture capital in the country, for example, expanded from €28.62 million to €30.39 million[186]. A Crunchbase survey of eight major tech investors in Romania corroborated this data, indicating that they are bullish about future sector growth[187]. While Romania's economy faces systemic challenges in the coming years, exacerbated by the country's limited technological capital, it also possesses a promising technology and start-up environment which can be leveraged as a springboard for future innovation development.

184 MacDowall, A. (2017, September 18). How Romania became a popular tech destination. Financial Times. https://www.ft.com/content/a0652dba-632f-11e7-8814-0ac7eb84e5f1; Novak, J., Spiridon, D., Purta, M., Marciniak, T., Ignatowicz, K., Rozenbaum, K., & Yearwood, K. (2018). Rise of the Digital Challengers: How digitization can become the next growth engine for Central and Eastern Europe: Perspective on Romania.

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186 Iordache, B. Romanian Venture Report 2020. How to Web. (n.d.) https://www.howtoweb.co/romanian-venture-report-2020/

187 Butcher, M. (2021, January 24). 8 investors tell us the story behind the Romanian startup boom. Techcrunch. https://techcrunch.com/2021/01/23/8-investors-tell-us-the-story-behind-the-romanian-startup-boom/

Supercharging the Recovery Across CEE9: A Regional Approach to Innovation Policy

There are significant differences in innovative capacity across the EU, with the bloc's innovative strengths in areas such as education, public research, industry, such as mobility and aerospace and digital regulation. But the bloc also faces considerable pressure from other advanced and emerging economies, particularly in the development and adoption of frontier technologies. At a more granular level, the Scandinavian countries and Germany stand out as global leaders in R&D intensity and green technology, Estonia has leapfrogged other post-Soviet members to become a digital powerhouse *(see in the Spotlight Feature for an analysis),* and countries such as, Netherlands, Belgium and France have among the most knowledge-intensive workforces in the world[188].

By contrast, as the forthcoming GLOBSEC Strategic Transformation Index (STI) results indicate, the CEE9-region tends to be less productive, less educated, and broadly less innovative than its Western and Northern peers. As per STI scores in CEE9, Austria is the clear forerunner, while the Central European countries (Czechia, Slovakia, Hungary, Poland), along with Slovenia, are among the most manufacturing-intensive in Europe, with strong competencies in mobility and industrials. Croatia is highly reliant upon tourism and has devoted significant resources toward sustainable economic development. Bulgaria and Romania, by contrast, are yet to achieve parity in development and productivity with their CEE9-peers.

Despite the differences among countries at the European level and regional levels, CEE9-region's shared endowments and developed core competencies present a policy opportunity. Moreover, while the CEE9-economies are among the least innovative in the EU, they possess economic, societal, and demographic circumstances highly compatible with next-generation technology and Industry 4.0.

Given that most CEE9-countries have high manufacturing intensities in medium/high-tech industries, are export-intensive, produce large cohorts of STEM graduates, are facing stagnant or declining populations, these nations are well positioned to embrace underlying Industry 4.0 technologies and other productivity-enhancing systems. ICT and e-mobility represent two obvious innovation industries where the region could emerge as a global leader. Nearshoring by European firms and dispersion of RRF funds may provide a significant opportunity for CEE9-countries to gain market share and specialization in emerging technology sectors such as green-tech, clean-tech, and cyber-security.

EU policy landscape plays an obvious role in sharpening Europe's competitive edge in R&D, entrepreneurship, and technology adoption, but to a significant degree it is at the regional and local levels where substantive reform and investment must occur. A streamlined policy approach targeting a regional innovation ecosystem – e.g., along the Danube Valley – could focus on the such competencies in technology, mobility, and industry by-an-large. Individual CEE9-country analysis reveals these areas – private sector digitalisation, green economy, reforms towards Industry 4.0, and common risk capital pool, especially early-stage – to be common enablers and denominators for a shared regional policy approach to innovation in CEE9.

Such exemplar areas should be of interest to both policy makers and the private sector. The GLOBSEC Tatra Summit platform offers an ideal conversation platform for cultivating such multistakeholder policy discussion at the highest-level and identifying policy opportunity for a streamlined and coordinated regional approach to innovation in CEE9. Pinning down such areas could, furthermore, encourage countries to share their experiences in designing policy reforms, funding programs, monitoring and evaluation, and program results. Specific recommendations could be drafted and shared as a tangible deliverable of such policy discussions, which could centre on:

- **Effective deployment of the RRF** to support digital education and infrastructure, spur green innovation in areas such as e-mobility, energy, and resource extraction, and develop knowledge-based industries such as Industry 4.0 manufacturing, software development, and ICT.
- **Establishment of public research, innovation, and capital investment institutions** akin to Austria's Research Promotion Agency, Czechia's Mobility Innovation Hub, Korea's specialised research centres, or state-backed venture capital firms in Hungary and Israel. These institutions should not crowd out private activity, but rather strive to develop and attract human capital, support basic and applied R&D alongside private firms, and share risk with investors. Ultimately, the importance of these institutions should decline over time as the private innovation sector becomes self-sustaining.
- **Incentivise European firms and firms with high European sales to nearshore production in the CEE9.** Shifting global supply chains for medical devices, specialised chemicals, and tech devices, among other goods, provide a rare opportunity for CEE9 countries to leverage their strong manufacturing competencies and relatively low labour costs to attract foreign companies and develop new competencies.
- **Apply public resources toward upstreaming existing competencies.** Czechia, Slovakia, Slovenia, and Hungary, for example, are all

188 European Commission. (2020). Science, research, and innovation performance of the EU 2020: A fair, green, and digital Europe.

significant players in manufacturing automobile parts and assembling automobiles. However, some of the most valuable and high-tech components of these vehicles, such as the engine, chassis, hardware, and software are developed and manufactured abroad. For example, in Slovakia, the country with the most vehicles produced per capita in the world, there is only one automotive company, Kia, who produces engines in Slovakia[189]. R&D for these key components and general automotive design is almost exclusively done abroad[190]. Slovakia, among other CEE9 countries, possesses significant competencies for producing and designing more advanced components, and should seek to move into higher-value activities.

- **Support the acquisition and adoption of frontier technology by domestic companies.** This can include physical capital investments, business software, or industrial inputs. Attaining first-mover status in niche, yet growing, technologies could provide CEE9 countries with long-term advantages in relevant industries. At the very least, frontier industrial and digital tech will meaningfully improve productivity.
- **Promote R&D through grants and tax benefits to bring CEE9 research intensity** to the current European standard.
- **Invest in e-government technology, digital infrastructure, and technology education to improve the ease of doing business domestically,** while developing human capital.

At the same time, the CEE9's development is also dependent upon greater regulatory and market cohesion at the European level. Moreover, while public policy and investment may facilitate and seed applied research, technology diffusion, and capital markets, government activity is not a replacement for the private sector. Public resources should not be focused upon long-term direct support for innovative enterprises per se, but rather nourish enabling conditions for fostering the growth and development of indigenous start-ups, industry champions, risk investors, research institutions, and incubators which cumulatively produce a self-sustaining innovation ecosystem.

- **Greater integration of markets and cohesion of regulatory policies.** The completion of European Banking and Capital Market Unions represent two critical goals.
- **The adoption of innovation-oriented regulation.** The EU should both encourage and facilitate the emergence of European champions akin to Airbus which can compete with North American and Asian companies at scale, and produce proportionally more R&D. Similarly, the EU should forcefully implement forward-looking technology regulation, as it has with the GDPR and emerging AI regulation, to positively influence global technology development and design.
- **Expanded application of European innovation platforms** such as InvestEU and the Important Projects of Common European Interest facility to finance future leaders in emerging technology sectors.
- **Leverage EU single market and labour mobility** to attract foreign specialists and innovation industries, particularly in relatively underdeveloped regions**.**

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Chapter 2. New Approaches to Skill-provision in Central Europe

By Soňa Muzikárová and Miroslav Beblavý.

The 2021 STI indicates sub-index (E.) *Education* to be one of the relative weakest structural areas, not only relative to European average but even relative to the lacklustre standards of the CEE9 region. But education is a necessary fundament for super-charging a vibrant innovation-led growth in the region, and the present outmoded CEE9 education systems are at best calibrated to the outdated manufacturing-fuelled macro models, and at worst markedly divorced from real labour market needs. For some CEE9 countries, their education system quality is not only poor in relative terms but has deteriorated over time. What's more, an instant classic government-centred top-down education reform will take at least a decade to translate to improved economic outcomes in 'the real world'.

The Covid-19 pandemic and the transformation impetus it creates is a unique opportunity to take a leap on the education agenda in CEE9. The following chapter rests on the basic premise to rid "education reform" of the stigma of "impossible reform" and closely examine alternatives to a top-down skills provision. Both, prompter results, and complementarity may be achieved by using bottom-up approaches, as an alternative to the lengthy top-down approach.

The chapter is organised as follows: focusing on Slovakia, Czechia, Hungary, and Poland within the broader CEE9, it, first, surveys the successes and failures of Central European governments' skills strategy and provision *(Section I)*. *Section II* then examines how to bypass the policymakers through successful examples of bottom-up change, and their potential for Central Europe. The chapter concludes *(Section III)* with a catalogue of existing bottom-up education initiatives in the region of Central Europe and the world.

Successes and Failures of Central European Governments' Skills Strategy

All CEE9 countries have rolled out school system reforms during the past two decades, but only a few have succeeded in transitioning from the post-communist status quo to one that generates sustained improvements in the creation of human capital. **The goal of this section is to better understand the existing variation in education quality and learning outcomes across select economies of CEE9.** We focus on the four economies within the CEE9 sample – namely Slovakia, Czechia, Hungary, and Poland – as a case study to *first*, present where they stand on educational systems' quality and outcomes; and *second*, to review in depth the institutional arrangements, government policies and reforms that may have led to their current standing.

Current State of V4 Education Systems

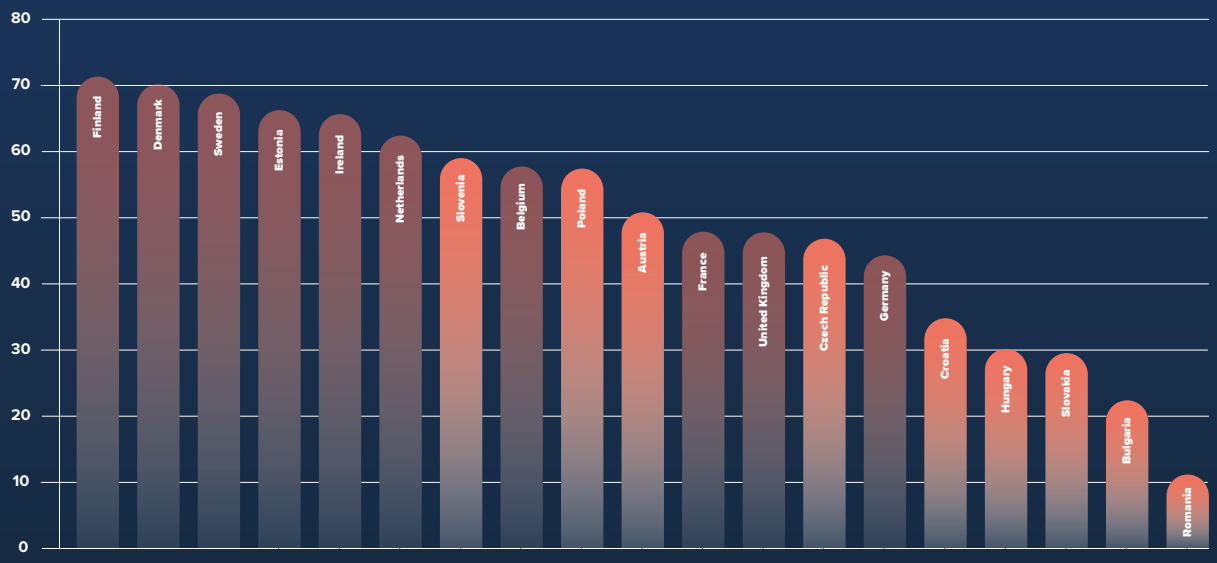
Despite the common transitional experience, the educational quality within the focus countries but also the broader CEE9 sample **varies** (Figure 1). This is corroborated by both, education *conditions* (factors such as education expenditures) and *outcomes* (e.g., PISA test scores), both of which are included in the STI Education Pillar (Table 1).

Table I. STI Education Pillar Data Inputs 2021

Variable	Description	Unit	Source
EDUCATION OUTCOMES: PISA scores: reading	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in reading	scores (available at 3-year basis)	OECD
EDUCATION OUTCOMES: PISA scores: mathematics	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in mathematics	scores (available at 3-year basis)	OECD
EDUCATION OUTCOMES: PISA scores: science	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in science	scores (available at 3-year basis)	OECD
ADULT LEARNING: Participation rate in education and training	participation rate in education and training for the last 4 weeks for people aged 25-64 years; survey-based measure: 'Have you participated in any training or education in the last 4 weeks?'	% of total respondents	Eurostat
TRANSITION TO WORK: Early leavers from education and training	percentage of the population aged 18-24 having attained at most lower secondary education and not being involved in further education or training may face difficulties in the labour market	% of total enrolled, 18-24 years old	Eurostat
Public expenditure on education	public expenditure on education, All ISCED 2011 levels excluding early childhood educational development	% of GDP	Eurostat
HIGHER EDUCATION: Tertiary education enrollment	measures tertiary school enrollment; tertiary education requires successful completion of education at the secondary level	% of gross	World Bank
HIGHER EDUCATION: Tertiary educational attainment	measures the share of the population aged 30-34 who have successfully completed tertiary studies (e.g. university, higher technical institution, etc.)	% of population aged 30 to 34	Eurostat
ACADEMIC STAFF: Classroom teachers & academic staff	classroom teachers and academic staff, primary education	count scaled by population	Eurostat
ACADEMIC STAFF: Ratio of pupils and students to teachers and academic staff	ratio of pupils and students to teachers and academic staff by education level and programme orientation [pre-primary education]	%	Eurostat

Sources: Eurostat, OECD, World Bank, GLOBSEC.

Figure 1. STI Education Pillar 2021



Sources: GLOBSEC.

Divergent education outcomes resulted for these countries, despite having a shared starting point. By PISA test scores, Poland overall outperforms other countries under review (Figure 2). Initially, the Polish outcome is better only marginally for the overall score, and even inferior to other countries for scores in science and math. Over time, however, Poland clearly becomes the top performer across all disciplines. Moreover, the gap between Poland and other countries widens over time, which can be ascribed to the overall effectiveness of Polish education reforms, as we explain later.

Figure 2. V4 Education Outcomes over Time measured by PISA scores

Source: OECD.

Poland is closely shadowed by Czechia, which is, on average, the second-best performer by PISA scores over time and across disciplines. Hungary and the Slovak Republic lag behind. What is more, their performance fails to post improvements over time. Both countries have seen a deteriorating trend between 2009 and 2015, with an uptick in the last measurement in 2018. It will be interesting to see what the 2021 assessment brings, with wide lockdowns and digital schooling on-and-off since March 2020 due to the pandemic. Poland is the top performer in 2015 also by alternative education outcome metrics, such as TIMMS in both science and math surpassed by Czechia in 2019, leaving behind Slovakia across both, time, and discipline (Figure 3).

Much of this educational outcome variation has been ascribed to these countries' different institutional arrangements following the dissolution of the Soviet bloc. The four countries in focus had the same starting point in 1990, embodied by similar political and economic conditions, common ambition to transition to market economy and build democratic institutions, and a shared desire to access western economic clubs in some cases. Most importantly, the inherited educational systems were based on the socialist model. The shared post-communist heritage and the later divergence in institutional settings and educational outcomes makes the region **a particularly good case study of the sources of education policy successes and failures.**

Figure 3. V4 Education Outcomes over Time by TIMMS (LHS) and PIAAC results, 2012 (RHS)

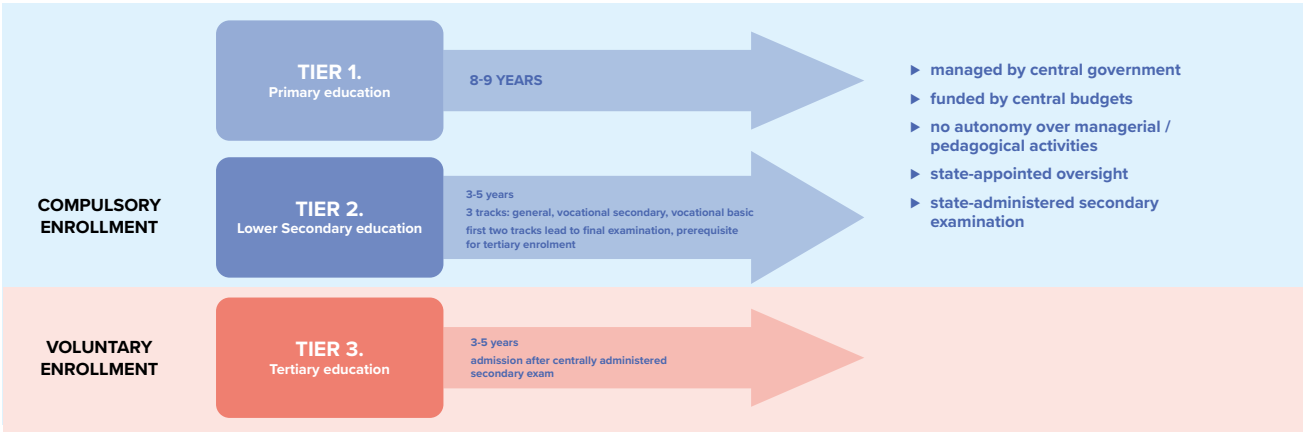
Sources: TIMMS, OECD.

Institutional Arrangements, Government Policies and Reforms: Inherited Systemic Settings (1990s)

In 1990 and early transition years, these central European economies' education systems shared similar starting points, broadly summarised in Figure 3. Notably, in secondary education, the vocational track used to dominate the general track, reflecting the demand for technical engineers of the centrally planned economy[191]. The transition, among other things, brought bankruptcies of centrally planned state-owned enterprises, resulting in deep economic recession and stark rise in unemployment in the early transition years.

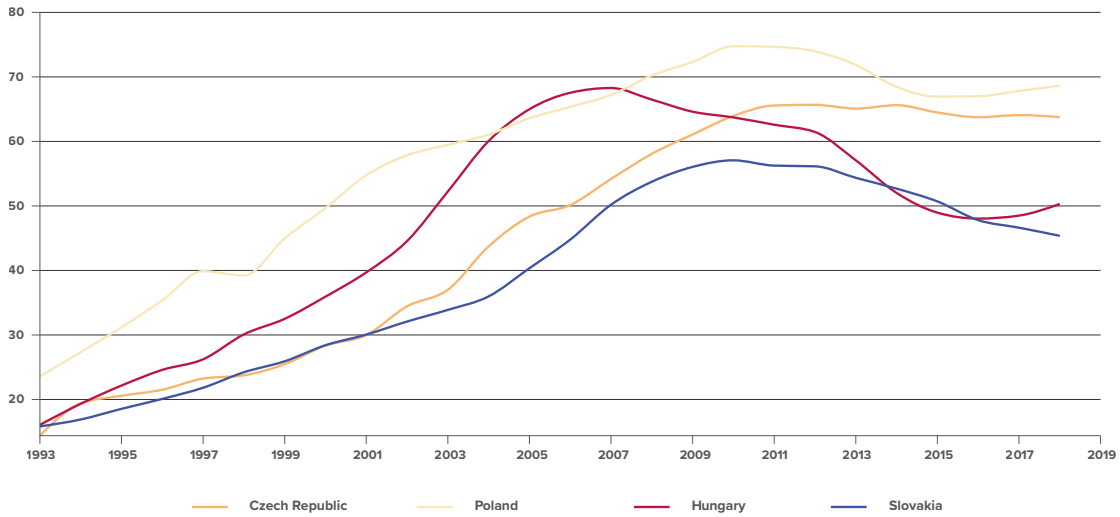
These economy-wide shifts – namely the shrinking of agricultural and industrial jobs – **profoundly altered the demand for education** in the years that followed. The regional economies saw a dramatic outflow from vocational secondary tracks in favour of the general tracks, as the former started to be seen inadequate with the raging structural changes in the labour markets. Inflows in secondary general tracks were accompanied by the rise of tertiary education, which was most pronounced for Poland and Hungary and flatter for Slovakia (Figure 5). This reflects a high rate of return on tertiary education, ranging from 20% to 30% in the pre-crisis years for Czechia, Hungary, and Poland, compared to only 5% to 8% in Germany or the Nordic countries[192]. It reflected not only changing economic structure during the transition, but also the fact that the higher education system had been artificially limited under Communism, leading to pent-up demand.

Figure 4. V4 Inherited Post-communist Education Structure



Sources: OECD, Herbst & Wojciuk 2014.

Figure 5. V4 transitional surge in demand for tertiary degrees (% of gross enrolment ratio)



Source: World Bank.

191 Herbst, M., & Wojciuk, A. (2014). Common Origin, Different Paths. Transformation of Education systems in the Czech Republic, Slovakia, Hungary, and Poland. GRINCOH Working Paper Series, (4.07). http://www.grincoh.eu/media/serie_4_societies_and_social_change/grincoh_wp4.07_herbst_wojciuk.pdf

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Differences between the Approaches to Educational Reforms

Crucial changes occurred with respect to configuring the systemic foundations ranging from pedagogy, teacher quality, education organisation, governance, curricula, and financing. These settings are essential for calibrating the systems by provision of the necessary information, resources, and structures required to monitor and improve performance. But both, the pace, and the ways in which these changes unfolded differed across V4 and contributed to divergent education outcomes.

● *Teaching quality*

Great systems attract great teachers and prioritise teaching quality. Salaries matter but so do factors, such as career advancement, or individual responsibility as professionals and leaders of reform. Top-down initiatives alone proved insufficient in achieving deep and lasting changes[193], as mandating compliance and achieving excellence often require different incentives. Poland grasped and reflected these principles well in its 1999 reform, which introduced voluntary teacher professional development, dispersed teacher training centres, and four-level teacher path with associated salary hikes to incentivise enrolment, with an additional option of bonuses to high-performing teachers awarded by schools[194]. Its teachers have directly participated in shaping the system by being able to choose the curricula they wish to use from pre-approved lists, subject to systemic monitoring. These arrangements contributed to the Polish teacher salaries ranking at the top within the V4 sub-sample, albeit still among the lowest in OECD (Figure 6, LHS). It is worthy to note, however, that increases in teacher salaries tend to improve education outcomes only if they are coupled with well-designed systems for selection of future teachers, their initial training and future professional development. Centralised funding and salary grid systems also contribute to low competitiveness of the teacher profession in dynamic economic regions, particularly the countries' capitals. One can hypothesise that this also serves to decrease the attractiveness of the teacher profession, as the opinion-making classes (policymakers, business, cultural and educational elites) are concentrated in the capital and skew the perceptions.

The other three central European countries have used different mixes of mandating and incentivising for teacher quality, with more emphasis on the former. Typically, they view teacher certification as non-negotiable, but many training programs suffer from poor quality, formalism, and outdated methods[195]. **Importantly, the attractiveness of the teaching profession suffers of negative selection, with the most talented graduates avoiding this career path partly due to the low pay.** The OECD has expressed this concern in the latest recommendations for Slovakia stating that better-trained and -paid teachers are necessary parts of Slovakia's next economic chapter[196]. Some progress has recently been achieved on this front in Hungary and Czechia, when in 2017 almost 5-15% wage increase has been achieved in some education sectors[197] but not enough, and teacher's working conditions should be further bettered. The success of the calibration of the teacher professionalization policy is not one-size-fits-all, of course, different mixes work for different contexts. Countries like Hong Kong, for example, place an emphasis on a "soft" mandating to incite further training, heavily drawing on what teachers have been doing[198]. What additionally matters is that teacher quality policies are accompanied by regular assessments, monitoring, and performance evaluation to create reliable metrics on performance and hold schools accountable for progress on the education agenda.

● *Organisation & Funding*

According to the OECD (2019)[199], decentralisation is among "the most important reforms of the past 50 years" (p. 3). While the benefits of an optimal level of **decentralisation** may vary in scale and scope – depending on capacity and competence at all levels of government and adequate coordination – it may **enhance allocative efficiency, improve quality of public service, and in some cases is linked to faster economic growth**[200]. The V4 decentralisation conditions are diverse and have fluctuated over time. According to both, literature and country experience, varying degrees of centralization can lead to improvements in education outcomes[201], e.g., Singapore's very centralised education structure is ranked in leading spots globally and serves as a case in point. Many other systems, on the other hand, have benefitted from differently calibrated decentralisation policies.

193 Schleicher, A., & Organisation for Economic Co-operation and Development (Eds.). (2011). Building a high-quality teaching profession: lessons from around the world. OECD. http://www.oecd.org/education/school/programmeforinternationalstudentassessmentpisa/47506177.pdf

194 Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world´s most improved school systems keep getting better. McKinsey & Company. https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/How%20the%20worlds%20most%20improved%20school%20systems%20keep%20getting%20better/How_the_worlds_most_improved_school_systems_keep_getting_better.pdf

195 Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world´s most improved school systems keep getting better. McKinsey & Company.

