Keeping Pace with the 21st Century

Higher Education and Research in the Visegrad 4 Countries

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ABSTRACT
Countries of the EU Visegrad Four group are gradually exhausting the sources of their extensive economic growth model. Moreover, they are facing new challenges like fast development in ICT, automation, robotics and other technologies, climate change, ageing populations, bleeding mass migration of the most talented and educated, etc. The paper argues that switching to a more knowledge-based growth model seems inevitable in order to avoid the so-called ‘middle income trap’. Focusing on higher education and scientific research, it gives hard data-based evidence on why the required transformation is going to be difficult: higher education in these countries is in disarray, and private and public R&D is low. Policy implications and recommendations are put forward at the end.

A Convergence Story of Three Decades

The outbreak of the COVID-19 pandemic in the first quarter of 2020 has already had a significant impact on the world economy.[4] National and local measures to mitigate the contagion have resulted in economic havoc: business and institution closures, proliferation of home offices, mass layoffs and so on. Markets hardest hit by the crisis are rapidly eroding, supply chains are clogging, complete industries are threatened, many businesses may expect

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[4] The first draft of the paper was written in February and March 2020, at the beginning of the global coronavirus outbreak, but some revisions were added in April 2020.

long-term income losses, and communities feel the uncertainty and stress of managing their daily life.

Although it is unclear when and how all this may recede over the months and years ahead, it is clear that crises like this hit the most vulnerable the hardest. The present (hopefully) temporary shock may target local weaknesses, while making some strengths less relevant, but fast reactions to the shock should not overshadow the problems of long-term sustainability. Resilience will be an essential factor in survival and future development. Individuals, firms and whole economies have to master a new environment, adopt and develop new technologies and face new regulations. Research and development, fast and radical innovation, and a well-educated, flexible workforce will certainly be among the necessary ingredients of success. Among others, together with easing the immediate pain, the countries of the Visegrad 4 (V4) group must rethink and redesign their approach to scientific research and higher education, and their position in the 'talent war'.

The present Visegrad Four informal group of countries was formed by Czechoslovakia, Hungary and Poland in 1991, after the summit of the three countries' leaders in the historic town of Visegrad on the Danube. The Czech Republic and Slovakia became separate and independent countries after the dissolution of Czechoslovakia in 1993. Therefore, the group is known as the Visegrad Four. Its original purpose was to improve, extend and promote economic, cultural and political cooperation and act as a lobby group, while moving ahead with their integration in the European Union. It is also worth noting that large parts of these countries had been parts of the Habsburg Monarchy before the end of World War I, and each became a satellite state of the Soviet Union after WW II.[5] In the early nineties, they all embraced market economy and a democratic political system almost simultaneously. All the four countries are members of NATO and joined the European Union together in 2004.

Basic economic data for the V4 counties is summarized in *Table 1* vis-a-vis three more developed EU member states, namely Austria, Finland and the Netherlands. Given the subject of this study, there would be little point in comparing the V4 countries to large EU members like Germany or France. Austria is a direct neighbour of the V4 group and, as the former centre of the Habsburg Empire, historically is closely connected to all V4 countries. Finland is frequently referred to as a European education and innovation 'over-achiever', while the Netherlands is arguably a European leader in science and education.

Although the GDP per capita in the V4 countries is still well below that of the EU27 average and the three reference countries, it is conspicuous that they are steadily converging to the EU average *(see Fig. 1).*[6] This is not surprising and reflects the well-known conditional convergence story. Well-integrated low-income countries tend to grow faster than their more developed peers just by importing capital and know-how from abroad. However, as we argue later in the paper, this FDI-led catching-up strategy clearly has its limits. Switching to a more

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[5] Hungary's prominent historian, Jenő Szűcs describes the Visegrad 4 countries as a special European region stuck between the two worlds of the East and the West (Szűcs 1983). Nölke and Vliegenthart (2009) conceptualize the economies of East and Central Europe as 'Dependent Market Economies' where the hierarchy between the headquarters of transnational corporations and their local subsidiaries replaces markets.

[6] The first draft of his paper was written before the Covid-19 crisis. Therefore, its wide-ranging implications could not be taken into account. We strongly believe, however, that the sad events have unfortunately strengthened its main argument.

knowledge-based growth strategy seems to be unavoidable in order to avoid the so-called ‘middle income trap’.