196 OECD. (2019). OECD Economic Surveys Slovak Republic. OECD. https://doi.org/10.1787/eco_surveys-svk-2019-en

197 OECD. (2019). OECD Economic Surveys Hungary. OECD. https://doi.org/10.1787/eco_surveys-hun-2019-en; OECD. (2018). OECD Economic Survey Czech Republic. OECD. https://doi.org/10.1787/eco_surveys-cze-2018-en

198 Sweeting, A. (2008). Teacher Professionalization in Hong Kong: Historical Perspectives. In D. Johnson & R. Maclean (Eds.), Teaching: Professionalization, Development and Leadership (pp. 45–65). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8186-6_4

199 OECD. (2019). Making Decentralisation Work: A Handbook for Policy-Makers. OECD. https://doi.org/10.1787/g2g9faa7-en

200 OECD. (2019). Making Decentralisation Work: A Handbook for Policy-Makers. OECD. https://www.oecd.org/cfe/Policy%20highlights_decentralisation-Final.pdf; Iimi, A., (2005). Decentralization and economic growth revisited: an empirical note. Journal of Urban Economics, 57(3), 449–461. https://doi.org/10.1016/j.jue.2004.12.007; Aray, H. (2018). More on decentralization and economic growth: More on decentralization and economic growth. Papers in Regional Science, 97(4), 971–993. https://doi.org/10.1111/pirs.12305

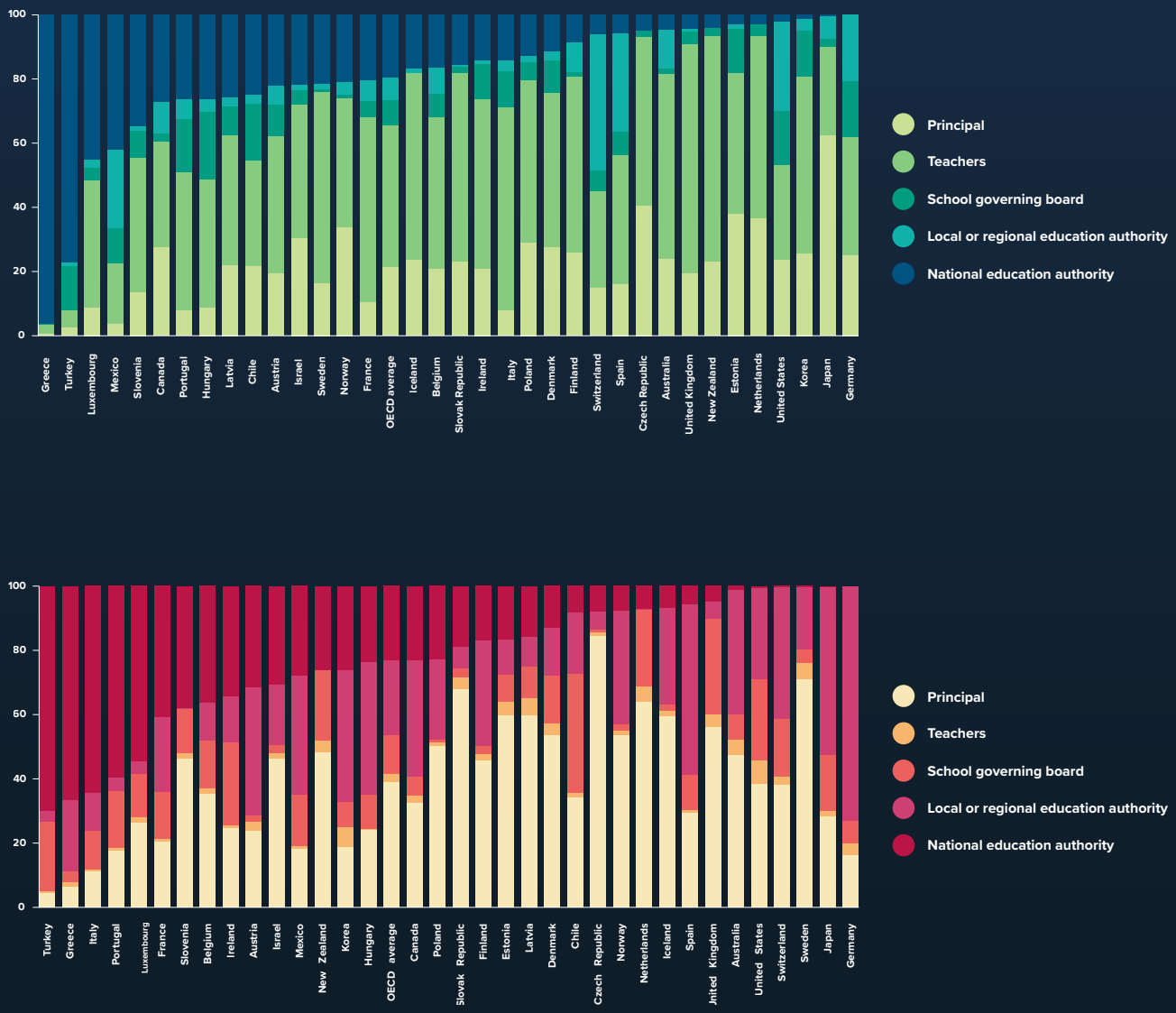
201 OECD. (2018). How decentralised are education systems, and what does it mean for schools? Education Indicators in Focus No. 64; Education Indicators in Focus, Vol. 64 https://doi.org/10.1787/e14575d5-en

Figure 6. Average gross annual upper secondary teachers' salaries with 15 years of experience compared to wages of tertiary-educated workers (USD PPP Dollars, 2019, LHS); Teachers who participated in a network for professional development 12 months prior to the survey (2018, RHS)

Sources: OECD, OECD TALIS, authors' calculations.

As centrally imposed education control was being increasingly relaxed across CEE9 in the transition years, greater extent of decentralisation appeared to correspond with better education outcomes. Poland – the sub-sample top performer – pioneered it to a substantial degree, with streamlined municipalities being tasked with carrying out restructuring in the early post-transition years[202]. This was a part of a broader sentiment that schools should not be "managed from the distance" (p.34), and equally pertained to school funding and administrative powers. Gradually, it became clear that decentralisation interacts with capacity of municipalities, which is particularly low in Czechia and Slovakia due to their small average size (together with France, these two countries have the highest number of municipalities per capita in Europe). Additionally, Hungary promoted a high initial level of decentralisation – where municipalities were entrusted with quality of instruction and development of curricula, but it backfired. Despite the higher average size, it was still too low to take on such complex tasks. The unintended adverse effect was vast between-school variation, which to-date remains one of the highest in OECD. Due to these effects much of the decentralisation has been rolled back, and Hungary became the most centralised system in V4, with Czechia and Poland being most decentralised of the bunch (Figure 7).

Figure 7. Decision-making at Different Levels in OECD countries (2018): Curriculum (LHS) and Resources (RHS)



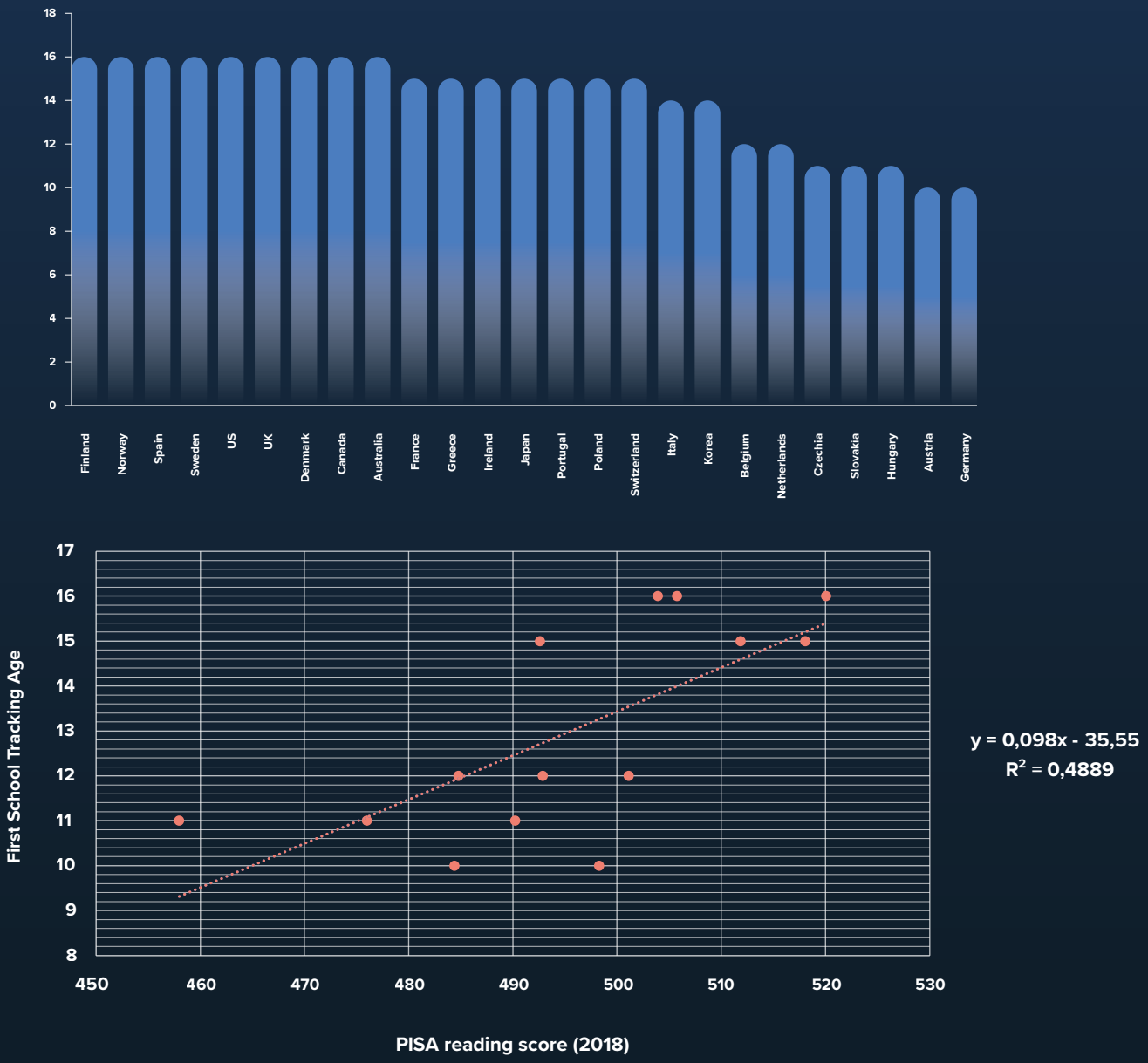
Source: OECD.

202 Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world´s most improved school systems keep getting better. McKinsey & Company.

School Tracking & Stratification

The baseline with respect to secondary school tracking (i.e., splitting students into different academic tracks by age and/or aptitude) is that **early tracking increases educational inequality[203] and decreases student ability** in some cases[204]. Empirical findings suggest that orientation towards milder/later forms of ability-tracking may raise educational levels and increase wages, with the strongest effects occurring among individuals from low socioeconomic backgrounds[205]. Moreover, greater number of tracks is negatively associated with education outcomes at the secondary level[206].

Figure 8. First Tracking by Age (international comparison, LHS); in Relation to Education Outcomes by PISA (2018, RHS)



Sources: OECD, IFO[207] authors' calculations.,

203 Woessmann, L., & Hanushek E.A. (2005). Does Educational Tracking Affect Performance and Inequality? Differences-in-Differences Evidence Across Countries. Discussion paper Series, IZA DP, (1901). http://ftp.iza.org/dp1901.pdf

204 Piopiunik, M. (2014). The effects of early tracking on student performance: Evidence from a school reform in Bavaria. Economics of Education Review, 42, 12–33. https://doi.org/10.1016/j.econedurev.2014.06.002

205 Canaan, S. (2020). The long-run effects of reducing early school tracking. Journal of Public Economics, 187. https://doi.org/10.1016/j.jpubeco.2020.104206

206 OECD. (2020). Sorting and selecting students between and within schools. In OECD, PISA 2018 Results (Volume V). OECD. https://doi.org/10.1787/5d9b15a4-en

207 Woessmann, L. (2009). International Evidence on School Tracking: A Review. ifo DICE Report, ifo Institute - Leibniz Institute for Economic Research at the University of Munich, 7(01), 26-34. https://www.ifo.de/DocDL/dicereport109-rr1.pdf

The V4 realities are broadly in line with these predictions. Poland – the sub-sample education top performer – extended the general secondary track by one year in 1999, effectively delaying the tracking into academic, general, and vocational in secondary schools[208]. Meanwhile, Czech, and Slovak schools have hybrid systems, where there is a partial selection after the 4th grade in the German manner, but vast majority of students continue in the same school and the official selection only takes place after the 9th grade. This has been criticised by international organisations such as OECD and some steps were taken to limit the early selection. However, excessive focus on this issue misses the larger point. In these countries, education outcomes exhibit some of the largest between-school variation in OECD[209] which can only partially be explained by official early tracking. A more important factor is that they practice a combination of parental school choice and freedom of schools to specialise and choose their pupils (with some limits), which lead to concentration of pupils from higher socioeconomic strata in prestige school, as well as considerable segregation of the excluded Roma pupils even in absence of formal tracking.

● *Monitoring & Assessment*

Data plays a formidable role in improving education outcomes. It allows for monitoring progress by leaders and calling attention where resources need to be channelled, but also holds education stakeholders accountable for raising quality and steering the system culture from "teaching to learning" (p.37)[210]. Granting relatively large degree of freedom to teachers, principals, and regions, Poland implemented progress monitoring alongside reform programs by introducing national examinations at grades six, nine, and twelve, supplemented by annual students' tests. The remaining countries have had comparatively lesser access to information on the equality of instruction over the history, with the standardised test in the form of secondary school exit exam ('maturita', 'matura') being the alpha-omega, later augmented by other tests, such as 9th grade primary school national standardised tests in Slovakia. Some of the existing systems rely on internal school assessments, which is lacking in shared standards and comparability.

The bottom line is that no uniform policy recipe exists to facilitate sustained improvements in education quality. The V4 experience, however, which started at the same starting point in terms of education systemic setup and outcomes, and ended up in divergent education results, offers interesting insights. It has shown that countries that decentralise their organisation, governance, and funding, while ensuring capacity building at all levels of government, those with quality comprehensive schools for all children, and teacher professionalization programs that grant a large degree of responsibility, but also with respect to critical facets of education, such as curricula choice, and incentivise professionalization of the teaching profession with both, financial and non-financial incentives, while properly monitoring student outcomes (Poland, to lesser extent Czechia), outperform more centralised systems, with more segregation, formal but lower quality teacher training, poor incentivisation of teaching staff, and less frequent/ institutionalised monitoring (Hungary and Slovakia).

208 Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world´s most improved school systems keep getting better. McKinsey & Company.

209 OECD. (2006). Education at a Glance 2006: OECD Indicators, Education at a Glance. OECD. https://doi.org/10.1787/eag-2006-en

210 Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world´s most improved school systems keep getting better. McKinsey & Company.

BOX 2. How to Spend it: Education Reform Embodied in the Central European Recovery and Resilience Plans

The Recovery and Resilience Facility (RRF)

The RRF is the key instrument at the heart of NextGenerationEU, the EU's plan for emerging stronger from the Covid-19 pandemic. The RRF will make €672.5 billion in loans and grants available to support reforms and investments undertaken by EU Member States. Its objective is to alleviate the economic and social fallouts from the coronavirus pandemic and make European economies and societies more sustainable, resilient, and better prepared for the challenges and opportunities of the green and digital transitions. The focus of the V4 countries is on the grant financing, of which Poland will get €23.9 bn, Hungary €7 bn, Czechia €6.7 bn, and Slovakia €6.6 bn.

The Recovery and Resilience Plans (RRPs) and RRF spending

Accessing funds from the EU's Recovery and Resilience Facility (RRF) is contingent upon drafting and submitting detailed national Recovery and Resilience Plans (RRPs) in Brussels. The rationale is to make the release of the EU funds contingent upon passing economic reforms. The RRPs have been also embedded in the European Semester, the EU's framework for economic policy coordination.

But guaranteeing successful recovery spending is a high-stake challenge. Even though RRPs are by EU law limited to "investment", this does not mean only spending on capital stock, but can be any non-recurrent expenditure. Nonetheless, this approach is very restrictive and the size and the need for massive spending is likely to push the plans towards large-scale projects. RRPs do not limit how Member States spend the funding in terms of recipients. The funds can flow to bottom-up initiatives, NGOs, and the private sector. However, given the RRF's structure, it is likely most funds will be likely spent on more traditional public sector projects.

In general, criticisms of the draft recovery plans outlined by the various governments in V4 have centred around a lack of overall vision for transformation (i.e., funds flow e.g., in patching up budgets of ministries), absent consultations with the public, not being ambitious enough on the green agenda, and being prone to corruption. The positive news is that all four plans feature a component on education reform, including curricula, digital skills and changing labour market needs. The following section presents an overview of goals, allocations, and measure for V4 region, as incorporated in its respective RRPs.

The Slovak RRP features "attracting talent" as a separate component. Substantial attention is also paid to curricular reform, but regrettably top-down only. In terms of higher education, there is an ambition to create two top universities in the largest cities by merger of existing capacity, but such endeavour will require overcoming substantial bottlenecks and thus carries downside risks. Considerable funds are set to be channelled to primary and secondary educational institutions, probably in the form of grants to schools, but unfortunately, mostly for construction purposes. The onus will be on upgrading the capacities of preschools and educational institutions for minorities.

The Czech RRP features "education and labour market" as a distinct pillar, with 21% allocation[211]. The pillar incorporates education curriculum reform – including higher education – with an emphasis on digital skills, adapting to new forms of learning and responding to the changing needs of the labour market in the post-Covid era. Funds should be also allocated to support inclusion, target individual approach to students (e.g., by tutoring) and improve teaching quality. The overall rationale for these innovations is to attract capital and business, which will help transform the economy.

Poland is the largest recipient of grants under RRF from V4. The Plan's priorities for reforms and investment include "labour market, education and childcare" under the Resilience and Competitiveness pillar (4.1 bn EUR) and "e-education" under the Digital Transformation pillar (€3 bn). **The Hungarian plan** proposes to spend €3.3 bn on universities, however, the alleged accompanying privatization of Hungarian higher education is a source of concern, as more than two-thirds of universities are to be managed by asset management foundations, free of public supervision. Nonetheless, the plan features upgrading the quality and accessibility of education – both, in general and higher tracks – with an emphasis on digital skills and improved performance of the scientific sector "to put the country back on the path of economic growth".

211 Government of Czechia. National Recovery Plan. (n.d.) https://www.planobnovycr.cz/

Starting from the Bottom: The Potential of Bottom-up Skill Initiatives for Central Europe

Improvements in skills and education are often presumed to be responsibility and prerogative of governments. This is natural in a world where the public sector delivers a bulk of formal training activities, particularly for children and youth. However, the reality is much more complicated. Large-scale government action tends to be preceded by small, frequently private initiatives that point attention to what is needed, but also possible. Given that the top-down approach to education reform frequently fails, and not just in Central Europe, we wanted to showcase examples of bottom-up skills initiatives which could be a basis for a broader action by policymakers.

The projects and organisations examined in this section fall into six categories:

- Targeting specific skills, ranging from language skills, digital skills, professional/vocational skills to citizenship skills and critical thinking skills
- Bypassing formal education systems and creating alternatives in liaison with the private and third sectors
- Making global education content more accessible to students and learners
- Transforming higher educational institution to attract talent, brains, and capital
- Connecting students and the world of work
- Preventing brain drain and stimulating brain gain

Three key criteria for selection were innovation, impact, and scalability. The last criterion is particularly important. The bottom-up schemes must be scalable – as opposed to being centred around a single "non-replicable" individual – for a meaningful macroeconomic impact. While the list is potentially endless, we decided to present 4 examples in each area. About three quarters are from Central Europe itself, but there is always at least one example of global best practice included. Before we move on to specific examples of bottom-up initiatives, it is useful to quickly look at what economic and political theory and history have to say on their role and how they interact with the leviathan of public sector delivery.

Education and the Role of Top-Down Public Delivery

Economics suggests that public provision should primarily focus on public goods – activities such as national defence, roads, or public lighting, which are *non-rivalrous* (i.e., the consumption of the good or service by one person does not prevent its consumption by others) and *non-excludable* (i.e., it is impossible to prevent the consumption of the good or service by others once it has been provided)[212]. In practice, the public provision goes much further and tends to be a result of one or more of the following three factors:

● *Positive externalities and spill over effects and consequent market under provision*

The main utility of public services lies in the fact that there are positive externalities to their consumption, meaning that they have a beneficial effect on a third party – the wider society or the government[213]. They produce a spill over effect, as they lead to unaccounted-for economic events in contexts different from the ones in which they were produced. Consequently, we can observe that activities with positive externalities are often unprovided or underprovided, given that their marginal benefit is greater for the society than for private individuals and companies that could choose to produce them. Education is a prime example of an activity with a positive externality, as individuals capture only some of the benefits of their human capital investment and the rest is to the benefit of their employers or to the society at large[214]. There are numerous public policy actions that governments take to correct this. The most common one in the skills area is the provision of compulsory and free education, either through the public provision of education or by subsidizing education to incentivise the private sector to provide it.

● *Equity concerns*

Governments also tend to be concerned with equity. Large social inequalities, particularly when transmitted across generations, lead not only to economic inefficiency, but also to social and political turmoil as the more unequal Western societies have experienced in the recent decades[215]. In education, inequality is often linked to unequal access to a certain type of education, or to a more prestigious or higher quality version of it, or to a situation where – despite formal equality – some groups or individuals do not have the resources to access education to the same extent as others.

212 Oakland, W. H. (1987). Theory of public goods. In Handbook of public economics, 2, 485-535. Elsevier. https://doi.org/10.1016/S1573-4420(87)80004-6

213 Dahlman, C. J. (1979). The problem of externality. The journal of law and economics, 22(1), 141-162. https://doi.org/10.1086/466936

214 Weisbrod, B. A. (1964). External Benefits of Public Education. Industrial Relations, 19(4). Princeton: Industrial Relations Section, Princeton University. https://doi.org/10.7202/027528ar

215 Lieberman, R.C., Mettler, S., Pepinsky, T.B., Roberts, K.M., & Valelly, R. (2019). The Trump Presidency and American Democracy: A Historical and Comparative Analysis. Perspectives on politics, 17(2), 470–479. https://doi.org/10.1017/S1537592718003286; Robinson, J. A., & Acemoglu, D. (2006). Economic Origins of Dictatorship and Democracy. Cambridge University Press. http://www.cambridge.org/us/catalogue/catalogue.asp?isbn=0521855268

● *Political agenda and priorities*

There might also be other political reasons to fund public services. The government can, for instance, use public services as a means through which to discipline its population according to its interests or to position itself as a caretaker to appeal to the citizens. For instance, as numerous anthropologists have argued[216], in some cases the practical use of infrastructure comes second to the state's efforts to use infrastructure to convey to its citizens the promise to build development and modernity. There are motivations related to the consolidation of political power for which governments find it strategic and necessary to fund education. Much has been said in humanities on the role that education has played in nation-building[217]. For instance, Hobsbawm (1990) has argued that only 12-13% of French people spoke French at the time of the French Revolution. Consequently, after the revolution free public instruction for all was established, the main objective of which was the enforcement of a common national language. This was done not only with the aim of fostering a national identity but to homogenise thinking and communication in the context of urbanization and the creation of national labour markets[218].

Bottom-Up Approach to Innovation and Service Delivery

For all these reasons, national governments have been deeply involved in the provision of various public services, including education, ever since the birth of modern nations and nation-states in the 19th century. However, in most instances, such services did not come about in a single instance and based on a grand central plan. On the contrary, **many services which are now considered essential and universally provided by the public sector, were originally created from the bottom up and later taken over** and consolidated by the government. In this "patchwork" model, private, mutual, or parochial organisations provide service when and where they can while there is no governmental guarantee of universal provision or access.

This can happen on a market basis, where entrepreneurs perceive an opportunity to serve unmet demand or meet it better than the public sector. A contemporary example is private for-profit education in many poorer countries, where the less affluent would prefer to pay from their very scarce resources rather than send their children to dysfunctional public schools[219].

Alternatively, the bottom-up solutions can be based on ideas of self-help, community, and mutuality. Religious organisations have been frequent providers of education services throughout history[220]. In our more secular age, there is also a growing breed of social entrepreneurs, individuals who act like entrepreneurs but without the for-profit motivation (ibid.).

Such bottom-up innovation can take place and flourish even in environments with very low governance capacities – for example, in newly independent Bangladesh, non-governmental organisations led by BRAC created a whole microcredit ecosystem, which played an important role in the development of the country and particularly of its women[221]. Indeed, if the gap between perceived need and public sector capacity is too great, it can stimulate bottom-up innovation. However, the bottom-up provision tends to become a victim of its own success – if such services come to be seen as essential, the patchwork nature of private provision often becomes unacceptable and leads to government-based consolidation. Depending on the point of view and the nature of the consolidation, this can appear either as the government crowding out private initiative and stultifying innovation or, in a more positive scenario, the public sector learning and building upon bottom-up innovation in a systematic way.

216 Anand, N., Gupta, A., & Appel, H. (Eds.). (2018). The promise of infrastructure. Duke University Press.

217 Zophy, J. W. (1975). The Formation of National States in Western Europe: Tilly, Charles, ed.: (Studies in Political Development) Princeton : Princeton University Press 711 pp., Publication Date: July 25, 1975. History: Reviews of New Books, 4(1), 5–5. https://doi.org/10.1080/03612759.1975.9945166; Anderson, B. R. O. (2006). Imagined communities: Reflections on the origin and spread of nationalism (Rev. ed). Verso.

218 Gellner, E. (1983). Nationalism and the two forms of cohesion in complex societies. British Academy: Oxford University Press.

219 Pedró, F., Leroux, G., & Watanabe, M. (2015). The privatization of education in developing countries: Evidence and policy implications. UNESCO Working Papers on Education Policy N° 2.

220 Wales, J., Aslam, M., Hine, S., Rawal, S., & Wild, L. (2015). The role and impact of philanthropic and religious schools in developing countries.

221 Zaman, H. (1999). Assessing the poverty and vulnerability impact of micro-credit in Bangladesh. World Bank Policy Research Working Paper Series, (2145). http://documents.worldbank.org/curated/en/630461468741915080/Assessing-the-impact-of-micro-credit-on-poverty-and-vulnerability-in-Bangladesh

Grassroots Education Achievements in Central Europe and Beyond

Targeting Specific Skills Gaps

Formal education system is a juggernaut that is supposed to deliver a huge variety of outputs and outcomes. Children and youth are supposed to imbibe everything from mathematical formulas to civics and appreciation of music. Parents, employers, and governments demand not just specific subject knowledge in a very long list of topics, but also a variety of skills relevant to family, labour market and citizenship. Schools are expected to instil even good habits and help with prevention of obesity and drugs. No wonder that they often fail to deliver focus and innovation in specific areas.

Bottom-up initiatives work in the opposite position. They lack the guaranteed revenue and pipeline of pupils that the formal education system enjoys, but they also have the freedom to work on just one thing and rethink it without anyone looking over their shoulder. When it works, it can provide marvellous results that the school system can utilise. A good example is ***Slovak Debate Association,*** one of the founding members of IDEA - the International Debate Education Association. SDA's unique contribution lies in the fact that it is one of the few Slovak non-governmental organisations that has systematically worked on fostering critical thinking among young people - an area that has been continuously neglected by formal education syllabi. Unlike many other organisations in this area, SDA's 60 debating clubs are spread around the entire country, including rural areas and less developed regions. Moreover, on top of teaching its members analytical, argumentation, and public speaking skills, it provides them with leadership experience, as the majority of debate clubs are coached and administered by high school students. Authors can attest from personal experience that when you meet a smart, opinionated and accomplished young woman or man from Slovakia, there is a good chance she or he participated in the program.

A similar laser-like focus is displayed by ***Czechitas***, a non-governmental organisation inspired by the US project 'Girls Who Code'. Its activities target university students and professionals and include workshops in coding, graphic design, digital marketing, and data science, online academies, and summer schools. Czechitas' impact is related to the sheer magnitude of the people they were able to touch with their projects - since 2014 they have organised 600 events with over 18,000 participants. Czechia has a long-standing tradition in information technology, with the antivirus giant Avast just one example of the Czechs' success in this field. Information technology has also long been taught in schools. Nonetheless, Czechitas are filling the gap that a formal education system is not well equipped to handle – gender disparity.

Bottom-up initiatives can also more easily wade into culturally and politically sensitive areas. When a minister of education in Slovakia wanted to introduce something as innocuous as yoga to schools – as an elective exercise technique – the uproar led by Catholic bishops killed the idea. For anyone who believes that this is a peculiarity of Eastern Europeans, just a note that something very similar also recently happened in Alabama. With migration being a hot button topic, governments in Central Europe have been both slow and reluctant to do anything visible for the migrants' integration. Enter Mareena, a civic organisation providing opportunities for foreigners to integrate into the Slovak society. One of their main activities is the provision of paid Slovak language courses for migrants that include insights about the Slovak society and culture, but by equally giving Slovaks the opportunity to get acquainted with other cultures by participating in courses of foreign languages, several of which are not widely available in language schools. This way it connects the provision of opportunities to develop language skills with a message.

Each of these three organisations have been selected because their work is already reaching large audiences. However, for a truly global and massive scale that can be achieved over time with persistence and a good organisation model, they can look to the Duke of Edinburgh's Award (DofE). The youth program, established in the United Kingdom in 1956 by the recently deceased husband of Queen Elizabeth II, now operates in over 140 countries. Participants are asked to set goals in the areas of volunteering, physical activity, skills, and an expedition they need to take part in with a group. DofE enables its participants to explore a range of areas related to personal development, while giving them the flexibility to pursue the goals they are particularly interested in. DofE also trains the participants' soft skills, such as resilience, problem-solving, and teamwork.

Creating Alternatives to the Formal Education Systems to Provide Broadly-based Learning Interventions

While programs such as Czechitas or Mareena are highly focused and, at least in budgetary terms, relatively small activities, there is also potential for **creating full scale alternatives to existing schools and universities.** These can work with students of any age, but examples in this report are predominantly in upper secondary or tertiary education.

LEAF Academy is an international boarding high school "for future leadership" based in Bratislava aimed at students 14-19 years of age. At a global scale, similar services are provided by ***United World Colleges (UWC)***, a network of boarding schools and related short-term educational programs with the mission of "making education a force to unite people, nations, and cultures for peace and a sustainable future". It is currently composed of 18 international schools with students from over 150 countries.

At the tertiary, level, ***ŠKODA AUTO University*** is the only education institution in Czechia that was founded

BOX 3. Overview of Existing Bottom-Up Education Initiatives in Central Europe and the World

1. Targeting specific skills (language skills, digital skills, critical thinking skills, etc.)

- Slovenská Debatná Asociácia (SK) (http://www.sda.sk)
- InoBat Battery Academy (SK) (https://www.thebatteryacademy.com/en/)
- Czechitas (CZ) (https://www.czechitas.cz/cs/)
- Mareena (SK) (https://mareena.sk)
- *DofE (UK) (https://www.dofe.org)*

2. Bypassing formal education systems and creating alternatives in liaison with the private and third sectors

- LEAF Academy (SK) (https://www.leafacademy.eu)
- ŠKODA AUTO Vysoká Škola (CZ) (https://www.savs.cz)
- Mathias Corvinus Collegium (HU) (https://mcc.hu/en/vision)
- *United World College (UWC) (https://www.uwc.org)*

3. Making global education content more accessible to students and learners

- Centrum Pro Talentovanou Mládež (CZ) (https://www.ctm-academy.cz/o-nas)
- Global Online Academy (HU, SK, CZ) (https://www.aisb.hu/en/learning/global-online-academy/)
- *Khan Academy (US) (https://www.khanacademy.org)*

4. Transforming higher educational institution to attract talent, brains, and capital (including greenfield and joint projects)

- Prague AI (CZ) (https://prg.ai/en/about-us/)
- Perspektywy Education Foundation (PL) (http://perspektywy.org/fundacja/)
- Central European University (HU) (https://www.ceu.edu)
- *Toulouse University of Economics (FR) (https://www.tse-fr.eu)*

5. Connecting students and the world of work

- Otevřená věda (CZ) (https://www.otevrenaveda.cz/cs/index.html)
- Future Medical Leaders Academy (SK) (https://www.fmla.sk)
- Invendor Innovation Academy (HU) (http://invendor.hu/invendor-innovation-academy/)
- *Nepris (US) (https://www.nepris.com/about)*

6. Brain circulation

- Vráť sa (SK) (https://www.vratsa.sk)
- CHANGE! (HU) (https://cor.europa.eu/en/engage/studies/Documents/addressing-brain-drain/addressing-brain-drain.pdf)
- South Moravian Program for Distinguished Researchers (CZ) (https://www.jcmm.cz/projekt/somopro_en)
- *Brain Back Umbria (IT) (https://cor.europa.eu/en/engage/studies/Documents/addressing-brain-drain/addressing-brain-drain.pdf)*

by a large multinational company. It offers bachelor's and master's degree programs that combine education in economics with courses from computer science, mechanical engineering, and electrical engineering, and usually include courses in at least two foreign languages.

Mathias Corvinus Collegium (MCC) takes a different approach, providing training programs for exceptionally talented students in the upper grades of primary school, high schools, higher education, but also for graduate young adults. Unlike the other institutions, MCC does not frame itself as a full-blown alternative to public education institutions, but as a complementary one that can help talented students perform better in the formal education system.

The prime advantage of the approach taken by these institutions is that it provides deep and wide-ranging interventions in lives of participants, frequently providing **a comprehensive education experience.** Given that Central European countries allow private institutions and frequently even provide funding for those that follow local accreditation and regulatory standards, it is worth noting that examples in this section generally work outside of it. The motivation is the resulting liberty to do things differently and not be encumbered by restrictions imposed by what is often seen as low-quality, parochial, or outdated requirements. Therefore, the ŠKODA AUTO University has international institutional ACBSP accreditation from the American Accreditation Council for Business Schools and Program and the Leaf Academy provides American high school diploma enhanced by the U.S. system of Advanced Placement credits. In this, they follow global examples such as the UWC, which graduates students with the globally recognised International Baccalaureate Diploma Program (IBDP). Providing full-scale educational alternative requires substantial resources with a measure of stability. Except for MCC, which is largely funded by the Hungarian state, all these initiatives have a single donor – a corporation or a wealthy individual – that guarantees the financial stability.

Supplementing national systems by making global education content more accessible to students and learners

One of the great promises of globalization, supercharged by the internet, is the availability of the same information and digital tools to everyone around the world. The concept drives such well-known concepts as MOOCs (Massive Open Online Courses), where US-based ventures such as Coursera or EdX take the lead. One of the global leaders of this movement, literally created in a California garage, is ***Khan Academy*** - a non-profit organisation established in 2006 with the aim of creating online learning methods to educate students. It focuses on short videos for learners of all ages, and it has always been conceived as a free platform to remove barriers for students from lower socio-economic backgrounds to access top-quality education and follow their own pace, despite not having the support of private tutors.

Other initiatives follow similar logic through different methods. For example, ***Global Online Academy*** is a non-profit organisation that has formed a network of 85 high-performing independent schools in over 15 countries, including three schools located in the four countries under review. Its aim is to offer high-quality online courses all of which are taught by a selection of teachers from its member schools. The courses offered enable students to pursue more specialised areas than the ones that are available to them at school - for instance, Bioethics, Game Theory, or Medical Problem Solving. In Czechia, ***Centrum Pro Talentovanou Mládež*** (Centre for Talented Youth) is also a non-profit organisation offering students the possibility to take Advanced Placement (AP) preparation courses and take the internationally recognised AP exams in a number of subjects. They also facilitate online courses in over 100 subjects at different levels of difficulty. Moreover, they organise Discovery Saturdays - an in-school semester-long program one Saturday every month for children at the age of 5-14 years currently taking place in three cities.

Generally, the edge of these initiatives is in creation of a learning environment that allows learners to follow their own pace and interests, combined with high quality content that would often be difficult to create locally, particularly for very niche topics.

Transforming higher education institutions to attract talent, brains, and capital

After the fall of the Iron Curtain, higher education in Central Europe underwent rapid expansion, driven by factors described in Section I and, in a space of two decades, largely converged with student numbers in other Western countries. However, there has not been a corresponding convergence in quality. While there are individual examples of excellence, with the top tier Czech, and to a lesser extent Polish and Hungarian institutions entering global rankings, they lag behind their respective counterparts in Austria, Netherlands, or Germany. This is not just a Central European phenomenon. A moribund university system impervious to change, with only a small number of pockets of excellence, is also present, for example, in France or Italy.

There is a number of grassroots projects using very different approaches to bypass this gridlock. Globally, an interesting role model is ***Toulouse University of Economics*** in France. It took 30 years to create a world-class economics school within a public university, but the school is currently chaired by Jean Tirole who became a Nobel laureate in 2014 and it has a record-breaking number of European Research Council grants and places among the best in Europe in rankings based on quality-weighted publications. TSE is thus an impressive case study of a leading school emerging as a result of bottom-up efforts by a determined group of experts.

George Soros followed a similar, but even more radical approach when he established ***Central European***

University (CEU) from scratch in 1991. Before it was forced to leave Hungary in 2019, it was the highest-ranked academic institution focusing on social sciences in post-communist Central Europe. It was also probably the most expensive privately funded education project in the region. CEU combines academic excellence based on meritocratic global recruitment with strong attachment to promotion of democracy and human rights.

When the deep pockets to fund a brand new university are lacking, smaller scale bottom-up projects to transform higher education in a specific field or collaborating with existing institutions are possible.

Prg.AI is a non-profit initiative created by academics from the Czech Technical University, Charles University, and the Czech Academy of Sciences, with the City of Prague also significantly contributing. To position Prague as a globally competitive location for AI education and research, the initiative works on implementation of an AI curriculum in secondary schools with the help of leading experts and the City of Prague, as well as a prg.ai Minor program for CTU and CU students interested in the topic.

To the north, ***Perspektywy Education Foundation (PEF)*** is an independent, non-profit organisation that works both domestically and internationally to improve and promote Polish higher education through better information. Domestically, it organises public debates and seminars in all 18 academic centres for high school students on higher education opportunities, attracting over 200,000 participants annually. Internationally, it promotes Polish higher education institutions in order to attract foreign talent.

Connecting students and the world of work

The need to forge better connections between education and the world of work has been recognised as a challenge for several decades. During the communist times, even pupils from academically oriented schools had to visit factories to see what "real work" looks like though there is no evidence it contributed to better understanding of or paths into an industrial career. More relevantly, apprenticeships and vocational education modelled on Germany and Austria dominated the upper secondary education system before 1989. Even though demographic and economic changes led to a reduction of this model, it is still going strong and has been reinvigorated in recent years as governments react to demands by major employers to provide replacement for retiring workers in manufacturing, construction, and other blue-collar sectors. With hundreds of millions of euros in domestic and Structural Funds invested and millions of students across the region, this is one of the major focal points of public policy.

However, even here there are large gaps where grassroots action can play an important role. For example, in the US, ***Nepris*** bridges the gap between education and industry by allowing teachers to invite a virtual guest speaker for their class who can speak about how particular curricula topics are applied in their work, give guidance to students on their projects, or help to evaluate students' projects. It recognises that teachers and firms often do not have the time and other resource to do this matching on their own.

Bottom-up projects can also reflect the changing shape of work in the innovation society. For example, ***Invendor Innovation Academy*** in Hungary has a program aimed at young entrepreneurs at the age of 16-19. It is a semester-long course aimed at high school students and young university students, with weekly club sessions, mentoring sessions, and the opportunity to execute a business idea. Its objective is not just to stimulate entrepreneurship of students, but to focus them on innovative ideas.
A similar emphasis on innovation is present in the project ***Otevřená věda*** by the Czech Academy of Sciences. While educational courses for teachers and individuals who are interested in popularising science are also a part of this initiative, it is primarily known for creating a portal that connects students to the staff on particular research projects who are looking for interns. This makes it easier for students to get work experience in the subject area they want to pursue, increasing the amount of real-world practical knowledge they can get outside of their school syllabi. In Bratislava, Slovakia, ***Future Medical Leaders Academy*** is an initiative first created by medical students from the Comenius University in Bratislava, the main objective of which is to provide students of medicine with 'soft' interpersonal skills. It is a two-semester course full of workshops, discussions, and lectures on the topics of critical thinking, public presentation, ethical dilemmas, the basics of financial management, medical law, leadership, etc.

Preventing brain drain and stimulating brain gain

Central European countries are historically used to being sources of migration rather than destinations. However, in both of these areas, change has been afoot for several years now. For example, ***Vráť sa*** (Return) is a Slovak non-governmental initiative trying to prevent a further continuation in brain drain by showing how, through coming home, one can make an impact while not sacrificing quality of life or job opportunities.

However, bleeding of talents is not just a national, but also a regional problem. Therefore, there is an increasing number of initiatives that try to achieve the same at a smaller scale. For a global role model, we selected ***Brain Back Umbria, an Italian*** project led by the regional agency for socio-economic and territorial research that aimed to mitigate the outflow of citizens of Umbria. Their activities ranged from conducting surveys focused on the citizens who migrated, development of a typical migrant profile and then implementing policies specifically aimed at these groups. Tangible outcomes of the project included the creation of a database of the citizens who reside abroad and of a community group on LinkedIn, the emergence of 16 start-ups, three 'Business Visits' in the food, fashion, and tourist industries, and a new project website, which gained

83,207 views in the 2012-2015 period. In Central Europe, a similar path is taken by ***CHANGE!***, a joint project of the Nagykanizsa City Council and the Urban Local Group (ULG), consisting of young people, NGOs, and representatives of social institutions.

The second approach is to attract new high-powered talent – be it from other countries or return of long-term migrants. ***The South Moravian Program for Distinguished Researchers*** is a grant scheme that offers financial support to host institutions to help them pay for research costs, as well as the personal expenses of researchers. Researchers who have spent a period of at least 2 out of the last 3 years outside Czechia are eligible. The program managed to have a retention rate of 13 out of 27 fellows choosing to remain in the region.

Conclusions and Policy Roadmap: The Post-Covid Skills Reset

An inclusive economic recovery starts with economic growth, jobs, skills, and equity. But against the backdrop of the failure of many governments to adequately reform education and provide for skills of 21st century, we surveyed and explored the potential of bottom-up approaches to education and skill provision, as an alternative to public service provision.

We took stock of the post-communist starting points, divergent policy approaches, and education outcomes of four Central European (Slovakia, Czechia, Poland, Hungary), explored the potential of bottom-up skill initiatives for Central Europe, and mapped grassroots education achievements in the region and beyond. We also presented national strategies of the respective governments to tackle skills provision, as embedded in respective national Recovery & Resilience Plans.

The choices made by policymakers, business leaders, and other key actors today will shape Central European societies for decades to come. At this critical juncture, leaders are to lay down the foundations consciously and pre-emptively for a new social contract to provide opportunities for all.

Key points & Recommendations for Public Policy

- **Broadly-based, well-designed top-down education reforms are still any system's best bet,** as Poland and Estonia have shown. Therefore, in the quest to escape the middle-income trap, and upgrade towards innovative, intelligent, and sustainable growth paradigm, effective public skill provision **should be prioritised with utmost urgency.**
- But in the absence or incompleteness of top-down reforms delivering tangible results – and in the face of the pressing need – **successful grassroots alternatives** can be extremely important, despite their smaller size for at least 3 reasons: (a.) they partly fill the void left by public policy; (b.) act as a complementary source of skills to the formal system; and, (c.) pilot approaches and schemes that can be adopted more broadly and improve education systems.
- The pronounced advantage of the bottom-up approaches to skills provision is that they could improve education outcomes faster. The obvious downside is that they do so typically at a small(er) initial scale. However, if policymakers devoted more attention and resources to recognition, validation and scaling of successful bottom-up initiatives, these could quickly spread, especially in smaller countries
- We recognise and appreciate that funds have been allotted toward education reforms and skills upgrades under the Recovery & Resilience Fund umbrella in all four economies under review. What is important is to use these funds not only for physical infrastructure investment projects, but also to **support challenges to the status quo, including support and scaling of bottom-up initiatives.**

Key points & Recommendations for the Private Sector

- **The private sector should not stay a passive agent** on the road towards the knowledge-based economy.
- It should allocate resources, create synergies and partnerships across sectors and industries, to help upgrade the skillset of labour, starting with areas that are closest and most relevant to its needs
- The private sector can learn from existing success stories (see catalogue of initiatives) that can be replicated, scaled, or developed.
- Admittedly, the COVID-19 pandemic has increased the pressure on the private sector revenue and margins. In contributing to shaping the new social contract, the private sector should also be able to tap funds under the Recovery & Resilience Fund umbrella to scale-up existing bottom-up initiatives or develop them further.

Spotlight: Bottom-Up Education Initiatives in Central Europe

Targeting specific skills (language skills, digital skills, professional/vocational skills, critical thinking skills, etc.)

- **Slovak Debate Association (Slovenská Debatná Asociácia) (SK) (http://www.sda.sk)**

Slovenská Debatná Asociácia (SDA) is an independent apolitical civic association established in 1999 that focuses on promoting critical thinking, openness, and citizenship among the youth. Its activity consists of facilitating six debating programs targeted at a variety of groups, the biggest of which is the high school competitive debating program with over 500 students. As a part of it, the association organises dozens of seminars, training sessions, as well as tournaments that take place in all regions of Slovakia. It is one of the founding members of IDEA - the International Debate Education Association. SDA's unique contribution lies in the fact that it is one of the few Slovak non-governmental organisations that has systematically worked on fostering critical thinking among young people - an area that has been continuously neglected by formal education syllabi. Unlike many other organisations in this area, SDA's 60 debating clubs are spread around the entire country, including rural areas and less developed regions. Moreover, on top of teaching its members analytical, argumentation, and public speaking skills, it provides them with leadership experience, as the majority of debate clubs are coached and administered by high school students. While SDA currently employs three people, a great portion of SDA's work is conducted by its volunteers. These are mostly alumni of the high school program who go on to develop their skills this way in various capacities.

- **InoBat Battery Academy (SK) (https://www.thebatteryacademy.com/en/)**

InoBat Battery Academy is an educational campaign powered by InoBat, which aims to increase awareness on the battery ecosystem among students, graduates, young professionals, battery enthusiasts and others. In its initial phase, the 12-month project aims to introduce different aspects of this industry via monthly videos, lectures, and podcasts with leading experts on battery R&D, production, supply chain, recycling and much more. It is also a platform for hands-on experience- in July two students had the opportunity to take part in a shadowing program, rotating between several departments involving key InoBat personnel. Later, the Academy will be expanded and used for InoBat's training purposes in its Voderady facility. InoBat is a Slovakia-based company established in January 2019 focusing on innovative energy solutions. Its main industry verticals are InoBat Auto (EV battery R&D and production company), InoBat Energy (entity developing stationary energy storage systems) and InoBat Recycling (battery recycling solution provider). Its flagship project, InoBat Auto, is developing a world-first AI-driven battery research centre and production line in Voderady, Slovakia, which will begin producing its first batteries in 2022. In addition, InoBat is also working on expanding the charging infrastructure through InoBat Charging and developing hydrogen and alternative fuel solutions via InoBat HydrogenSlovenská Debatná Asociácia (SDA) is an independent apolitical civic association established in 1999 that focuses on promoting critical thinking, openness, and citizenship among the youth.

- **Czechitas (CZ) (https://www.czechitas.cz/cs/)**

Czechitas is a non-governmental organisation inspired by the US project 'Girls Who Code' that aims to spark interest and educate girls and women in the area of IT. Its activities targeted at university students and professionals include workshops in coding, graphic design, digital marketing, and data science, online academies, and summer schools. Moreover, Czechitas also organises an annual prize for the best undergraduate thesis in IT-related subject areas, provides career counselling, as well as scholarships to lower the (re-)entry barriers into the industry. The organisation creates workshops, summer schools, tutorials, and other resources for children and teenagers, as well.

Being aware of the increasing importance of digital literacy on the labour market and the inevitable path to the gradual automatization of many jobs, the organisation aims to overcome the gender inequality present in the technology industry. Czechitas' impact is related to the sheer magnitude of the people they were able to touch with their projects - since 2014 they have organised 600 events with over 18,000 participants. In 2016 they were awarded the European Citizen Prize from the European Union and became the first Central/Eastern European organisation to be granted a Google.org grant for their requalifying course 'Digital Academy'. They received this grant again in 2018 which allowed them to further expand into more Czech regions.

- **Mareena (SK) (https://mareena.sk)**

Mareena is a civic organisation the vision of which is that Slovakia becomes a country that provides a safe and dignified home for all, regardless of their nationality and ethnic or religious identity. Its goals include providing opportunities for foreigners to integrate into the Slovak society, supporting the local communities of Slovaks and foreigners to build relationships, as well as raising awareness of topics related to diversity, migration, and integration. On top of workshops, as well as media campaigns for inclusivity, one of their main activities is the provision of paid language courses - in Slovak for the foreigners they work with, but also in Arabic, Persian, Russian, and Swahili.

Given the difficulties foreigners often face when trying to assimilate after arriving in Slovakia and the lack of systematic support they have available from the state, Mareena does important work in accounting for this gap. It does this by offering them Slovak language courses that include insights about the Slovak society and culture, but by equally giving Slovaks the opportunity to get acquainted with other cultures by participating in courses of foreign languages, several of which are not widely available in language schools. This way it connects the provision of opportunities to develop language skills with a message.

- **DofE (UK) (https://www.dofe.org)**

Duke of Edinburgh's Award (DofE) is a program aimed at the youth established in the United Kingdom in 1956, which now operates in over 140 countries. The program takes between one and four years to complete, depending on the level of the award the participant aims to obtain. With the support of their adult Leaders, participants are asked to set goals in the areas of volunteering, physical activity, skills, and an expedition they need to take part in with a group. In order to obtain the award, participants are monitored and evaluated by a person who is knowledgeable in the area of their goals.

DofE enables its participants to explore a range of areas related to personal development, while giving them the flexibility to pursue the goals they are particularly interested in. In conjunction with the fact that they can benefit from the supervision and mentorship of their Leaders, they have an ideal environment to develop the skills of their choice. However, more importantly, DofE trains the participants' soft skills, such as resilience, problem-solving, and teamwork. They are able to develop these as they move through the levels of difficulty, as more commitment is expected from them as they progress.

Bypassing formal education systems and creating alternatives in liaison with the private and third sectors

- **LEAF Academy (SK) (https://www.leafacademy.eu)**

LEAF Academy is an international boarding high school "for future leadership" based in Bratislava aimed at students 14-19 of age. It has a 2-year and 4-year program, and its American-style AP curriculum provides an academically rigorous education with a strong emphasis on leadership, entrepreneurship, moral values, and self-awareness. These elements are synthesised with a focus on practice and application of knowledge in the real world through cooperation on real-life projects with the school's business and NGO partners.

Given LEAF Academy's status as a foreign educational organisation, it is not required to follow Slovakia's national high school curriculum. This has allowed it to craft a syllabus that is more appropriately tailored to a 21st-century approach to high school education, as seen in its focus on experiential learning and value-driven teaching. LEAF Academy provides scholarships in order for all teenagers to be able to attend regardless of their socio-economic situation and partially also funding international students, thus attempting to create an inclusive, diverse environment.

- **ŠKODA AUTO Vysoká Škola (CZ) (https://www.savs.cz)**

ŠKODA AUTO University in Mladá Boleslav was established in 2000 by the biggest automobile manufacturer in Czechia and is thus the only education institution in the country that was founded by a large multinational company. They offer bachelor's and master's degree programs that combine education in economics with courses from computer science, mechanical engineering, and electrical engineering, and usually include courses in at least two foreign languages. A part of the bachelor's studies is a compulsory internship with a top employer either in Czechia or abroad.

Since 2014 ŠKODA AUTO University has held a prestigious international institutional ACBSP accreditation from the American Accreditation Council for Business Schools and Programs. This has opened new doors for the graduates of the university to get more opportunities and enter markets overseas despite the university's unusual origins in the Central European context. The university synthesis the ability to provide teaching given by the experts in the field with a strong emphasis on the practical element of education through internships and work placements facilitated by ŠKODA AUTO. This enables the company to tailor the structure of their programs to the expectations they have for their future potential workforce, removing an extra step in the relationship between students and employers.

- **Mathias Corvinus Collegium (HU) (https://mcc.hu/en/vision)**

While Mathias Corvinus Collegium (MCC) has been creating educational opportunities for young people for over two decades, it has the ambition of becoming "the most important young talent nurturing institution in the Carpathian Basin" in the upcoming years. MCC provides training programs for exceptionally talented students in the upper grades of primary school, high schools, higher education, but also for graduate young adults. The organisation sees itself to be a space for individualised education and small-group teaching, with knowledge acquired being tailored to the students' interests and beyond a superficial level.

Despite the clear distinctiveness of its teaching methods compared to those at state universities, MCC does not frame itself to be an alternative to public higher education institutions. Instead, it wants to act as a complementary form of obtaining knowledge that can help students perform better in the formal education system. This way it bypasses the formal education system, as it proposes new channels through which learning can happen that do not aim to fully imitate the state ones. In the future, the organisation wants to be present in all 19 Hungarian counties and 16 other Hungarian-majority cities in the Carpathian Basin.

- **United World Colleges (https://www.uwc.org)**

United World Colleges is a global network of boarding schools and related short-term educational programs with the mission of "making education a force to unite people, nations, and cultures for peace and a sustainable future". It is currently composed of 18 international schools that teach the International Baccalaureate Diploma Program (IBDP) and that are spread across four continents. Students come from over 150 countries and a great portion of them receive full or partial financial support.

There are numerous ways in which the UWC approach to education forms its students to carry a strong sense of citizenship, personal integrity, and multicultural awareness. UWC organises volunteering and experiential opportunities for its students to explore the countries in which they are studying. In conjunction with the fact that they are surrounded by students of dozens of nationalities, they are encouraged to celebrate diversity and get insight into other cultures. Moreover, as the IBDP includes a mandatory 'creativity, activity, service' component, it enables students to create their own projects on top of their academic pursuits. These often contribute to the local communities, while facilitating the students' personal development.

Making global education content more accessible to students and learners

- **Centrum Pro Talentovanou Mládež (CZ) (https://www.ctm-academy.cz/o-nas)**

Centrum Pro Talentovanou Mládež (CTM) is a non-profit organisation for students "who seek an individual and flexible approach to education." CTM offers students the possibility to take AP preparation courses and take the internationally recognised AP exams in a number of subjects. Likewise, they facilitate online courses in over 100 subjects at different levels of difficulty. Moreover, they organise Discovery Saturdays - an in-school semester-long program one Saturday every month for children at the age of 5-14 years currently taking place in three cities.

CTM's edge is based on the fact that its online programs, preparatory courses, and exams for students from elementary schools to high schools create a learning environment that allows them to follow their own pace and interests. Likewise, the ability to access the opportunity to take AP exams allows students who are considering applying to universities abroad to measure their accomplishments internationally and demonstrate their commitment to rigorous academics in their subject. This increases the competitiveness of their application.

- **Global Online Academy (HU, SK & CZ) (https://www.aisb.hu/en/learning/global-online-academy/)**

Global Online Academy is a non-profit organisation that has formed a network of 85 high-performing independent schools in over 15 countries, including three schools located in the four Central European countries under review. Its aim is to offer high-quality online courses all of which are taught by a selection of teachers from its member schools. The courses offered enable students to pursue more specialised areas than the ones that are available to them at school - for instance, Bioethics, Game Theory, or Medical Problem Solving. Furthermore, this teaching style provides students with a network of other students interested in their subject, given that they collaborate on projects and assignments that are a part of the curriculum.

The academy enables students to have more agency over the education they want to have on top of their mandatory school lessons, since in the Academy they can choose courses from a wide range of disciplines. Moreover, the asynchronous nature of these lectures gives students the opportunity to work on their time management, given that they partake in the Academy in parallel with their formal education. This project is, therefore, a successful case study of educational institutions sharing their resources and thus offering their students a richer educational experience.

- **Khan Academy (US) (https://www.khanacademy.org)**

Khan Academy is a non-profit organisation from the United States established in 2006 with the aim of creating online learning methods to educate students. It produces short videos in a number of languages that explain the material from different areas, ranging from subjects covered in school to preparation courses for standardised tests, such as the SAT or AP exams. Moreover, the platform also offers content from other organisations such as the popular YouTube channel Crash Course or the Museum of Modern Art. While these online lessons also come with practice exercises and materials for teachers, these resources are offered for free.

Khan Academy frames its initiative as a supplement to formal education. Given that is yet another source for students to learn the content of their syllabi, it puts a certain degree of pressure off of the teachers who can now cater more specifically to students' personalised needs. Moreover, since it is a free platform, it removes the barriers for students from lower socio-economic backgrounds to access top-quality education and follow their own pace, despite not having the support of private tutors. This is particularly important in the context of preparatory courses for standardised tests, as the students' performance at these determines the direction of their future. Therefore, improving access to preparatory resources helps to improve the starting point these students have when applying for universities.

Transforming higher educational institution to attract talent, brains, and capital (including greenfield and joint projects)

- **Prague AI (CZ) (https://prg.ai/en/about-us/)**

Prague AI is a non-profit initiative created by academics from the Czech Technical University, Charles University, and the Czech Academy of Sciences, with the City of Prague also significantly contributing. The "unprecedented synergy of human and institutional resources" aims to fully take advantage of the potential of Prague to be transformed into a European centre of artificial intelligence. They want to do so by building a platform that would encourage the Prague innovation ecosystem to join the global community in the research and application of AI. One of the initiative's activities includes the implementation of an AI curriculum in secondary schools with the help of leading experts and the City of Prague, as well as a prg.ai Minor program for CTU and CU students interested in AI.

- **Perspektywy Education Foundation (PL) (http://perspektywy.org/fundacja/)**

Perspektywy Education Foundation (PEF) is an independent, non-profit organisation established in 1998 to promote education. The board of the foundation is made up of the current and former rectors of Polish universities and other important public figures interested in the development of Polish higher education institutions. Its activities include organising public debates and seminars in all 18 academic centres for high school students on higher education opportunities, attracting over 200,000 participants annually. Likewise, it focuses on promoting Polish higher education institutions globally in order to attract talent from abroad. Moreover, it also supports projects that promote the participation of women in STEM, for instance, conducting a survey in cooperation with Siemens on women's potential for the technological industry.

The objective of a great portion of PEF's work (such as their university fairs) is to spread awareness of the options students have for the future, thus contributing significantly to their ability to make more informed decisions appropriate for their situation. The organisation's STEM program for girls also devotes resources towards getting an in-depth understanding of sexism in this field, increasing the chances that better policies can be taken on the basis of this analysis.

- **Central European University (HU) (https://www.ceu.edu)**

Central European University (CEU) is a private research university located in Vienna and Budapest established in 1991 by the hedge fund manager, philanthropist, and political activist George Soros. It focuses on conducting teaching and research in social sciences and humanities and has an exceptionally international student body. Given that the Hungarian government refused to sign an agreement that would allow the university to continue operating in Hungary, in September 2019 it relocated to Vienna.

CEU was the highest-ranked institution among Hungarian universities before it was forced to leave the country. Given its tie to the Open Society Foundations and the fact that it was first located in Central Europe due to the recognition that the region lacked an independent international university, CEU is strongly devoted to the promotion of democracy and human rights. It combines its regional studies with an international outlook, conducts interdisciplinary and comparative research, and promotes good governance and rule of law. The three decades of its existence have thus proven that even an institution with a strong regional focus can provide world-class education, attract international talent, and act as a pillar for the advancement of academic freedom.

- **Toulouse University of Economics (FR) (https://www.tse-fr.eu)**

The Toulouse University of Economics (TSE) is a school within the Toulouse 1 University Capitole based in Toulouse, France. When Jean-Jacques Laffont, a prominent economist, returned to Toulouse, his hometown, in 1979, he had the vision to create a world-class economics school within a public university. He got together a group of like-minded colleagues who were equally determined for economics to bring benefit for society and its everyday running, and this laid the foundation for what became the Toulouse School of Economics 30 years later. The school is currently chaired by Jean Tirole who became a Nobel laureate in 2014.

On top of being led by a Nobel Prize winner despite its short lifetime, the school has a record-breaking number of European Research Council grants and places among the best in Europe in rankings based on quality-weighted publications. In 2007 TSE was chosen by the French government and the Academy of Sciences as one of 13 "Réseaux Thématiques de Recherche Avancée". This allowed the school to establish a private foundation - the Jean-Jacques Laffont Foundation - which facilitates world class research in economics and in social sciences. TSE is thus an impressive case study of a leading school emerging as a result of bottom-up efforts by a determined group of experts.

Connecting students and the world of work

- **Otevřená věda (CZ) (https://www.otevrenaveda.cz/cs/index.html)**

Otevřená věda is a project by the Czech Academy of Sciences that aims for students, teachers, and the general public to build a relationship with science. While educational courses for teachers and individuals who are interested in popularising science are also a part of this initiative, it is primarily known for creating a portal that connects students to the staff on particular research projects who are looking for interns.

This portal allows students to have a systematic transparent overview of the opportunities they have available if they want to have an internship in academia. This makes it easier for students to get work experience in the subject area they want to pursue, increasing the amount of real-world practical knowledge they can get outside of their school syllabi. Consequently, it helps to create a workforce that is more sufficiently prepared for the actual everyday content of their jobs.

- **Future Medical Leaders Academy (SK) (https://www.fmla.sk)**

Future Medical Leaders Academy is an initiative first created by medical students from the Comenius University in Bratislava, the main objective of which is to provide students of medicine with 'soft' interpersonal skills. It is a two-semester course full of workshops, discussions, and lectures on the topics of critical thinking, public presentation, ethical dilemmas, the basics of financial management, medical law, leadership, etc. The course is based on the internationally renowned concept CanMEDS.

The academy is a complementary source of knowledge to the formal education system students of medicine are required to pass. Instead of deepening the 'hard' technical skills, the program aims to create individuals who will be holistically prepared to take on the role of a doctor with all of the character traits, emotional maturity, and communication skills this implies. For this reason, it acts as good preparation for the labour market.

- **Invendor Innovation Academy (HU) (http://invendor.hu/invendor-innovation-academy/)**

Invendor Innovation Academy (IIA) has been run by Invendor Advisory Services - a company with an influential presence in the CEE start-up community that provides start-up incubation services and organises innovation programs - in various versions since 2015. Their academy has programs targeted at two main groups: companies and working professionals, as well as young entrepreneurs at the age of 16-19. The former is aimed at professionals regardless of the type of organisation they come from and at business leaders who need help with their company's innovation strategy. The objective of this course is to use a community-fostering ecosystem-based approach to teach its participants useful methodologies through practical training in areas such as service design, UX, AI in human resources, or Agile Teams. The latter is a semester-long course aimed at high school students and young university students, with weekly club sessions, mentoring sessions, and the opportunity to execute a business idea.

IIA is a successful case study of a bottom-up approach to education for both of the programs it runs. In the case of the program aimed at experienced professionals, IIA ensures that the skills of employees are up to date with the trendiest tools and best practices, thus accounting for the hardships formal education institutions have with adapting their syllabi to the needs of the industries at such a quick pace. With respect to the course for students, IIA provides an important platform for the youth to work on their entrepreneurial skills, receive career guidance, and develop such soft skills as teamwork or critical thinking.

- **Nepris (US) (https://www.nepris.com/about)**

Nepris is a social community based in the United States that aims to bridge the gap between education and industry. It allows teachers to invite a virtual guest speaker for their class who can speak about how particular curricula topics are applied in their work, give guidance to students on their projects, or help to evaluate students' projects. The organisation publishes industry videos that are readily available to teachers at all times and has developed a career explorer tool, which allows students to research and compare potential careers.

Nepris recognises that teachers often do not have the time to research and invite guest speakers or mentors and even less so to organise field trips. Likewise, most firms have difficulties in doing a large-scale outreach, in a way that would not exclude rural school districts, due to what the platform identifies as geographic and curriculum barriers. For this reason, Nepris has stepped in to bridge this gap and make engagement with industry an integral part of education, instead of an afterthought.

Preventing brain drain and stimulating brain gain

- **Vráť sa (SK) (https://www.vratsa.sk)**

Vráť sa is a non-governmental initiative led by the Slovak organisation LEAF, AmCham Slovakia and Sapie. Its objective is to prevent a further continuation in brain drain by highlighting the value-driven reasoning for why returning back to Slovakia makes an impact while showing that this step does not mean sacrificing the quality of life or the lucrativeness of job opportunities. The initiative's website includes tutorials on the bureaucratic steps that need to be taken for one to return, testimonials of other young professionals who decided to return to Slovakia, and the most recent job offers.

Vráť sa is a meaningful initiative because it collects all the important resources that could contribute to one making the decision to return to their home country - calls for enthusiasm, clear explanations on the official procedures, and a platform to look for work opportunities to be able to stay in Slovakia in the long-term. As a result, it is a resource that provides a good starting point and makes the process of returning easier.

- **CHANGE! (HU) (https://cor.europa.eu/en/engage/studies/Documents/addressing-brain-drain/addressing-brain-drain.pdf)**

CHANGE! was an URBACT project that took place in 2015-2018 and was organised by the Nagykanizsa City Council and the Urban Local Group (ULG), consisting of young people, NGOs, and representatives of social institutions. The first stage of the project was led by ULG which designed a problem tree that highlighted the main difficulties the municipality had in responding to its diverse and highly skilled local community needs. This activity revealed that these struggles were rooted in the lack of communication between the authorities and the youth, who consequently felt ignored and unrepresented. As a result, the Integrated Action Plan led to the creation of the 'Base-Youth Community' where the youth can work on their initiatives and project under the guidance of mentors, the 'Incubator Centre' where the youth is given funds and mentoring to successfully enter the local entrepreneurial market and the 'Benovative.com platform', an online innovation hub.

The impact of this project is not exclusive to the municipality's impressive ability to address the young people's demands to provide entrepreneurial opportunities through a three-part solution. As a part of the initiative, it created a mid-term youth policy (2018-2022), which is the very first municipal document specifically designed for young people and their concerns. Moreover, it provided young entrepreneurs with regional tax allowances as incentives to open start-ups in the town. As a result of this process, it embraced a more bottom-up and horizontal approach to decision-making, as proven by the existence of new successful partnerships with local enterprises and other stakeholders for the development of this strategy that aims to let locals participate in building a future of their town.

- **South Moravian Program for Distinguished Researchers (CZ) (https://www.jcmm.cz/projekt/somopro_en)**

The South Moravian Program for Distinguished Researchers is a grant scheme that offers financial support to host institutions to help them pay for research costs, as well as the personal expenses of researchers. Individuals who hold a doctoral degree or have at least 4 years of research experience and have spent a period of at least 2 out of the last 3 years outside Czechia are eligible. Researchers are allowed to choose their specialization; however, this specialization must not be in human or social sciences.

The program provides academic funding in order to incentivise experienced researchers to migrate into educational institutions in South Moravia. As a result, 71 researchers from 27 countries received financial support, leading to 2,116 months of research and 237 publications. The program also managed to have a retention rate of 13 out of 27 fellows choosing to remain in the region. This enabled the program to improve the regional talent attraction capacity and generated an inflow of financial resources into the local economy.

- **Brain Back Umbria (IT) (https://cor.europa.eu/en/engage/studies/Documents/addressing-brain-drain/addressing-brain-drain.pdf)**

Brain Back Umbria was a project led by the regional agency for socio-economic and territorial research that aimed to mitigate the outflow of citizens of Umbria, a region in Italy, abroad. The local authorities recognised that the existing sources of data on emigration (available from the Register of Italians Resident Abroad (AIRE) and the local universities) were incomplete, primarily given that registering in the AIRE is not compulsory when moving in the Schengen area. Therefore, they conducted custom-made qualitative and quantitative research focused on the citizens who migrated because of the lack of employment opportunities. Based on a sample of 1,400 which they targeted through a 'Keep in touch' survey circulated on social media, they were able to develop a typical profile of the migrants. The following are examples of policies that were implemented in response: For instance, they started providing grants up to 20,000 euros per person to support innovative start-ups in the region and thus encourage the return of the business-making capacities. Moreover, they began organising regional events for the people who returned to the region, with the aim of spreading awareness of the opportunities available in Umbria and fostering a sense of belonging to motivate them to stay. Likewise, they organised 'Business Visits' which had the objective of internationalizing Umbrian SMEs and facilitating dialogue between Umbrian companies and Umbrian professionals abroad.

Tangible outcomes of the project included the creation of a database of the citizens who reside abroad and of a community group on LinkedIn, the emergence of 16 start-ups, three 'Business Visits' in the food, fashion, and tourist industries, and a new project website, which gained 83,207 views in the 2012-2015 period. The lesson in the bigger picture is that regional efforts that aim for 'brain regain' can be successful, as long as authorities have access to reliable data on the size and characteristics of who the target group of their policies is. Given the positive impact achieved in the first edition, it was further renewed for the 2014-2020 period.

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2. Benchmarking Strategic Transformation

Chapter 3. CEE Strategic Transformation Index, Rankings & Policy Recommendations

The CEE9 regional economy's strategic transformation is a winning transformation that leans heavily on innovation, while being intensely aware of its past and present, growth drivers to-date, and its regional macroeconomic, financial, and structural makeup. As such:

- the conceptual framework is formulated with awareness and sensibility for the region's past performance and current economic structure in mind *(a backward-looking element)*
- while placing an emphasis on innovation as means to address pain points and shared challenges *(the forward-looking element)*. It is conducive to the sustainable growth of its economies and the long-term prosperity of its societies, enabled and buttressed by the strategic policy playbook.

GLOBSEC has pooled and leveraged regional expertise – as embodied by data, empirical evidence, international institutions' country surveillance, and the know-how of institutions/individuals partnered on this project – **to identify the big areas where change is necessary to reroute the CEE9 region onto a dynamic and sustainable growth trajectory.** There is a shared basis – a set of common macroeconomic features among CEE9 countries – that provide a viable foundation for this exercise.

The section that follows presents an overview of the main concepts and building blocks of the GLOBSEC CEE Strategic Transformation Index. The composite index consists of two main pillars: *(1) Economic Structure & Resilience;* and *(2) Innovation Economy.* The former broadly captures the performance and structure of the CEE economy, which is closely linked to the regional economies' economic and financial vulnerabilities that need to be addressed to foster resilient economies. The latter draws on the earlier discussions that amount to the prediction that innovation is key to unlocking the region's growth potential, escaping the middle-income trap, and raising the standards of living permanently and sustainably.

The two basic pillars are further disaggregated into eight sub-dimensions (four each) that provide more granular insight into dimensions of strategic transformation of the CEE economy. An elaborated roadmap of the key considerations leading up to the choice of the conceptual dimensions is presented in the 1st edition of the report. The section that follows presents the sub-dimensions, detailing their conceptual components and corresponding data series/proxies that represent them:

Table II. GLOBSEC CEE Strategic Transformation Index 2021: Framework

Pillar 1. Economic Structure & Resilience

Openness

a. Global value chains (GVC) forward participation
b. Foreign direct investment (FDI) openness
c. Index of export market penetration

External Resilience

d. Economic complexity
e. Terms of trade volatility
f. Herfindahl-Hirschman Product/Market Concentration Index

Productivity and Value-added

g. Total factor productivity
h. Medium/high-tech industry value-added in total manufacturing value-added
i. Sophistication of exports
j. Employment in knowledge-intensive activities, share of total employment
k. High-technology exports as a per cent share of manufactured exports

Financial Structure

l. Long-term interest rate for convergence purposes
m. Loans to households as a ratio of gross disposable income
n. MFIs lending margins on loans to non-financial corporations (NFC)
o. House price-to-income ratio
p. Bank non-performing loans as a share of gross loans

Pillar 2. Innovation Economy

Education Cluster

q. PISA scores: reading
r. PISA scores: mathematics
s. PISA scores: science
t. Participation rate in education and training
u. Early leavers from education and training
v. Public expenditure on education
w. Tertiary education enrolment
x. Tertiary educational attainment
y. Classroom teachers & academic staff
z. Ratio of pupils and students to teachers and academic staff

Green Economy

aa. Production-based CO2-productivity
ab. Domestic material consumption per capita
ac. Resource productivity and domestic material consumption (DMC)
ad. Renewable share in final energy consumption
ae. Recycling rate of municipal waste
af. Air quality: Mean population exposure to PM2.5
ag. Greenhouse gas emissions

Digital Economy

ah. Households - level of internet access, Percentage of households
ai. Individuals - internet use, Percentage of individuals
aj. Internet purchases by individuals in 3 months as a percentage of individuals
ak. E-government activities of individuals via websites (last 12 months), in %
al. Value of e-commerce sales, Enterprises' total turnover from e-commerce sales
am. E-commerce sales, Enterprises with e-commerce sales of at least 1% turnover, % of enterprises

Innovative Capacity

an. Patents
ao. Trademarks
ap. Designs
aq. Gross domestic expenditures on R&D
ar. Venture capital expenditures
as. R&D Personnel
at. Researchers head count
au. Human resources in science and technology

Source: GLOBSEC.

The conceptual framework results from a combination of theoretical, conceptual, empirical, and agnostic underpinnings. It builds upon relevant empirical literature and evidence, lets historical data 'speak', reflects on the recent policy recommendations of international institutions as a part of its regular country surveillance, and considers other composite measures of innovation. It also leverages authors' and GLOBSEC knowledge- and institutional partners' as well as its network of distinguished research fellows' familiarity with the CEE9 regional macroeconomy.

Despite authors' best efforts to design the STI conceptual framework exhaustively, the framework would benefit from even more comprehensive choice of variables, including ones covering the following concepts: fiscal sustainability, labour and product market flexibility (more comprehensive measure of internal competitiveness), immigration (penetration and policy), democracy (strength), quality of institutions, business environment, rule of law (efficiency) and corruption, and a measure of effective absorption and effective use of the European Commission funds. Either on the basis of insufficient/unavailable data and/or due to parsimony concerns some trade-offs must have been made. Authors thus recommend using the Index in conjunction with individual data series where available, convening more information of these economic dimensions for a more complete picture.

The resulting index is compiled as eight sub-indices at a country-level on a normalised dataset on an annual basis, using weights derived from the first loading obtained through Principal Component Analysis. The aggregate is computed as an unweighted average across components, which are then averaged into the final index. More detailed notes on the methodology are provided in Section 3.: Research and Methodology.

Country Rankings

Figure 1. The CEE Strategic Transformation Index 2021: Global Ranking

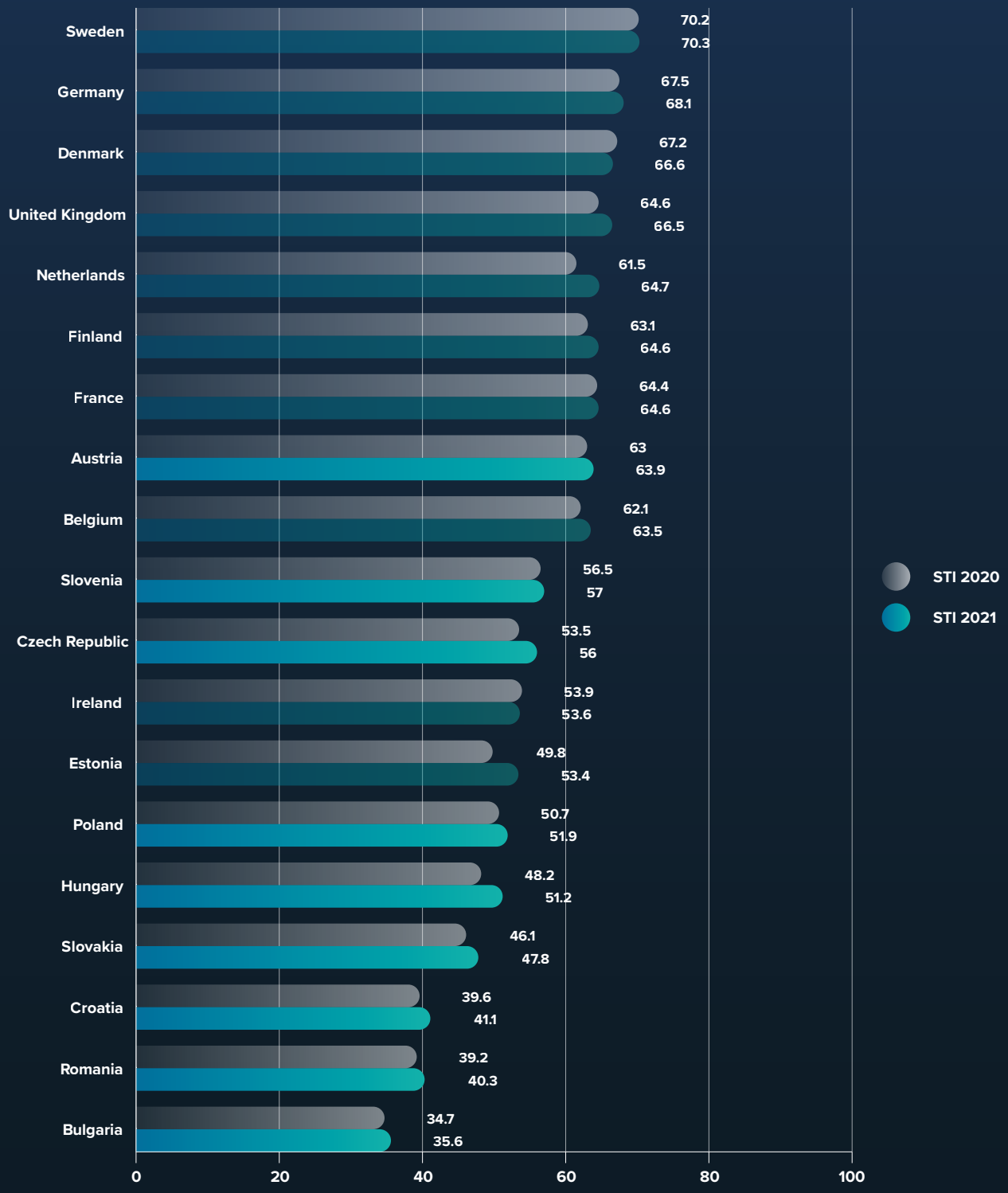
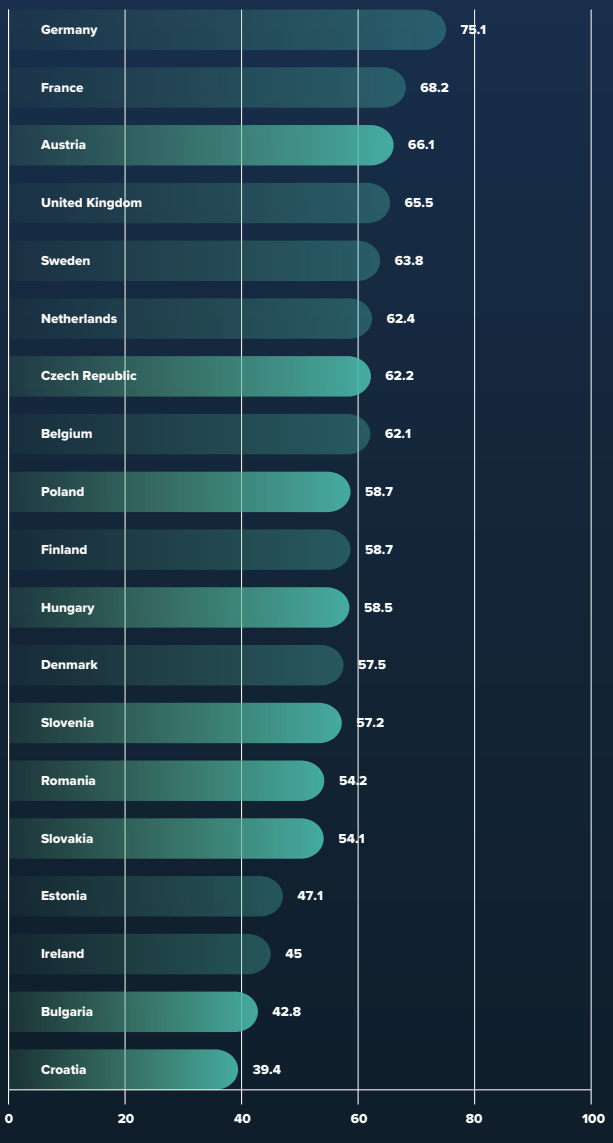
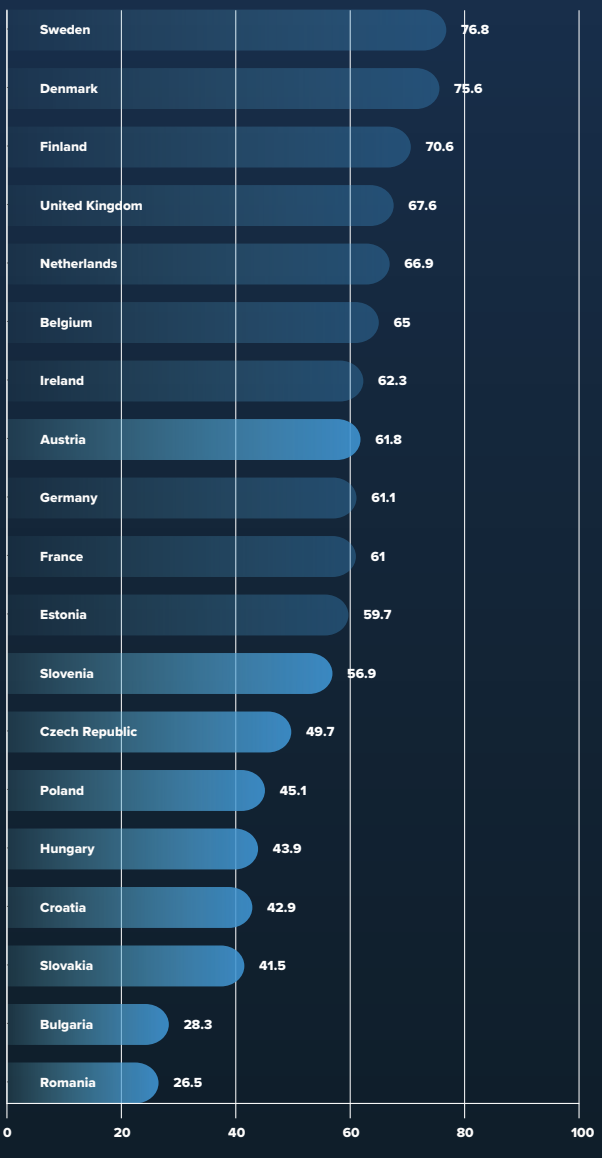


Figure 2. The CEE Strategic Transformation Index 2021

Pillar 1. Economic Structure & Resilience (LHS)



Pillar 2. Innovation Economy (RHS)



Relative Performance by Sub-index

Figure 3. The CEE Strategic Transformation Index 2021 by sub-index

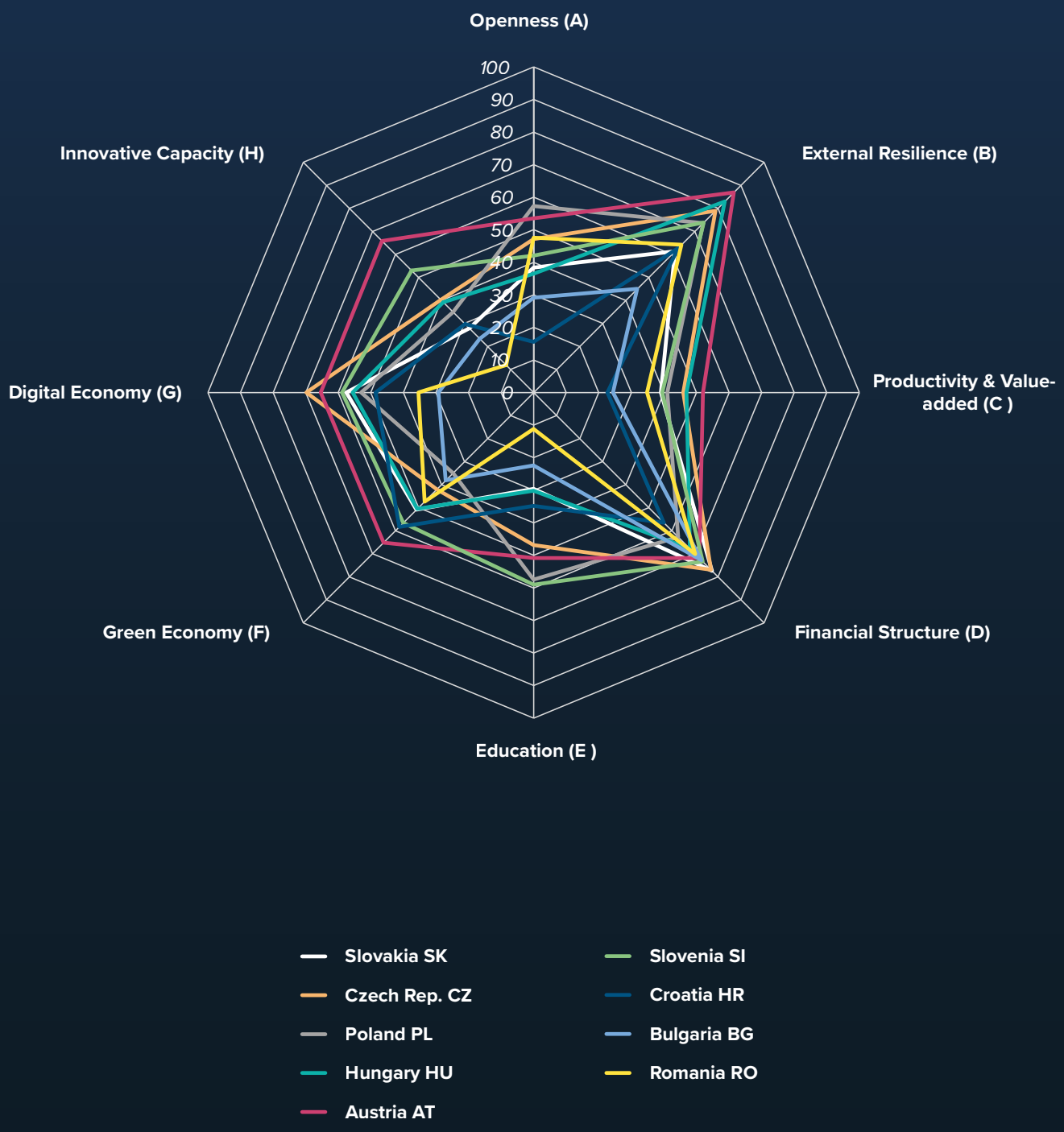


Figure 4. GLOBSEC CEE Strategic Transformation Index 2021 Heatmap: CEE9 vis-à-vis Control Group

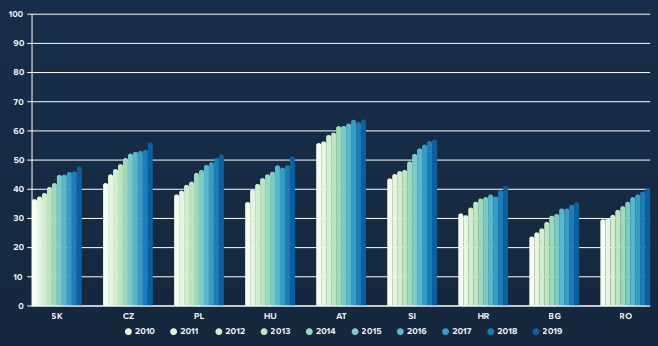
	Openness (A)	External Resilience (B)	Productivity & Value-added (C)	Financial Structure (D)	Education (E)	Green Economy (F)	Digital Economy (G)	Innovative Capacity (H)
Slovakia	38.4	61.4	39	77.5	29.5	50.9	57.5	28
Czech Rep.	47.1	78.9	45.9	77	46.8	42.1	69.8	40.3
Poland	57.3	73.6	41	62.7	57.4	35	53	35
Hungary	36.5	83	46.9	67.8	30.2	50.5	55.6	39.2
Austria	53.5	86.9	52	71.8	50.8	65.2	65.4	65.9
Slovenia	42.1	73.9	39.5	73.3	59	56.6	58.8	53
Croatia	15.6	62.7	22.7	56.5	34.8	58.3	48.6	29.7
Bulgaria	29.1	45	24.4	72.7	22.4	38.2	29.2	23.4
Romania	47.5	64.2	34.8	70.2	11.2	47.4	35.4	12
Germany	74.1	79.5	70.2	76.7	44.3	61	71.2	67.8
Belgium	53.7	65.6	60.1	69.1	57.7	59.5	76.6	66
Denmark	41.1	63.7	62.2	63	70.2	66.9	89.3	76.1
Estonia	30.3	62.6	22.8	72.8	66.3	48.3	67.8	56.3
Finland	48.7	55.9	52.3	77.9	71.3	60.5	77.1	73.5
France	67.9	66.1	72.1	66.5	47.9	67.5	69.8	58.6
Ireland	10.8	33.4	87.9	47.8	65.7	56.9	81.2	45.3
Netherlands	63.5	64.6	62.8	58.8	62.4	62.4	78	65
Sweden	54.3	73.8	62.6	64.5	68.8	78.8	86.6	73
United Kingdom	75.1	63.8	61.6	61.3	47.8	69.4	80.6	72.6

Note: The heatmap uses conditional formatting, which rests on automatic thresholds (maxima and minima) by each column ("Openness (A)", External Resilience (B)", etc.), applied separately for the CEE9-sample (top block), and for the control group of advanced economies (bottom block). Best performance is designated by bright green and worst performance by bright red.

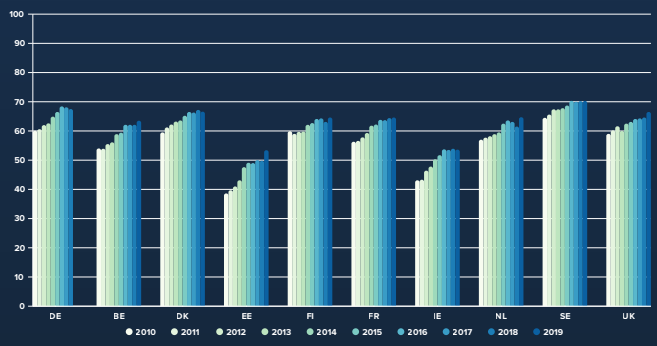
CEE9 Region: Temporal Perspective

Figure 5. Temporal Performance by CEE9-country vis-à-vis Control Group

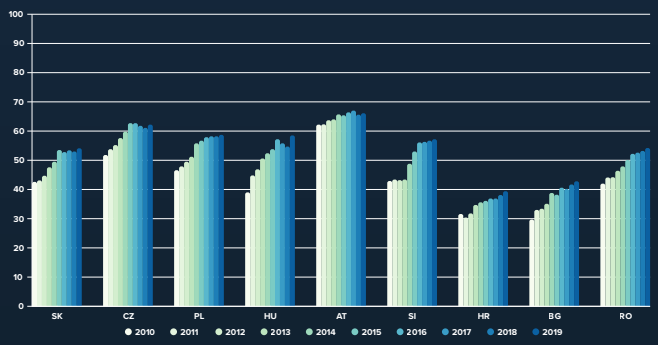
CEE9: overall index



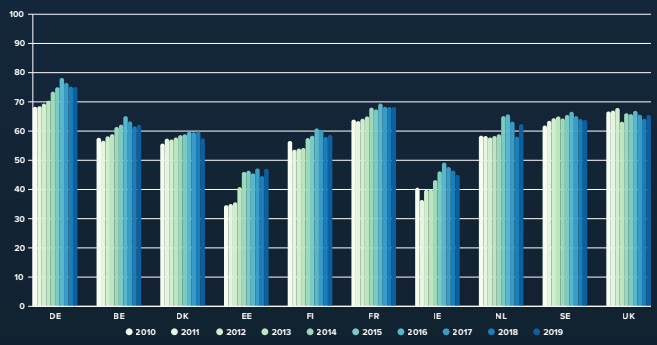
Control Group: overall index



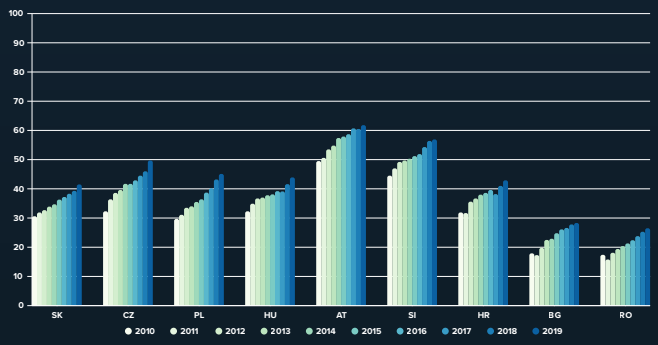
CEE9: Pillar 1



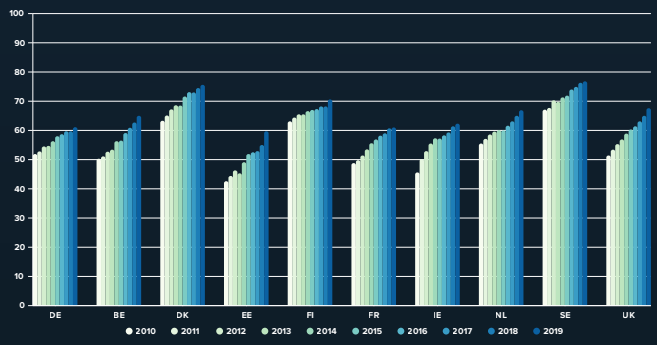
Control Group: Pillar 1



CEE9: Pillar 2



Control Group: Pillar 2



CEE9 Region: Key Findings 2021

- **The 2021 STI update refers to pre-Covid19 information.** The 2021 GLOBSEC CEE Strategic Transformation Index (STI) rankings uphold ***Austria*** as the CEE9 regional forerunner with 63.9 points (from *63.0* in 2020), followed by ***Slovenia*** with 57.0 *(56.5)* and ***Czechia*** with 56.0 *(53.5) (Figure 1).* Split into the two main pillars, ***Austria*** with 66.1 points *(65.6)* and ***Czechia*** with 62.2 points *(61.1)* remain CEE9 regional leaders in terms of *Pillar 1: Macroeconomic Structure & Resilience;* while ***Austria*** at 61.8 points *(60.5)* and ***Slovenia*** at 56.9 points *(56.4)* show strongest performance in *Pillar 2: Innovation Economy among CEE9 (Figure 2).*

- **Countries under review have – by overall score, as well as by Pillar 1 and 2 scores – improved their standings since 2020** in most cases *(Figure 5)*. Overall, CEE9 countries that have been steadily improving their performance over the reference period are ranked relatively better than those countries, where sustained performance improvements faltered.

- **The relative rankings are intuitive in the broader country milieu**[222]. European economies proclaimed for their strong macroeconomic fundamentals (Germany, France) remain featured at the top of Pillar 1, while Nordic European countries (Sweden, Denmark, Finland) and the UK known for their innovation muscle endure at the pinnacle of Pillar 2. Like in 2020, moreover, the CEE9 economy remains more pronouncedly powered by Pillar 1 than Pillar 2, as evidenced by the relative higher scores of CEE9 countries in the former.

- **The 2021 STI aggregate outcomes are driven by underlying developments in the eight thematic sub-indices** *(Figures 3 and 4),* **which expose countries' individual structural strengths and weaknesses.** Based on the 2021 Index update, the CEE9 relative performance by sub-index remains broadly unchanged. Under Pillar 1, Poland and Austria exhibit best relative performance in Openness (A); Austria, Hungary and Czechia show greatest relative strength in External Resilience (B) and Productivity and Value-added (C); and the Slovak Republic, Czechia and Slovenia display the most solid relative financial fundamentals (D)[223]. Under Pillar 2, Slovenia, Poland, and Austria exhibit strongest education outcomes (E); Austria, Croatia and Slovenia are closest to the greening frontier (F); Czechia, Austria, Slovenia remain top digital performers (G); and Austria and Slovenia demonstrate most advanced innovation economy (H).

- **The 2021 STI results show that CEE9's external resilience (sub-index B) has fared well pre-crisis,** even compared to the control group of advanced economies, driven by gains in economic complexity over recent years in many countries. Next STI update will show how the pandemic tried CEE9's economic resilience. Safeguarding it and improving it further will require investing in skilled labour, expanding domestic capital pools, and addressing ESG-related challenges.

- **The side-by-side comparison of CEE9 to the control group of advanced countries shows there is room for improvement even for the CEE9 top performers**. They should work towards moving closer to the 'distance to frontier' – the aggregate 'ideal' across all sub-indices of strategic economic transformation.

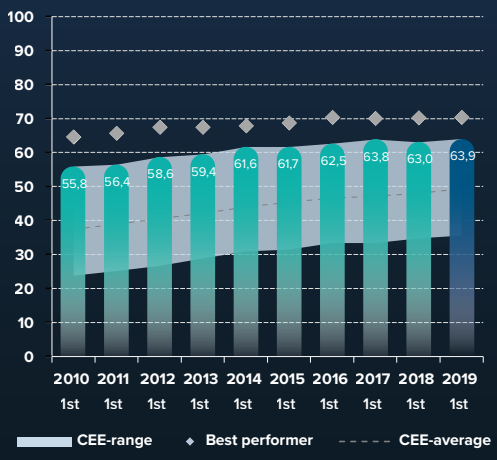
- **The section that follows offers detailed Country Profiles, with leads as to country-specific strengths and weaknesses and corresponding key insights for policy action.** The forthcoming policy insights constitute neither a comprehensive policy roadmap nor definitive answers to the complex endeavour of strategic economic transformation. Rather, they serve as an evidence-basis to anchor strategic policy discussions at the GLOBSEC Tatra Summit platform, call the attention of policymakers, private sector leaders and other key economic actors to the most pressing challenges CEE9 is facing and seek answers and solutions together.

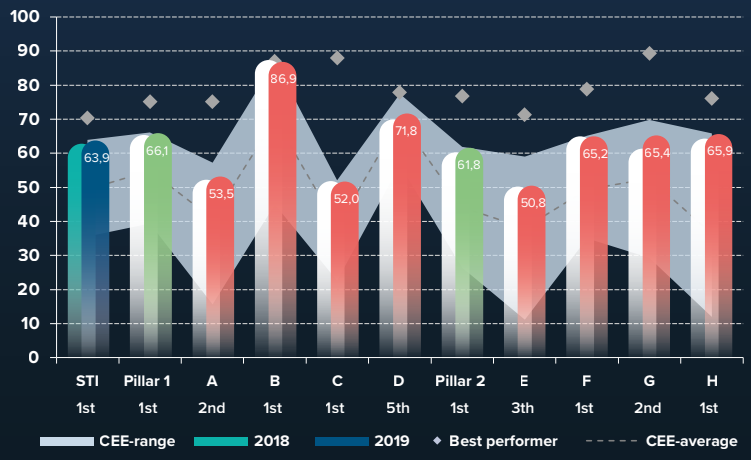
222 While the control group of advanced countries falls outside of the Report's main focus and serves more for CEE9-region's context, Ireland (18/19) and Denmark (12/19) score quite low on Pillar 1. For Ireland, this is driven by relatively weak financial fundamentals (sub-index D), low FDI openness and forward participation in global value chains (sub-index A), and low relative economic complexity, terms of trade volatility and low market concentration (sub-index B). Denmark's performance is dragged down by the unfavourable household debt to disposable income ratio (sub-index D), low exports share in knowledge-intense activities (sub-index C) and low economic complexity (sub-index B), while it also lags behind by most metrics in sub-index A. These two countries are, hence, somewhat penalised by the STI CEE9-tailored framework

223 The situation regarding country financial fundamentals is evolving rapidly due to the consequences from pandemic-related the government spending

STI Country Profile: Austria

#1/9





Austria retains its CEE9-region leader status by overall score and split into the two main pillars (Pillar 1. Macroeconomy and Resilience; Pillar 2. Innovation Economy, depicted in green). Moreover, by the eight structural sub-indices (depicted in yellow), it overtakes the CEE9-region in four structural areas: External Resilience (sub-index B), Productivity and Value-added (sub-index C), Green Economy (sub-index F) and the Capacity to Innovate (sub-index H).

Austria has posted sustained improvement in its overall performance over time. Compared to the 2020 STI vintage, it has improved its overall score to 63.9 points from 63.0, driven by improvements in both pillars. **Year-on-year improvements** under Pillar 1 emanate from Openness (sub-index A) and Financial Structure (D), while Pillar 2 advancements have ensued predominantly from Digital Economy (G) and Innovative Capacity (H).

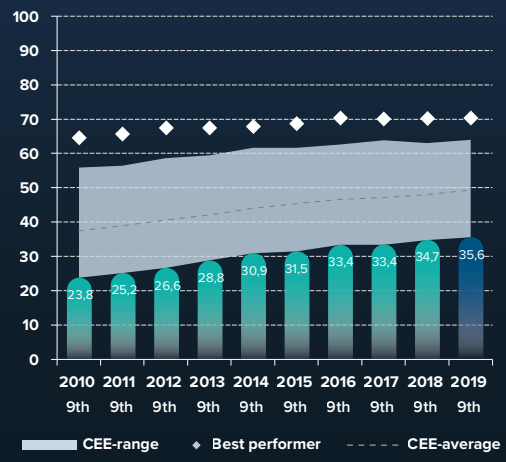
These developments are driven by positive individual performance in foreign direct investment openness (A) and 10-year benchmark bonds for convergence purposes (D) under Pillar 1, and by advances all-across-the-board in digital economy metrics (G), as well as innovation outcomes (particularly, patents and trademarks) and innovation conditions (particularly, R&D personnel and researcher count) (H) under Pillar 2. On the downside, year-on-year deterioration has been noted in export market penetration (A), terms of trade volatility (B), and housing affordability (D) under Pillar 1, and early leavers (E) and venture capital investments (H) under Pillar 2.

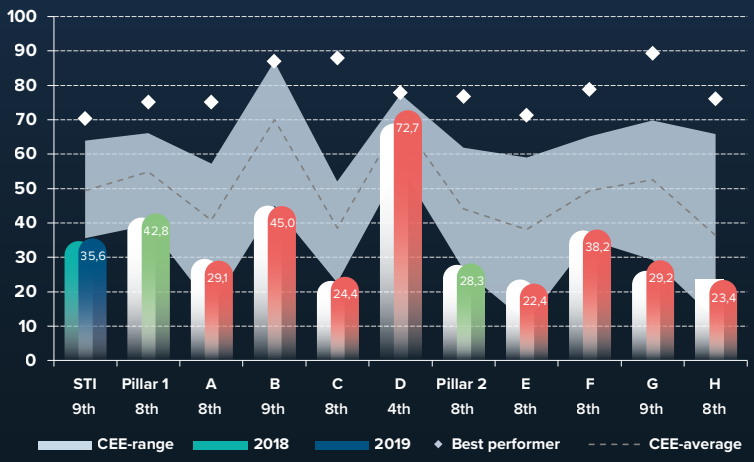
Despite outperforming the CEE9-region by a significant margin, Austria trails behind the advanced economies' top performers, which should serve as its yardstick to continue on the path of meaningful and sustainable economic progress. The 2021 index score indicates that the Austrian 'distance to frontier' – the aggregate 'ideal' across all sub-indices of strategic economic transformation – stands at 36.1 points, compared to the top performer's distance to frontier at 29.7 points. To stay on track towards closing the gap vis-à-vis European top performers, Austrian key economic actors should work together to address weakness in the following areas:

- **Focus policy efforts at improving education outcomes and invest in skills of tomorrow – especially digital – to foster strong recovery, enable social cohesion and further improve quality of life. Reskilling will promote productivity through reallocation towards new jobs and most productive firms**
- **While sustained progress has been made on the digital pillar, further investments are required in digital infrastructures of firms, e-commerce, and e-government solutions to remain competitive with other advanced economies**
- **On the innovation front, Austria outpaces its regional peers, demonstrating relatively superb innovation conditions – such as, long-term investments in R&D – but further efforts should be directed at meeting financing needs of start-ups and scale-ups in the absence of capital markets (reducing equity gap for growing companies and mid-caps), including innovative green-tech and clean-tech solutions aimed at climate protection**

STI Country Profile: Bulgaria

#9/9





Bulgaria lands the ninth spot in the CEE9-region by the aggregate 2021 score with 35.6 points, up from 34.7 a year ago. Bulgaria has, moreover, marginally improved its scores in each of the two main pillars compared to the 2020 index vintage.

Though the Bulgarian headline score underperforms the CEE9-average by a large margin – scoring 8th or 9th across most structural areas – it hits the mark in terms of Financial Structure (sub-index D), a development driven by sustained reduction in non-performing loans as well as movements in long-term interest rate for convergence purposes, which secures it 4th spot in the region. Under Pillar 2, an uptick in the Digital Economy (G) driven by improvement in the digital infrastructure (greater internet access, use, and e-commerce) is a positive sign, given Bulgaria's digital economy has taken a back-seat with the lowest regional rank overall. Despite lacklustre aggregate ranking, Bulgaria has posted improvements in its aggregate performance over time, especially until 2015 with a momentary plateau between 2016 and 2017.

Notwithstanding these positive developments, the index outcomes provide indications of numerous weaknesses across both pillars, that policy in liaison with the private sector should tackle to start closing the gap vis-à-vis the CEE9-average. Notably, poor PISA scores, deteriorating tertiary educational attainment, and relative high share of early leavers act as a drag on skills and exacerbate social exclusion (E), while retaining and attracting researchers is key to building the country's capacity to innovate (H). Macro-financial fundamentals under Pillar 1, in addition, would benefit from enhanced economic complexity, increased export market penetration, and exported product sophistication to reduce external vulnerabilities and capture greater value-added.

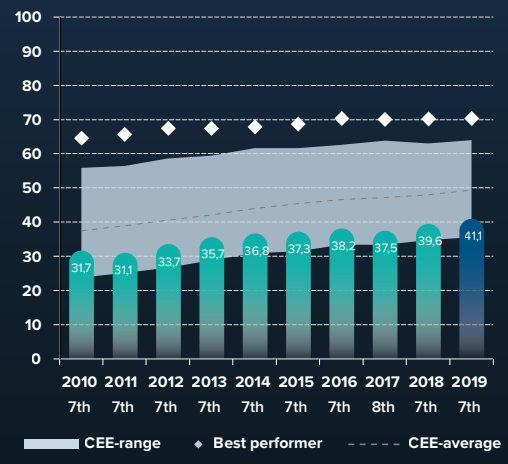
Bulgaria has joined the Exchange Rate Mechanism II (ERM II) in 2020, on track to euro adoption, showing a political commitment to stability and reform that will help to improve macroeconomic resilience. Finally, the future participation in the monetary union, the institutions of the Eurosystem and the deepening of the integration in the Single Market should boost macroeconomic resilience even further, increasing the confidence of foreign investors and starting a virtuous circle.

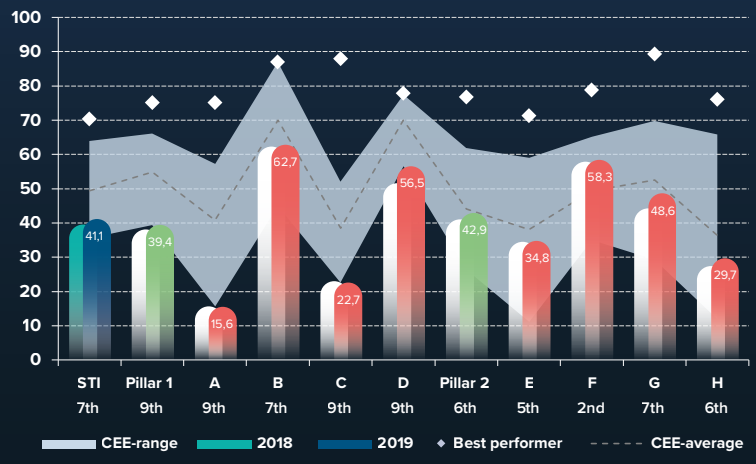
Country's key economic actors should join forces to address the root causes of Bulgaria's lacklustre overall strategic transformation position in conjunction with other transition issues that go beyond the STI framework, including of governance and the legal system (perceptions of corruption, informal economy), product market regulation and enhancing the business environment to ease reallocation, and financial market development, with the aim of producing an integrated growth agenda effective in unlocking sustainable economic growth and social prosperity. To that end, the 2021 STI provides the following leads:

- **Authorities should prioritise a blanket education reform to forge improvements in attainment across all age groups and across regions, fight inequality, social exclusion and reduce poverty**
- **Large-scale retooling of workers coupled with increased investments in next-generation technology may help narrowing the productivity gap with other EU countries**
- **Identifying potential strengths in existing economic structures and formation of collaborative strategic partnerships with industry may support capturing high-value-added opportunities, and strengthening links in international supply chains**

STI Country Profile: Croatia

#7/9





Croatia ranks seventh overall within the CEE9-region. While with the aggregate score of 41.1, Croatia underperforms the CEE9-average, its performance remarkably continues to be driven by Pillar 2 more strongly than by Pillar 1. Croatian macro-economy, as embodied by Pillar 1, is penalised by Croatia being least open among its peers (weighing down sub-index A), and least manufacturing-oriented (weighing down some variables in Productivity and Value-Added sub-index C).

Apart from factors that disadvantage Croatia by design under the current framework, **year-on-year improvements in the headline index is driven by stronger financial fundamentals,** notably, reduction in NPLs, MFI lending margins, and improvements in benchmark bond for convergence purposes (sub-index D) under Pillar 1. Like Bulgaria, Croatia has joined ERM II, awaiting the adoption of the euro, which can further improve the macro-resilience environment, increasing price transparency, and additionally boosting the tourism supply. Noticeable upticks are also observed in its Digital Economy (G), as well as its Capacity to Innovate (H) under Pillar 2. Broken down into individual drivers, increased internet use and value of e-commerce have buttressed sub-index G, while enhanced innovation outcomes and more R&D personnel sub-index H.

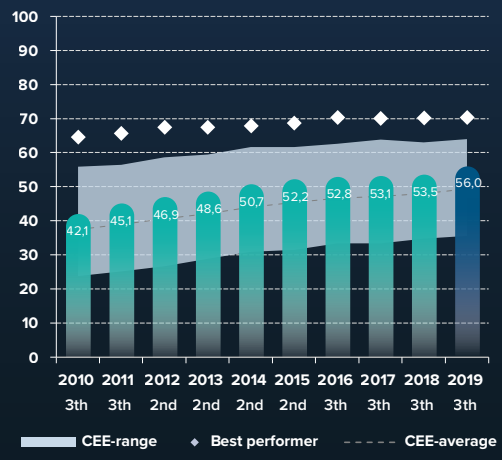
Croatian relative overall performance, importantly, continues to be bolstered by its outstanding Green Economy (F), as evidenced by the 2nd place overall within CEE9, and documented by individual measures including good relative CO2 productivity, low relative greenhouse gas emissions, and relatively large share of renewable energy in total energy consumption.

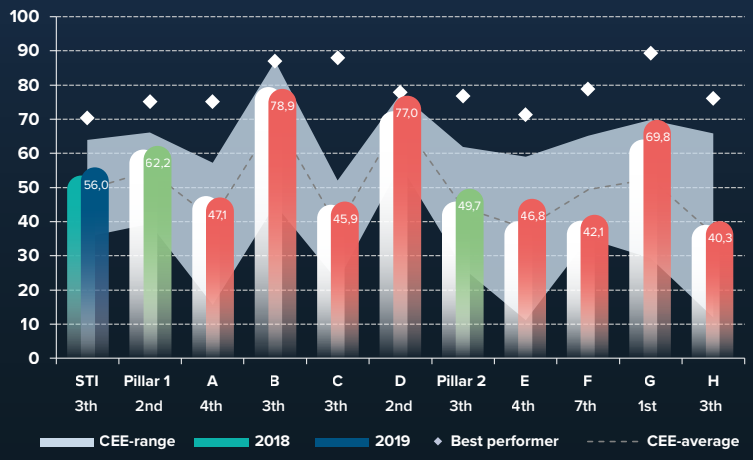
The STI-diagnostics reveals several weaknesses that need to be addressed to ease the rift vis-à-vis the regional benchmark-setter and leapfrog ahead. Croatia's relative education performance remains below-average. Moreover, an integrated long-term policy strategy focused on tourism and related sectors as tool for growth and development is needed, given the relatively important role of services and tourism in the Croatian economy, and its pronounced declining path of manufacturing value-added in GDP over time. Openness to foreign capital can help to further develop the tourism sector by enabling investment. The interdependence of tourism with other sectors of the economy should be taken to account. Higher value-added in services can be achieved through quality staff training & development programs, more efficient service provision achieved through take up of new systems and technologies and process innovation. Good relative performance in e-commerce in the digital realm suggests this is an avenue worth exploring/pursuing. Against such a background, national authorities and business leaders should cooperate in the following policy areas to unleash the country's transformation potential:

- **Coordinated policy approach should support the country's core competency in tourism, services, and related sectors as a key tool for growth and development. An emphasis should be placed upon furthering the green transition and developing green economy technologies to underpin it**
- **Productivity in services can be honed by combining human capital upgrades and capital investments, as well as advancing digitalisation and take up of new systems and technologies**
- **For greater resilience, consider diversifying economy and export profile. Croatia exports more raw materials as a percentage of total exports than any CEE9 country other than Bulgaria, and few capital or high-tech goods**

STI Country Profile: Czechia

#3/9





Czechia defends its third place in the overall 2021 STI ranking within CEE9. The 2021 overall Czech score (56.0) outshines the CEE9- average (49.4), narrowing the gap with the regional leader to an 8-point margin (Austria: 63.9). Year-on-year, Czechia has improved its headline score. In particular, it has further solidified its financial fundamentals (sub-index D) under Pillar 1 and posted advances in Education (E) driven by increased researcher count and furthered its Digital Economy (G) owing to further positive developments in e-commerce, internet use and e-government under Pillar 2. On the downside, Green Economy (F) and the Capacity to Innovate (H) remain stagnant.

In the past decade, the Czech economy leveraged its solid macro-economic fundamentals, including large degree of openness, forward international supply chains position, relative external resilience, and supportive financial structure. Its innovation performance – with the exception of a great leap on the digital frontier – has been average and requires upgrades to remain competitive in the changing global economy. Meanwhile, its underlying Education (E) picture has been mixed (see Chapter 2 for detailed analysis).

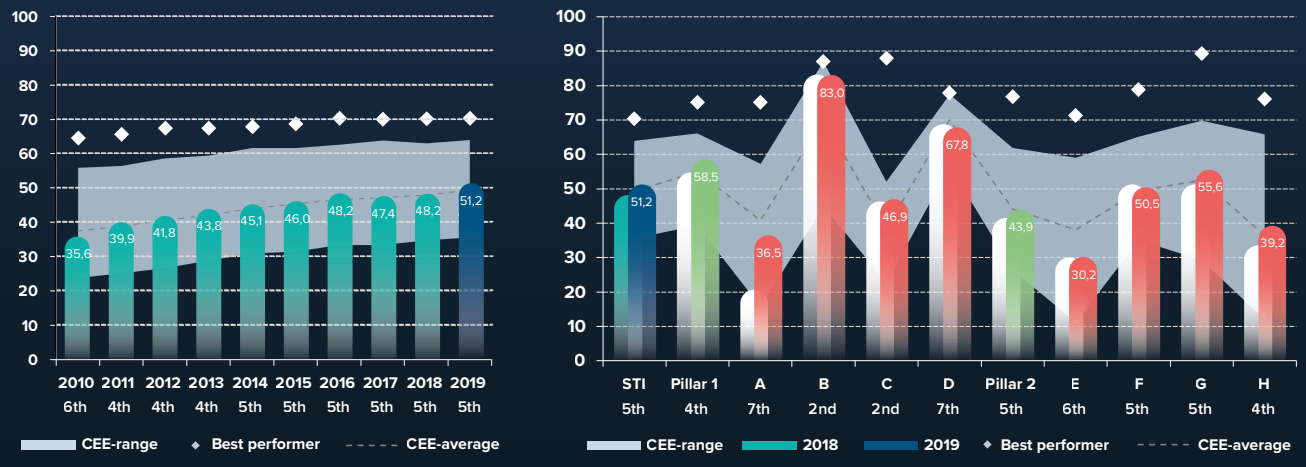
The Czech slightly above-average relative standing remains driven by the macro-resilience pillar more than its innovation economy. Its export-oriented economy continues to benefit from relatively diversified export profile, and export product sophistication, as further documented by a relatively high share of exports in knowledge-intense activities in gross exports. On the innovation side, Czechia posts the highest rank in terms of Digital Economy (G) – bolstered by heavy internet use and infrastructure, as indicated by internet purchases, e-commerce, and e-government services – but severely lags behind on the sustainability agenda (sub-index F), ranking 7th in the CEE9-region overall. Czechia has largely failed to transition towards the green economy and continues to be a heavy greenhouse gas emitter. In the coming years Czechia's greatest challenge will be retaining its strong growth while moving away from fossil fuels and polluting industries.

Czechia faces significant challenges in the coming years: overcoming the twin threats of population decline and labour productivity stagnation will require accelerated adoption of Industry 4.0 technologies as well as increased investment in R&D. While Czechia leads in niche innovative competencies, it struggles in broader adoption of ICT technologies and lacks dynamic capital markets. Deepening industrial innovation while sustainably broadening the scope of national development will be crucial to maintaining Czechia's economic inertia. Despite leading relative Digital Economy (G) position, more can be done to further digital transformation at the local enterprise-level to close the gap of average local SMEs vis-à-vis large export-driven companies, and at the level of public services. Structural policy priorities as highlighted by the 2021 STI results include:

- **Prioritise a sensible greening and decarbonization strategies to make growth engines cleaner, more resource-efficient and sustainable. Lagging in this area will leave Czechia badly exposed to industrial shifts that are expected to occur in the coming decade**
- **Leverage the high rate of digitalisation and solid education ranking to power ahead on laying down innovation-ecosystem and support innovative firms through creating an enabling policy environment**
- **Enhance R&D investments in implementing Industry 4.0 solutions and developing novel advanced manufacturing processes. Specific focus should be placed on e-mobility, given its core competency in automotive**

STI Country Profile: Hungary

#5/9



Hungary places fifth in the overall 2021 STI ranking within the CEE9 region, with an overall score of 51.2, right above the CEE9-average (49.4). Hungary's gap vis-à-vis the best regional performer (Austria: 63.9) hence narrows to 12.7 points. Like most other CEE9 regional economies, Hungary's headline relative performance is assisted more by the macro-resilience pillar than innovation.

Year-on-year, the improvement in the headline is underlain by gains in Openness (A) under Pillar 1 and in the Digital Economy (G) and the Capacity to Innovate (H) under Pillar 2. Individual indicators point to advances in FDI-openness (A), reductions in NPLs and better financing conditions (D), as well as improvements in internet use, access, e-government (G), and a notable uptick in innovation outcomes (designs), venture capital investment expenditures – an important ingredient of local entrepreneurship ecosystem – and increased research capacities on the innovation-front (H). Improvements in innovation outcomes and conditions have catapulted Hungary to 4th spot in sub-index H in CEE9, from 6th spot in 2020.

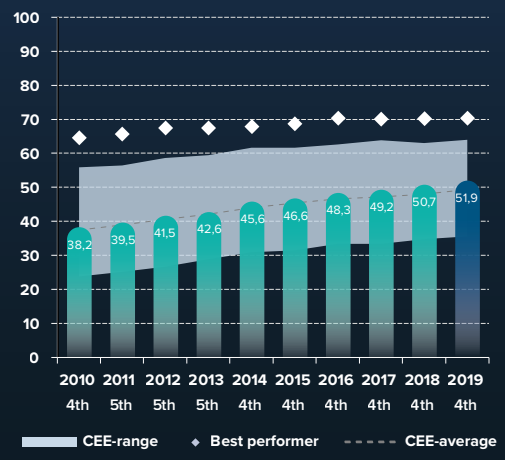
The relative rank has been over the time horizon examined bolstered by visible above-average performance in External Resilience (B), the second-best performance within CEE9 after Austria, documenting solid economic complexity of exports and a higher relative degree of export sophistication, which helps the economy cushioning shocks. The Hungarian economy has equally benefitted from a large relative degree of FDI openness, a high share of high-/medium-tech value-added share in total manufacturing value-added, and good relative performance in exports of knowledge intense activities.

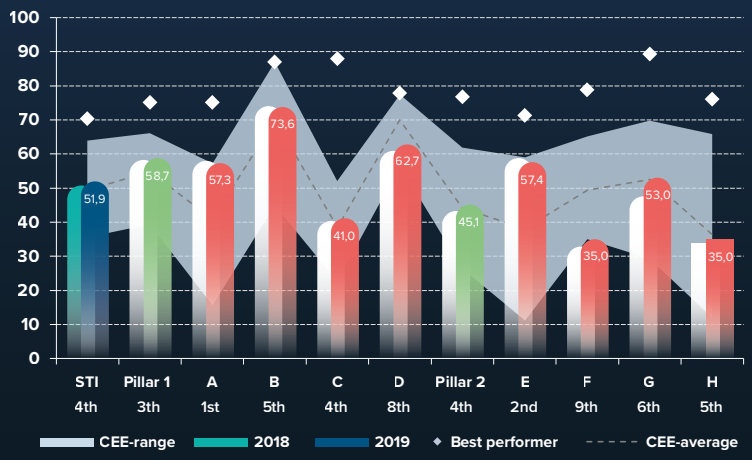
Despite these positive developments, Education (E) performance remains lacklustre and requires further policy prioritizing *(see Chapter 2 for detailed analysis).* Moreover, Hungary's position in Green Economy (F) has deteriorated year-on-year by one spot. The twin digital and green transitions should become firmly anchored in the country's growth strategy. To close the gap vis-à-vis region's leaders and pick up the pace towards the economic transformation frontier, Hungarian leaders and businessmen should work together to address the underlying weakness in the following strategic areas:

- **Educational attainment and outcomes – especially digital – can be further improved across age groups and regions to improve employability, fight social exclusion, and gear up for next-gen technology take up in legacy industry, government, and households. Involvement of the private sector in developing curricula of vocational institutions with the aim to better match skills with labour market needs may be useful (see Chapter 2 for a detailed comparative analysis and suggestions for policy on the education dossier)**
- **Hungary's double-challenge is to identify opportunities to upstream in ICT and mobility – and invest heavily in developing next-generation technologies and processes related to these sectors – while expanding its nascent start-up ecosystem and bringing SMEs on par with green and digital transitions**

STI Country Profile: Poland

#4/9





Poland reclaims the fourth spot in the overall 2021 STI ranking within the CEE9 region with overall score at 51.9 points, hovering right above the CEE9-average. As the largest economy in CEE9, Poland is critical to the economic development of the region and has been one of the fastest converging economy after 1990. In line with that, the solid relative ranking has benefitted from consistent macroeconomic fundamentals (Pillar 1), in the latter years joined by underlying strength in Education (E) under Pillar 2 *(see Chapter 2 for detailed analysis).*

Year-on-year, Poland has marginally improved upon its financial fundamentals (D) and somewhat enhanced its Green Economy (F), but its blanket advance in its Digital Economy (G) is most noteworthy and has propelled it to the 6th spot in CEE9-region overall from 7th a year ago. Its Capacity to Innovate (H) has also recorded mild gains, due to greater number of designs compared to year ago, more robust research human resources and larger venture capital investment expenditures.

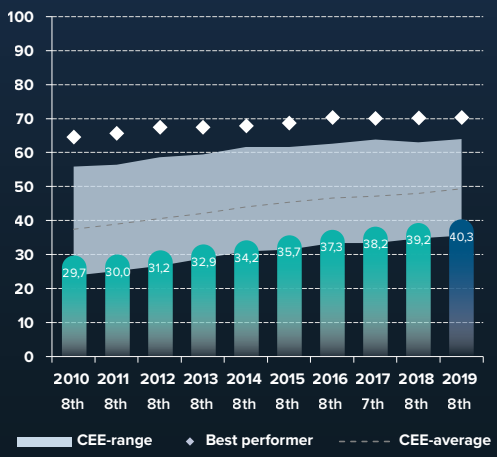
The Polish economy is among the most open and diverse in the region. The relative rank is fuelled by favourable position in value chains and high relative export market penetration. Similar to Austria, external resilience is aided by a relatively diversified export profile, which helps cushion against external shocks. Notwithstanding these positive developments, lingering weakness persists in making growth green and sustainable, as corroborated by Poland's ranking last in Green Economy (sub-index F), dragged down by most components, including limited resource productivity, low share of renewable energy, poor relative air quality, and high greenhouse gas emissions. Its innovation ecosystem is also dull, being one of the least research intense in the region. To overcome these deficits, Poland will need to invest in innovation fundamentals such as applied research, further its adoption of digital technologies, while effectively transitioning to a next-generation, green economy.

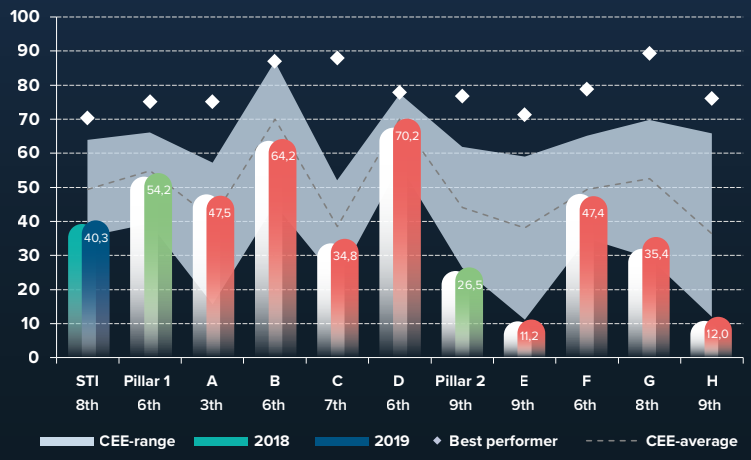
Despite marked year-on-year improvements in some areas, the insights provided by the 2021 STI provides clear pointers where key economy stakeholders should join forces and design practical business and policy solutions, in the quest to accelerate towards the strategic economic transformation frontier:

- **Put forth an actionable environmental strategy to radically reduce pollution levels and carbon emissions and make growth cleaner, resource-efficient and sustainable**
- **Liaise good macroeconomic fundamentals and strong education outcomes to support entrepreneurship and build innovative industries, including through incentivising basic and applied research using public-private partnerships, grants, subsidies, funding innovation centres**
- **Poland is one of region's most diversified economies but as demand for coal, extractives, industrials, and agriculture continues to decline, it may wish to identify emerging technologies with long-term growth potential which match Poland's natural competencies, and invest heavily in specialization in relevant industries**

STI Country Profile: Romania

#8/9





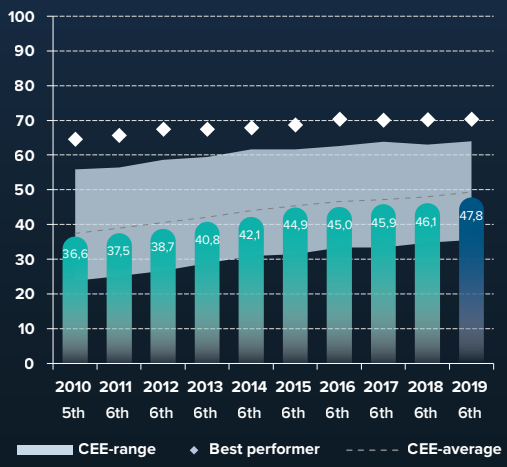
Romania scores eighth in the overall 2021 STI ranking within the CEE9-region with 40.3 points, placing it well beneath the CEE9-average score and a far cry to the strategic transformation path of the best performer (Austria: 63.9). Its score continues to be underpinned by macroeconomic fundamentals (Pillar 1), which broadly hit the average CEE9-mark. But its innovation performance has remained stagnant (Pillar 2), dragged down visibly by subdued Education metrics (E). Romania displays the weakest performance in its Capacity to Innovate (H) relative to its peer group.

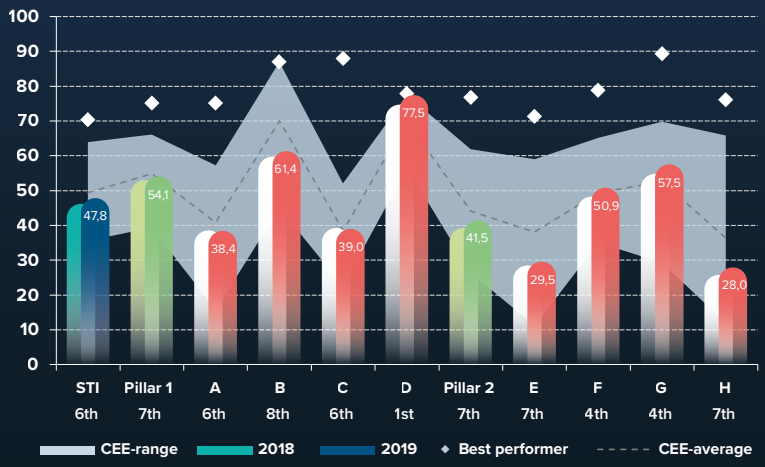
The year-on-year developments are, too, lacklustre, with only marginal improvements achieved, notably, in competitiveness as measured by HHI (B), exports of knowledge-intense activities and some gains in productivity (C), and reduction in NPLs (D) under Pillar 1. Pillar 2 benefitted from year-on-year advances in the Digital Economy (G) as well as improved innovation outcomes (patents, designs) and research personnel (H). On the flipside, its Green Economy (F) performance has deteriorated, descending to 6th overall position in CEE9 from 5th a year ago.

Like in case of Bulgaria, the structural policy priorities that follow should be buttressed by sustained improvement of economic fundamentals that go beyond the STI methodological framework, with the aim of producing an integrated growth agenda effective in unlocking sustainable economic growth and social prosperity. Based on the STI results, key economic actors should work in tandem to underpin most backward areas through sound business strategies and enabling policy action:

- **Take targeted policy action to enhance the country's educational attainment and equip workers with skills suited for the fast-changing economic environment. Focus on developing large pool of STEM graduates to buttress the country's emerging core competencies in outsourced IT services and software development**
- **Encourage higher productivity of the economy, including through further developing the country's tech ecosystem through grants, technical support and training, and public-private partnerships. While still in its infancy, Romania's digital sector has runway to grow and attract significant investment from abroad, but authorities must take conscientious steps to improve basic market conditions**
- **Make green transition a part of the development leap. The majority of the population has been exposed to stable, harmful level of air pollution in recent years**

STI Country Profile: Slovak Republic #6/9





The Slovak Republic remains at the sixth spot in the overall 2021 CEE9 STI rank, posting a slight improvement compared to year ago, driven evenly by all four sub-indices under Pillar 2, as well as gains in External Resilience (B) and Financial Structure (D) under Pillar 1. Notably, improvements in most Green Economy (F) metrics boosted Slovakia to 4th spot overall up from the 6th spot a year ago. Overall, the Slovak economy remains a regional champion when it comes to the financial fundamentals, propping up Pillar 1 as the main motor of its strategic transformation. The country has also made sustained progress in its Digital Economy (G) in recent years, as evidenced by an above-average relative standing and 4th overall place in CEE9.

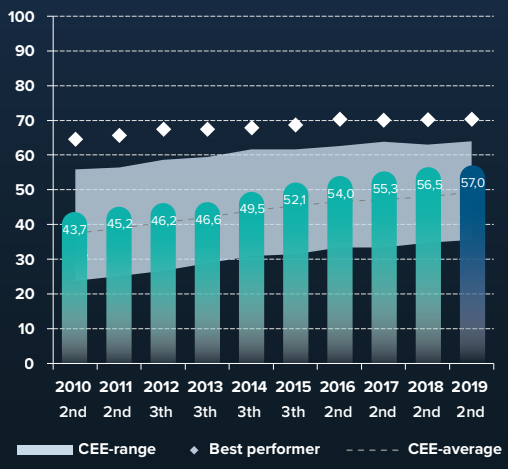
Despite this positive news, the principal culprit of the lacklustre overall relative position within CEE9 is persistent weakness in the country's Education (E) (*see Chapter 2 for detailed analysis)* as well as its Capacity to Innovate (H) (Pillar 2). The anaemic education performance – especially of marginalised communities – is documented by low PISA scores on the outcomes-side, and lingering weak relative adult training, mediocre transition to work results, low academic staff rank, and soft government expenditures on the conditions-side. In recent years, tertiary enrolment has been also on a decline, which we partly ascribe to the rising enrolment of nationals abroad.

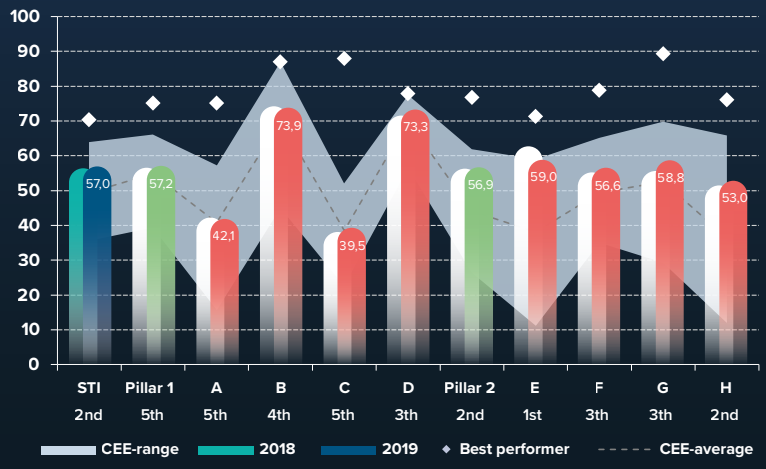
In terms of capability to innovate, besides the count of researchers/professionals engaged in the conception or creation of new knowledge/products that has seen increase over time, all other aspects require policy attention. This includes funding, innovation outcomes, such as patents, and the availability of capital to translate innovation into commercial outcomes, such as venture capital, especially in the absence of functional capital markets. Integrated policy approach may be required to successfully address the two related sub-domains (E and H). Policymakers and business leaders should work in tandem to address weakness in the following policy areas:

- **Focus on improving the quality of local human capital pool, including through better education attainment, retaining talent, and attracting brains from abroad. Bottom-up initiatives can complement top-down government reform and bring targeted results faster (see Chapter 2 for a detailed comparative analysis and suggestions for policy on the education dossier)**
- **Coordinated policy approach will be required to lay down solid innovation fundamentals and defend the country's competitive edge. Drawing on the country natural competencies and flagship industries, policies may entail incentivising applied research in mobility and increased investment in Industry 4.0 technologies across the manufacturing sector to prepare the economy for next-generation industry**

STI Country Profile: Slovenia

#2/9





Slovenia scores a second-best spot by the 2021 STI headline index in the CEE9-region, driven by balanced contribution of both main pillars. The Slovenian economy is well-diversified, benefitting from a differentiated export structure and portfolio. Among top exports of Slovenia are packaged medicaments, cars, refined petroleum, vehicle parts, and electrical lighting and signalling equipment, exporting mostly to Germany, Italy, Croatia, Austria, and France. Its robust medium-high tech export sector and product sophistication across automotive, pharmaceuticals, ICT, as well as a flourishing eco-innovation industry are, moreover, a testament to its relatively high economic complexity. Buttressed by outstanding education fundamentals, by regional standards, Slovenia has consistently ranked among the most innovative CEE9 countries.

Year-on-year, Slovenia has recorded mild improvements in each main pillar. It has maintained second-best performance by Pillar 2, fuelled pre-dominantly by improvements in Education (E), which now sets the mark for the region. The solid education base (E) reinforces relatively high share of employment in knowledge-intensive activities and significant proportion of medium and high-tech industry value-added in total manufacturing value-added. Sustained progress towards the green (F) and digital (G) frontiers has also been achieved. On the financial front (D), however, Slovenia needs to continue addressing financial risks, including non-performing loans as a share of total, and continue pursuing the stability of public finances and long-term fiscal sustainability.

As one of the top three performers within the CEE9 region, Slovenia should strive to benchmark itself to the more advanced control group of countries. Considered identified weaknesses and challenges of the Slovenian economy in comparison with a more advanced group of countries, Slovenia should prioritise faster and more efficient response to technological, demographic and climate change. To maintain momentous and sustainable progress on the transformation agenda, economic actors should work together and focus on the following policy priorities:

- **Focus on accelerating productivity growth through three main channels: i) strengthening R&D activity and innovation with a stronger emphasis on breakthrough innovation; (ii) accelerating digital transformation by introducing new business models, and shifting to most advanced technologies; and, (iii) increasing investment in human resources and the development of the 'workforce of the future', including by retraining workers to accelerate their transition to high-quality jobs with high value-added and lower carbon footprint**
- **Accelerate transition to a low-carbon, circular economy particularly by promoting sustainable mobility and upgrading related infrastructures, using state-of-the-art technological solutions, introducing new business models (including more efficient waste management), and significantly increasing the capacities for greater use of renewable energy sources**

The Road Ahead for Government

- **The choices made by policymakers, business leaders, and other key actors today will shape CEE9-region's societies for decades to come.** At this critical juncture, leaders are to lay down the foundations consciously and pre-emptively for a new economic and social contract to provide opportunities for all

- The GLOBSEC Strategic Transformation Index (STI) results indicate, the **CEE9-region tends to be less productive, less educated, and broadly less innovative** than its Western and Northern peers. As per 2021 STI scores in CEE9, Austria is the clear forerunner, while Czechia, Slovakia, Hungary, Poland along with Slovenia, are among the most manufacturing-intensive in Europe, with strong competencies in mobility and industrials. Croatia is highly reliant upon tourism and has devoted significant resources toward sustainable economic development. Bulgaria and Romania, by contrast, are yet to achieve parity in development and productivity with their CEE9-peers. T**he leads provided by the 2021 index highlight the recurring themes a**nd corresponding implications for government action. The report specifically highlights that progress is overdue in the following areas:

- Despite the differences among the CEE9 countries, **the region's shared endowments and developed core competencies present a policy opportunity.** Moreover, while the CEE9-economies are among the least innovative in the EU, they possess economic, societal, and demographic circumstances highly compatible with next-generation technology and Industry 4.0.

- Leveraging high manufacturing intensities in medium/high-tech industries, export-intensity, and large cohorts of STEM graduates, these nations are well positioned to embrace underlying Industry 4.0 technologies and other productivity-enhancing systems: ICT and e-mobility represent two obvious innovation industries where the region could emerge as a global leader. Dispersion of RRF funds may provide a significant opportunity for CEE9-countries to gain market share and specialization in emerging technology sectors such as green-tech, clean-tech, and cyber-security

- **A streamlined policy approach targeting a regional innovation ecosystem – e.g., along the Danube Valley** – could focus on the such competencies in technology, mobility, and industry by-an-large. Individual CEE9-country analysis (Chapter 1) reveals these areas – private sector digitalisation, green economy, reforms towards Industry 4.0, and common risk capital pool, especially early-stage – to be common enablers and denominators for a shared regional policy approach to innovation in CEE9. Pinning down such areas could, furthermore, encourage countries to share their experiences in designing policy reforms, funding programs, monitoring and evaluation, and program results

- **An inclusive economic recovery starts with economic growth, jobs, skills, and equity.** But against the backdrop of the failure of many governments to adequately reform education and provide for skills of 21st century, bottom-up approaches to education and skill provision have constituted robust alternative to public service provision in Central Europe, as evidenced by findings in Chapter 2

- **Broadly-based, well-designed top-down education reforms are still any system's best bet,** hence, in the quest to escape the middle-income trap, and upgrade towards innovative, intelligent, and sustainable growth paradigm, effective public skill provision should be prioritised with utmost urgency. But in the absence or incompleteness of top-down reforms delivering tangible results – and in the face of the pressing need – successful grassroots alternatives can be exploited as they (a.) they partly fill the void left by public policy; (b.) act as a complementary source of skills to the formal system; and (c.) pilot approaches and schemes that can be adopted more broadly and improve education systems.

- **The pronounced advantage of the bottom-up approaches to skills provision is that they could improve education outcomes faster.** The obvious downside is that they do so typically at a small(er) initial scale. However, if policymakers devoted more attention and resources to recognition, validation and scaling of successful bottom-up initiatives, these could quickly spread, especially in smaller countries

- **The funds allotted toward education reforms, skills upgrades, and innovation under the Recovery & Resilience Fund umbrella in CEE9 constitute a step in the right direction.** What is important is to use these funds not only for physical infrastructure investment projects, but also to challenge the status quo

The Road Ahead for Business

- **Igniting a deep transformation requires concerted action.** Policy solutions should benefit from collaborative, strategic partnerships with the private sector (and other key actors) to deliver on anticipated market outcomes. While governments must think beyond the traditional top-down policymaking, there is a business case for the private sector – emanating from risks faced by companies from systemic challenges – for actively shaping policy strategies (even to traditionally public objectives, such as education provision) to achieve results in an ever-complex economic environment
- **It is becoming increasingly obvious that public policy ends cannot be pursued in isolation,** as a part of secluded portfolios. Rather, to be successful, economic, environmental, and social goals must be pursued in tandem, as a part of integrated, wholesome strategic policy agenda that is inter-disciplinary, sustainable, inclusive, and targeting incentives and motivations of key economic actors
- **Kickstarting a deep transformation requires long-term leadership and commitment.** Governments should play a balancing role, levelling the playing field in terms of access to opportunity, harmonising policy formulation in terms risks and opportunities, and making sure incentives of all key involved actors are aligned. But l**ike-minded alliances of key economic actors around strategic interests and goals may carry the momentum of a strategic economic transformation** beyond fragile political cycles and continue progress even where political commitment/leadership is diluted
- **The private sector should not stay a passive agent on the road towards the knowledge-based economy.** It should allocate resources, create synergies and partnerships across sectors and industries, to help upgrade the skillset of its workforce, starting with areas that are closest and most relevant to its needs
- Admittedly, **the Covid-19 pandemic has increased the pressure on the private sector revenue and margins. I**n contributing to shaping the new economic and social contracts, the private sector should also be able to tap funds under the Recovery & Resilience Fund umbrella effectively and at a low-cost
- **Private enterprise is also responsible for actively shaping prevailing model of capitalism in the region.** While governments are to create enabling policy context, businesses must drive the underlying change. Commitment to sustainability, modernization, greater productivity through existing and new digital technologies, and resilient business models must be demonstrated in daily economic transactions and interactions of key actors. Social impact, balancing profits with purpose, and corporate responsibility, including promoting equality practices in organisational structures, entrenching sustainability as a part of a business strategies etc. is no longer optional for a long-term organisational success

How to Get Involved

To learn more about the CEE Strategic Transformation Index and engage with the Tatra Summit Platform work please refer to the following website: https://www.globsec.org/platforms/Tatra-Summit/Strategic-Transformation

3. Research & Methodology

Country Selection

The CEE Strategic Transformation Index is available at a CEE9 region aggregate level and at individual country-level. In the current report, CEE9 is defined as Slovakia, Czechia, Poland, Hungary, Austria, Slovenia, Croatia, Romania, and Bulgaria. Authors have deliberately targeted a narrower sample of CEE countries, leaving out the Baltic states (Estonia, Lithuania, and Latvia) and the Balkan countries (Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, Serbia) that are sometimes included in broader CEE compositions. For example, the OECD defines the Central and Eastern European Countries (CEECs) as a group comprising of Albania, Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, the Slovak Republic, Slovenia, and the three Baltic States: Estonia, Latvia, and Lithuania[224]. Authors duly acknowledge the existence of other definitions/country compositions of the CEE region.

The country choice has been deliberately narrowed to reflect GLOBSEC and partners' areas of regional economic expertise, the common transitional past of most of the included countries, real economic convergence performance to-date, as well as the role advanced economic clubs have played on its transformational path, as detailed in earlier. All included countries are EU members. Austria, Slovakia, and Slovenia are additionally euro area members, while Bulgaria and Croatia have been since July 2020 placed in the advanced phase of euro adoption[225]. All but one country (Croatia) are additionally members of the intergovernmental economic club, the OECD. These memberships represent a degree of 'like-mindedness' and basic level of institutional quality, which we leverage as a basis for the index. The memberships also interact with the quality, availability, breadth, coverage, and international comparability of the available statistics used for the purpose of the index computation. The quality of the information fed in is important to obtain meaningful index values and policy implications, and thereby deliver an informative diagnostic tool.

Austria has a special standing in the country sample, as it lacks the shared communist past and is pronouncedly more advanced on most macroeconomic counts than the remainder of the countries. Austria has been included on the double-basis of geographical proximity and economic and political ties to the Visegrad economies, and as a benchmark than many of the other countries can aspire to. Authors duly acknowledge the different stage of Austria's development from the rest of the CEE region, as hereby defined. Admittedly, the country choice can be deemed arbitrary. The CEE country composition can change in future vintages of the Index/Report.

To contextualise the rankings within a broader milieu and place them into a perspective vis-à-vis relevant benchmarks we include a broader country sample of richer European economies: Germany, Sweden, Denmark, Finland, Estonia, the Netherlands, Belgium, and France[226]. The basic rationale behind the choice of these control countries is two-fold: on a basis of trade ties with CEE in some cases, and as a convergence aspiration for the region. Germany and France tend to lead the way in terms of Pillar 1, i.e., perform best in terms of macro-resilience, while their Scandinavian counterparts set the mark for Pillar 2 (Innovation Economy). Including a sub-set of the richer European economies also improves the information power of the index. This can be seen in interpreting its values. For example, if the value of the index (sub-index) per a given country in 2019 is equal to 25, it can be interpreted as the country being at a ¼ point between the worst (most often, a CEE country in 2010) and the best performer (most often, an advanced country in 2018) in the sample available when first vintage of the STI was constructed. Thus, the index benchmarks each country and places it at a scale, passed its historical progress and vis-à-vis future potential advancement, where the mark is set by the advanced economies included.

We considered an inclusion of extra-EU innovation top performers that frequent leading spots in global rankings[227] (South Korea, Singapore, Israel, or the United States). Nevertheless, we prefer the selected sample of European advanced nations, as: one, the convergence paradigm of CEE makes more sense in the European context; two, EU proximity and trading links may play a role; and three, the similar institutional, cultural makeup of the selected countries – under the umbrella of EU like-mindedness, institutions, and Acquis Communautaire – matters.

224 OECD. (2001). OECD Glossary of Statistical Terms - Central and Eastern European Countries (CEECs) Definition. https://stats.oecd.org/glossary/detail.asp?ID=303

225 European Commission. (2020, July 10). Commission welcomes Bulgaria and Croatia's entry into the Exchange Rate Mechanism II [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1321

226 We deliberately leave out Mediterranean European countries – e.g., Spain, Italy, Greece due to stalled convergence post-Great Recession in some cases, and dissimilarities in economic structure vis-à-vis CEE, as shown in previous sections, (they are less open, less export-oriented, with greater contribution to gross value-added of services, etc.). On the other hand, they grapple with many problems the CEE is facing, including laggard productivity, the need to upgrade human capital, laggard innovation performance, low levels of R&D investments etc.

227 See for example here: Jamrisko, M., & Lu, W. (2020). Germany Breaks Korea's Six-Year Streak as Most Innovative Nation. Bloomberg. https://www.bloomberg.com/news/articles/2020-01-18/germany-breaks-korea-s-six-year-streak-as-most-innovative-nation

Data, Proxies

All data series deployed in the current analysis are sourced from major international databases (Eurostat, European Commission AMECO, European Central Bank, Penn World Tables, World Bank, OECD, WIPO, etc.) to facilitate cross-country comparability of the information included. The frequency used for all series is annual. Importantly, all deployed series are – as a rule – sourced from active datasets that get regularly updated. A detailed overview of the data used, including definitions, sources, time coverage and country coverage, along with basic data description statistics follows (Table III).

Table III. Data definitions, transformations, time, and country coverage

PILLAR	SUB-INDEX	SUB-INDEX COUNT	CLUSTER	DATA SERIES	DATA DEFINITION/TRANSFORMATION	UNIT	SOURCE	START	END	COUNTRY COVERAGE	TURNED SIGN TO 'MORE IS BETTER'
1	A	1	Openness	Global value chains (GVC) forward participation	domestic value-added in foreign exports as a share of gross exports; includes the value added generated by the exporting industry during its production processes as well as any value added coming from upstream domestic suppliers that is embodied in the exports	% of gross exports	OECD	2005	2015	all countries (broad index)	
1	A	2		Foreign direct investment (FDI) openness	defined as sum of FDI inflows (% of GDP) and FDI outflows (% of GDP); FDI net inflows are the value of inward direct investment made by non-resident investors in the reporting economy, including reinvested earnings and intra-company loans, net of repatriation of capital and repayment of loans; FDI net outflows are the value of outward direct investment made by the residents of the reporting economy to external economies, including reinvested earnings and intracompany loans, net of receipts from the repatriation of capital and repayment of loans	% of GDP	World Bank WDI	1990	2019	all	
1	A	3		Index of export market penetration	calculated as the number of countries to which the reporter exports a particular product divided by the number of countries that report importing the product that year; measures the extent to which country's exports reach already proven markets: a low export penetration may signal the presence of barriers to trade that are preventing firms from expanding the number of markets to which they export	index	World Bank	1990	2019	all	
1	B	1	External vulnerability	Economic complexity	defined in terms of an eigenvector of a matrix connecting countries to countries, which is a projection of the matrix connecting countries to the products they export; considers information on the diversity of countries and the ubiquity of products; measures economic complexity containing information about both the diversity of a country's export and their sophistication	index	Harvard Growth Lab	1995	2018	all	
1	B	2		Terms of trade volatility	computed as standard deviation of year on year growth rate of net barter terms of trade index (2000 = 100) over 5 years	standard deviation of 5-year growth rate	World Bank WDI	2005	2019	all	x
1	B	3		Herfindahl--Hirschman Product/Market Concentration Index	measures dispersion of trade value across an exporter's products; country with a preponderance of trade value concentrated in a very few products will have an index value close to 1; indicator of the exporter's vulnerability to trade shocks; measured over time, a fall in the index may be an indication of diversification in the exporter's trade profile	index	World Bank	1990	2019	all	x
1	C	1	Productivity & Value-added	Total factor productivity	TFP in 2015 sourced in current prices from Penn World Tables (variable CTFP; GDP-based measure; 2015=100) - ideal to facilitate country comparison at a point of time. To fill in observations in previous and subsquent periods, growth rates from EC AMECO total factor productivity (ZVGDF, index; 2015=100) are used	index; 2015=100	Penn World Tables 9.1, European Commission AMECO	1990	2020	all	
1	C	2		Medium/high-tech industry value--added	proportion of medium and high-tech industry value-added in total value-added of manufacturing	% of total manufacturing value--added	World Bank	1990	2018	all	
1	C	3		Sophistication of exports	is given by summing all the PRODY values for the products exported by the country, each weighted by the product's share in total exports; PRODY is calculated as a weighted average of per capita GDP of countries producing that product, with weights derived from revealed comparative advantage	weighted average by product's share in exports	World Bank	1990	2019	all except Romania *	
1	C	4		Employment in knowledge-intensive activities	employment in knowledge-intensive activities (manufacturing + services) as a share of total employment; classified as 'knowledge intensive' if employed tertiary educated persons represent more than 33 % of the total employment in that activity; the definition is built based on the average number of employed persons aged 15-64	% of total employment	European Commission AMECO	2008	2019	all	

PILLAR	SUB-INDEX	SUB-INDEX COUNT	CLUSTER	DATA SERIES	DATA DEFINITION/TRANSFORMATION	UNIT	SOURCE	START	END	COUNTRY COVERAGE	TURNED SIGN TO 'MORE IS BETTER'
1	C	5	Productivity & Value-added	High-technology exports	products with high R&D intensity (aerospace, computers, pharmaceuticals, scientific instruments, electrical machinery); weighted average; since industrial sectors specializing in a few high-tech products may also produce low-tech products, product approach used for international trade	% of total manufactured exports	World Bank	2007	2019	all	
1	D	1	Financial structure	Long-term interest rate for convergence purposes	harmonised long-term interest rates refer to government bonds maturing in ten years	% per annum; period averages; secondary market bond yields	ECB	1991	2020	all except Estonia *	x
1	D	2		Loans to households as a ratio of gross disposable income	loans granted to households as a ratio of gross disposable income (the amount of money that all of the individuals in the household sector have available for spending or saving after income distribution measures; for example, taxes, social contributions and benefits, have taken effect)	% of gross desposable income	ECB	1999	2020	all	x
1	D	3		MFIs lending margins on loans to non-financial corporations (NFC)	measures difference between Monetary Financial Institutions (MFIs') interest rates on new business loans and a weighted average interest rate on new deposits from non-financial corporations	percentage points	ECB	2003	2020	all	x
1	D	4		House price-to-income ratio	ratio of residential prices to disposable income: to ensure comparability of indices (2015=100) across countries and continuity across time, estimates from European Commission* paper are used for 2015, thereafter proceeding as follows: indexing of these estimates backwards and forwards by price-to-income ratios indices provided by OECD and since the OECD does not provide price-to-income ratio index for Croatia, constructing the index using data on house prices, real disposable income and deflator of consumption by Eurostat.	number of yearly incomes to purchase 100 square metres	European Commission*	1990	2020	all	x
1	D	5		Bank non-performing loans as a share of gross loans	the value of nonperforming loans divided by the total value of the loan portfolio (incl. NPLs before deduction of specific loan-loss provisions). The loan amount recorded as nonperforming should be the gross value of the loan as recorded on the balance sheet, not just the amount that is overdue	% of gross	World Bank	2006	2020	all	x
2	E	1	Education cluster	EDUCATION OUTCOMES: PISA scores: reading	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in reading	scores (available at 3-year basis)	OECD	2000	2018	all	
2	E	2		EDUCATION OUTCOMES: PISA scores: mathematics	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in mathematics	scores (available at 3-year basis)	OECD	2003	2018	all	
2	E	3		EDUCATION OUTCOMES: PISA scores: science	OECD international student assessment of 15-year-olds' ability, knowledge, skills to meet real-life challenges: average PISA score in science	scores (available at 3-year basis)	OECD	2006	2018	all	
2	E	4		ADULT LEARNING: Participation rate in education and training	participation rate in education and training for the last 4 weeks for people aged 25-64 years; survey-based measure: 'Have you participated in any training or education in the last 4 weeks?'	% of total respondents	Eurostat	1992	2020	all	
2	E	5		TRANSITION TO WORK: Early leavers from education and training	percentage of the population aged 18-24 having attained at most lower secondary education and not being involved in further education or training may face difficulties in the labour market	% of total enrolled, 18-24 years old	Eurostat	1992	2020	all	x
2	E	6		Public expenditure on education	public expenditure on education, All ISCED 2011 levels excluding early childhood educational development	% of GDP	Eurostat	2002	2018	all except Denmark, Croatia*	
2	E	7		HIGHER EDUCATION: Tertiary education enrollment	measures tertiary school enrollment; tertiary education requires successful completion of education at the secondary level	% of gross	World Bank	1990	2018	all	
2	E	8		HIGHER EDUCATION: Tertiary educational attainment	measures the share of the population aged 30-34 who have successfully completed tertiary studies (e.g. university, higher technical institution, etc.)	% of population aged 30 to 34	Eurostat	2000	2020	all	
2	E	9		ACADEMIC STAFF: Classroom teachers & academic staff	classroom teachers and academic staff, primary education	count scaled by population	Eurostat	2013	2019	all	
2	E	10		ACADEMIC STAFF: Ratio of pupils and students to teachers and academic staff	ratio of pupils and students to teachers and academic staff by education level and programme orientation [pre-primary education]	%	Eurostat	2013	2019	all except Ireland, Denmark, Estonia*	x

PILLAR	SUB-INDEX	SUB-INDEX COUNT	CLUSTER	DATA SERIES	DATA DEFINITION/TRANSFORMATION	UNIT	SOURCE	START	END	COUNTRY COVERAGE	TURNED SIGN TO 'MORE IS BETTER'
2	F	1	Green economy	Production-based CO2-productivity	calculated as real GDP generated per unit of energy--related CO2 emitted (includes CO2 emissions from combustion of coal, oil, natural gas and other fuels)	USD per kg	OECD	1990	2019	all	
2	F	2		Domestic material consumption per capita	amount of material directly used in an economy and equals direct material input (DMI) minus exports. DMI measures the direct input of materials for the use in the economy. DMI equals domestic extraction (DE) plus imports. For the 'per capita' calculation of the indicator the average population is used (the arithmetic mean of the population on 1st January of two consecutive years).	tonnes per capita	Eurostat	1990	2019	all	x
2	F	3		Resource productivity and domestic material consumption (DMC)	gross domestic product (GDP) divided by domestic material consumption (DMC). DMC measures the total amount of materials directly used by an economy. It is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports.	purchasing power standard (PPS) per kg; 2015 as reference year, data filled in using the EUR per kilogram chainlinked volumes series	Eurostat	2000	2019	all	
2	F	4		Renewable share in final energy consumption	share of renewable energy in final consumption of energy (includes consumption of energy derived from: hydro, solid biofuels,wind, solar, liquid biofuels, biogas, geothermal, marine and waste); total final energy consumption is calculated from national balances and statistics as total final consumption minus non-energy use	% of final energy consumption	IEA	1990	2016	all	
2	F	5		Recycling rate of municipal waste	measures the share of recycled municipal waste in the total municipal waste generation. Recycling includes material recycling, composting and anaerobic digestion. Expressed in percent (%) as both components measured in tonnes.	% of total municipal waste	Eurostat	1995	2019	all	
2	F	6		Air quality: Mean population exposure to PM2.5	mean population exposure to fine particulate matter, calculated as mean annual outdoor PM2.5 concentration weighted by population living in the area	concentration level, micrograms per cubic meter (µg/m3) in a year	OECD	1990	2019	all	x
2	F	7		Greenhouse gas emissions	national emissions, including international aviation of the so called 'Kyoto basket' of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the so-called F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen triflouride (NF3) and sulphur hexafluoride (SF6)) from all sectors of the GHG emission inventories (international aviation, excluding land use, land use change and forestry). Using each gas' individual global warming potential (GWP), they are being integrated into a single indicator expressed in units of CO2 equivalents.	tonnes per capita	Eurostat	1990	2019	all	x

PILLAR	SUB-INDEX	SUB-INDEX COUNT	CLUSTER	DATA SERIES	DATA DEFINITION/TRANSFORMATION	UNIT	SOURCE	START	END	COUNTRY COVERAGE	TURNED SIGN TO 'MORE IS BETTER'
2	G	1	Digital economy	Households internet access	percentage of householdswith have internet access	% of total households	Eurostat	2002	2020	all	
2	G	2		Individuals' internet use	percentage of individuals which have used the internet at least once within the last 3 months; survey-based measure	% of total respon-dents	Eurostat	2003	2020	all	
2	G	3		Internet purchases by individuals in 3 months	internet users who bought goods/services for private use in the previous 12 months	% of total internet users	Eurostat	2002	2020	all	
2	G	4		E-government acti-vities of individuals via web	percentage of internet users who have interacted with public authorities at least once in the last 12 months	% total internet users	Eurostat	2008	2020	all	
2	G	5		E-commerce sales, Enterprises' total turnover	total turnover from e-commerce sales: defined as the sale/purchase of goods/services, between businesses, households, individuals or private organisations, through electronic transactions via the internet or other computer-mediated networks	% of turno-ver coming from e-commer-ce sales	Eurostat	2010	2020	all	
2	G	6		E-commerce sales, Enterprises at least 1% turnover	sales coming from e-commerce which includes all enterprises, without financial sector (10 persons em-ployed or more) which have at least 1% turnover from e-commerce sales	% of total enterprises	Eurostat	2010	2020	all	
2	H	1	Innovative capacity	Patents	direct + PCT national phase entries patent applications (a patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem)	total count per 1000 population	WIPO	1990	2019	all	
2	H	2		Trademarks	total direct and via the Madrid system trademark applications (trademark is defined as a sign capable of distinguishing the goods/services of one enterprise from another, protected under intellectual property rights)	total count per 1000 population	WIPO	1990	2019	all except Belgium and Nether-lands *	
2	H	3		Designs	total direct and via the Hague system design applica-tions (an industrial design constitutes the ornamental aspect of an article and may consist of three dimensi-onal features, such as the shape of an article, or two dimensional features, such as patterns, lines or color)	total count per 1000 population	WIPO	1990	2019	all except Belgium and Nether-lands *	
2	H	4		Gross domestic expenditures on R&D	capital + current expenditures in 4 sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied rese-arch, and experimental development	% of GDP	World Bank	1996	2018	all	
2	H	5		Venture capital expenditures	sum of early stage (pre-seed, seed, start-up and other early stage) and later stage venture capital	% of GDP	OECD	2007	2020	all except Croatia and Bulgaria *	
2	H	6		R&D Personnel	include all persons employed directly on R&D, plus persons supplying direct services to R&D (managers, administrative, office staff)	in full time equivalents as % of economic active population	Eurostat	2007	2019	all	
2	H	7		Researchers head count	professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned	count scaled by population	Eurostat	2007	2019	all	
2	H	8		Human resources in science and technology	active population in the age group 25-64 that is classified as HRST (i.e. having successfully completed an education at the third level or being employed in science and technology) as a percentage of total active population aged 25-64	% of active population	Eurostat	2007	2020	all	

*EC paper available at: https://ec.europa.eu/info/sites/info/files/economy-finance/dp101_en_houselev.pdf

Table IV. Data descriptive statistics

Raw data (2010-2019)						Data after filling missing, interpolating, extrapolating				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Openness (A)										
a_fdi_openness	190	8,1	23,2	-83,1	146,4	190	8,1	23,2	-83,1	146,4
a_gvc_forward_participation	114	19,0	3,2	12,3	24,4	190	19,1	3,2	12,3	24,4
a_iemp	190	17,9	10,8	4,6	44,8	190	17,9	10,8	4,6	44,8
External resilience (B)										
b_econ-complexity	171	1,4	0,4	0,5	2,3	190	1,4	0,4	0,5	2,3
b_hh_product_mkt_conc	182	0,0	0,0	0,0	0,1	190	0,0	0,0	0,0	0,1
b_tot_volatility	190	1,7	0,8	0,5	3,9	190	1,7	0,8	0,5	3,9
Productivity & value-added (C)										
c_se	172	10,0	0,1	9,7	10,2	190	10,0	0,1	9,7	10,2
c_empkia	190	35,3	6,0	19,5	46,1	190	35,3	6,0	19,5	46,1
c_himva	171	46,4	9,3	24,7	62,5	190	46,4	9,3	24,7	62,5
c_tfp_pwt_ameco	190	82,7	15,9	57,3	134,0	190	82,7	15,9	57,3	134,0
c_xkia	188	15,7	6,5	6,1	32,8	190	15,6	6,5	6,1	32,8
Financial structure (D)										
d_10ybench_i	180	2,5	2,0	-0,3	9,6	190	2,4	1,9	-0,3	9,6
d_houseprice_income	187	10,0	2,3	6,7	17,3	190	9,9	2,3	6,7	17,3
d_hhdebt_dispincome	188	99,5	63,2	24,5	286,3	190	98,9	63,2	24,5	286,3
d_mfilendingrates	187	1,9	0,8	0,6	5,0	190	1,9	0,9	0,6	5,0
d_npl_totgross	184	6,1	5,2	0,5	25,7	190	6,0	5,2	-0,5	25,7
Education (E)										
e_pisam	57	493,6	23,7	429,9	523,4	190	493,4	23,7	429,9	533,4
e_pisar	57	490,9	26,3	419,8	526,4	190	490,8	26,0	419,8	530,7
e_pisasci	57	495,6	27,2	424,1	545,4	190	496,3	27,0	424,1	551,6
e_train	190	12,0	8,9	0,9	34,3	190	12,0	8,9	0,9	34,3
e_early_leavers	190	9,0	3,5	2,8	19,3	190	9,0	3,5	2,8	19,3
e_tert_edu	190	39,1	9,1	18,3	56,3	190	39,1	9,1	18,3	56,3
e_tert_enrol	166	68,7	11,4	45,4	94,9	190	68,9	11,4	45,4	94,9
e_acad_staff_pop	126	4,6	1,8	2,0	8,8	190	4,5	1,8	1,9	8,8
e_ratio_student	113	13,8	5,4	5,8	40,6	190	13,0	5,3	4,5	40,6
e_edu_gov_expend	146	5,1	1,2	2,6	8,8	190	5,1	1,3	2,6	8,8
Green economy (F)										
f_co2prod	187	6,0	2,5	1,8	16,0	190	6,0	2,5	1,8	16,0
f_pm25	190	14,4	5,3	5,3	27,4	190	14,4	5,3	5,3	27,4
f_renewables	133	19,5	12,1	3,7	53,1	190	19,9	12,1	3,7	53,1
f_greenhouse_emiss	190	9,6	2,7	5,2	16,8	190	9,6	2,7	5,2	16,8
f_recycle_rate	184	37,5	15,5	4,0	67,2	190	37,6	15,3	4,0	67,2
f_resource_prod	190	1,8	0,8	0,6	4,1	190	1,8	0,8	0,6	4,1
f_mat_capita	190	17,4	6,6	8,5	37,3	190	17,4	6,6	8,5	37,3
Digital economy (G)										
g_ecoms	188	17,4	7,2	3,0	36,0	190	17,5	7,2	3,0	36,0
g_ecomv	182	16,7	7,2	2,0	37,0	190	16,6	7,0	2,0	37,0
g_egov	190	51,6	20,5	5,0	92,0	190	51,6	20,5	5,0	92,0
g_intaccess	190	80,8	11,9	33,0	98,0	190	80,8	11,9	33,0	98,0
g_intbuy	190	39,7	19,9	2,0	80,0	190	39,7	19,9	2,0	80,0
g_intuse	190	81,4	11,8	40,0	98,0	190	81,4	11,8	40,0	98,0
Innovative capacity (H)										
h_patents	158	0,0	0,0	0,0	0,2	190	0,1	0,0	0,0	0,2
h_design	183	0,2	0,2	0,0	0,8	190	0,2	0,2	0,0	0,8
h_trademarks	170	1,9	0,9	0,4	3,7	190	1,9	0,9	0,4	3,7
h_rdexp	163	0,9	0,4	0,0	2,2	190	1,0	0,4	0,0	2,2
h_vc	177	0,0	0,0	0,0	0,1	190	0,0	0,0	-0,0	0,1
h_rd_personnel	190	1,2	0,5	0,3	2,2	190	1,2	0,5	0,3	2,2
h_hr_sci_tech	190	45,4	9,1	24,0	60,7	190	45,4	9,1	24,0	60,7
h_researchers	150	0,6	0,3	0,1	1,1	190	0,6	0,3	0,1	1,1

Method

Drawing on the conceptual framework and data, an empirical method – principal components analysis (PCA) – is deployed to get a sense of the internal structure of the data, as embodied by the total of 47 variables per each country, and its variance. PCA is a dimensionality-reduction technique often used to decrease the dimensionality of large datasets in an interpretable way. It does so by transforming a large set of variables into a smaller one by creating new uncorrelated linear combinations of the existing variables, the principal components (PCs)[228]. Principal components are the most important features of the dataset: they successively maximise variance (i.e., capture most of the original statistical information), while minimizing interpretation loss, and in such a way facilitate greater interpretability.

As a statistical method it is suitable for our purposes, as it adapts to the dataset at hand, rather than relying on a narrow choice of variables a priori. PCA is a standard statistical technique for pattern recognition and feature identification in a broad pool of information[229], and presents some additional advantages, including efficiently removing correlations between data series (since PCs are independent of one another). This fits well with our aim to distil the key drivers of CEE strategic economic transformation, while getting rid of information duplicities and correlations between variables. By reducing the number of features, it also helps in overcoming overfitting caused by too many variables in a dataset. PCA is applied at the normalised dataset to be able to obtain the resultant principal component loadings.

PCA can be ran on a pooled full country sample (per thematic cluster/sub-index), or at individual country-level (per thematic cluster-sub-index). The advantage of the former approach is that it exploits both within-country and cross-country correlations between variables. However, like pooled Ordinary Least Squares (OLS) estimation, it requires that relationship between variables to be the same in all countries. Otherwise, loadings of variables tend to be distributed across components more broadly. Conversely, the advantage of running PCA on individual country-level (by thematic cluster/sub-index) is the freedom of assumptions, i.e., that it is not required that there be the same linear relationship between variables in all countries. Hence, the latter approach allows for a priori country heterogeneity but at the expense of losing some cross-country information content.

Index Computation

As a main approach, PCA is estimated at individual country-level per sub-index. Since in individual countries there is a strong correlation between variables within clusters, most of the variation of the data can be explained by the first component loadings, which are then used to produce weights.

W**here entire time series are unavailable for a country** (in several cases as reported in Column 10 of Table III, marked with an asterisk), the missing time series are estimated using (1) other available series within the thematic cluster/subindex (if these contain missing values, we firstly interpolate observations using cubic splines); and, (2) a time dummy on a full sample; fitted values are then used to populate the missing time series. A similar method is used to fill in sparsely populated series (for example, government spending on education) and to fill in several series during early years (for example student-to-teacher ratio and academic stuff until 2012). When filling a datapoint in a particular year, we use only data which were available when this particular year was included in the STI index for the first time.

Reference years, missing data: Once the missing times series are filled in using this method, the index can be calculated across all countries from 2010 to 2019. A nine-year cross-country overlap is sufficient to obtain the index values. Data prior to 2010 are utilised only for data imputations. Missing data are interpolated using cubic splines (for example, for PISA data). Where a data series ends prior to 2019, the last available value is extrapolated to populate the series up to 2019. Once the missing times series/observations are populated using the method as described in the previous paragraph and through interpolation/extrapolation respectively, the index can be calculated across all countries from 2010 to 2019.

Outliers: Before the calculation of the index, standard data cleaning and outlier identification and treatment is performed. Specifically, outliers are identified based on standard deviations from the mean. An observation is considered to be an outlier if it is smaller or greater than cross-country mean -/+ twice cross-country standard deviation. Outliers are replaced by cross-country mean -/+ twice cross-country standard deviation. Outlier

228 Jolliffe, I. T., & Cadima, J. (2016). Principal component analysis: a review and recent developments. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 374(2065), 20150202. https://doi.org/10.1098/rsta.2015.0202

229 Lin, T. K. (2019). Adaptive Principal Component Analysis Combined with Feature Extraction-Based Method for Feature Identification in Manufacturing. Journal of Sensors, 2019. https://doi.org/10.1155/2019/5736104

identification is performed separately for each period, then of residuals obtained from regressions of each variable on (1) time dummies; and (2) country dummies. If the residual is smaller or greater than two standard deviations, it is identified as an outlier and replaced with fitted value +/- two standard deviation. This method of outlier identification/treatment[230] takes into account deviation from mean conditional on a year and a country.

Normalization: Before the application of PCA, data are normalised. To ensure comparability of the STI across vintages, we employ methodology which ensures that new data do not change how data are normalised. All data variables are treated, so their increase means getting closer to the desired outcome. This results in the following two normalization formulas:

- For the group where 'more is better' (most variables, except group that follows):

  x_norm = (x-min)/(max-min),

  where 'x' is the raw value at a point of time; 'min' is the minimum within the variable series; 'max' is the maximum within variable series; both 'min' and 'max' are calculated from the dataset used to calculate the first vintage of the STI.

- For the group where 'less is better'231:

  x_norm = (max-x)/(max-min),

  where 'x' is the raw value at a point of time; 'min' is the minimum within the variable series, 'max' is the maximum within variable series; both 'min' and 'max' are calculated from the dataset used to calculate the first vintage of the STI.

Skewness: Furthermore, variables where skewness is greater than 1 are squared to the power of ½; variables, where skewness is less than -1; are squared to the power of 2. Skewness is calculated from the dataset used to calculate the first vintage of the STI (2020).

Weights: To calculate weights, dataset used to quantify the first vintage of the STI is employed. This ensures that weights do not change across vintage and different vintages of the STI are comparable over time. PCA is run at a country-level, cluster by cluster. Since in individual countries there is a strong correlation between variables within clusters, most of the variation of the data can be explained by the first component (PC1). To obtain weights for each cluster at country-level, PC1 loading is squared to the power of 2. For example, PCA is ran for Slovakia for cluster 'a' (Openness), calculating weights w_a_SK, for cluster 'b' (External Resilience), calculating weights w_b_SK, for cluster 'c' (Productivity & Value-added), calculating weights w_c_SK etc. The squared loading is the percentage of variance in the variable explained by the principal component.

Index aggregation: Final weights for sub-index 'a' are calculated as an arithmetic average of w_a_SK, w_a_CZ, w_a_HU, w_a_PL etc., attaining sti_a. This is done for each of the eight clusters. Final index composite is an unweighted average of the 8 thematic sub-indices. Final index can be further split into 2 main pillars: (1) Macroeconomic Structure & Resilience and (2) Innovation Economy. The former is an unweighted average of the sub-indices 'A', 'B', 'C', 'D' and the latter of sub-indices 'E', 'F', 'G', 'H'.

230 Using this method, about 4% of observations per variable are identified as outliers (8 observations per variable on average)

231 Includes: Terms of trade volatility (B), Herfindahl-Hirschman Product/Market Concentration Index (B), House price-to-income ratio (D), Non-performing loans (D), Long-term interest rate for convergence purposes - 10 years maturity (D), Household debt as a ratio to gross disposable income (D), MFI lending margins to non-financial corporations (D), Adult education: Early leavers (E), Pupil/student-to-teacher ratio (E), Domestic material consumption per capita (F), Air quality: Mean population exposure to PM2.5 (F), and Greenhouse gas emissions (F).

Availability, Comparability & Further Work

The CEE Strategic Transformation Index is updated annually in the run-up to the annual GLOBSEC Tatra Summit. The cut-off date for the incoming information included in the index is August 30 every year. Looking ahead, each vintage will be obtained through the methodology described, by updating the data inputs, including new observations and historical data revisions. Loadings calculated on the 2020 sample have been retained, in order to make the index comparable not only across countries at a given point of time but also to have a meaningful year-on-year comparison. To that end, the same estimations to fill in missing series will be computed on the 2010-2019 sample. Minima, maxima, and skewness used to normalise the data will be also calculated using the 2010-2019 sample. Loadings, minima, maxima, and skewness are scheduled to be updated in the 2025 release.

The conceptual framework results from a combination of theoretical, conceptual, empirical, and agnostic underpinnings. It departs from relevant empirical literature and evidence, lets historical data 'speak', reflects on the recent policy recommendations of international institutions as a part of its regular country surveillance, and considers other composite measures of innovation. It also leverages authors' and GLOBSEC knowledge- and institutional partners' as well as its network of distinguished research fellows' familiarity with the CEE9 regional macroeconomy.

Admittedly, the CEE Strategic Transformation Index framework would benefit from even more comprehensive choice of variables, including ones covering the following concepts: fiscal sustainability, labour and product market flexibility (more comprehensive measure of internal competitiveness), immigration (penetration and policy), democracy (strength), quality of institutions, business environment, rule of law (efficiency) and corruption, and a measure of effective absorption and effective use of the European Commission funds. It would also benefit a more comprehensive measurement of local entrepreneurship. Here, the concept has been limited by model parsimony on the one hand, and international data availability and historical coverage for CEE9 countries on the other. Authors will duly monitor the availability of relevant data series going forward and potentially revise the conceptual framework in the future. Authors also recommend using the Index in conjunction with individual data series where available, convening more information of these economic dimensions for a more complete picture.

The CEE Strategic Transformation Index does not replace the usefulness and merit of individual indicators for economic analysis and policy. Individual indicators should continue to be monitored on a perpetual basis, as they provide a more detailed, granular, disaggregated insight into the drivers of broader developments across the sub-themes as hereby identified.

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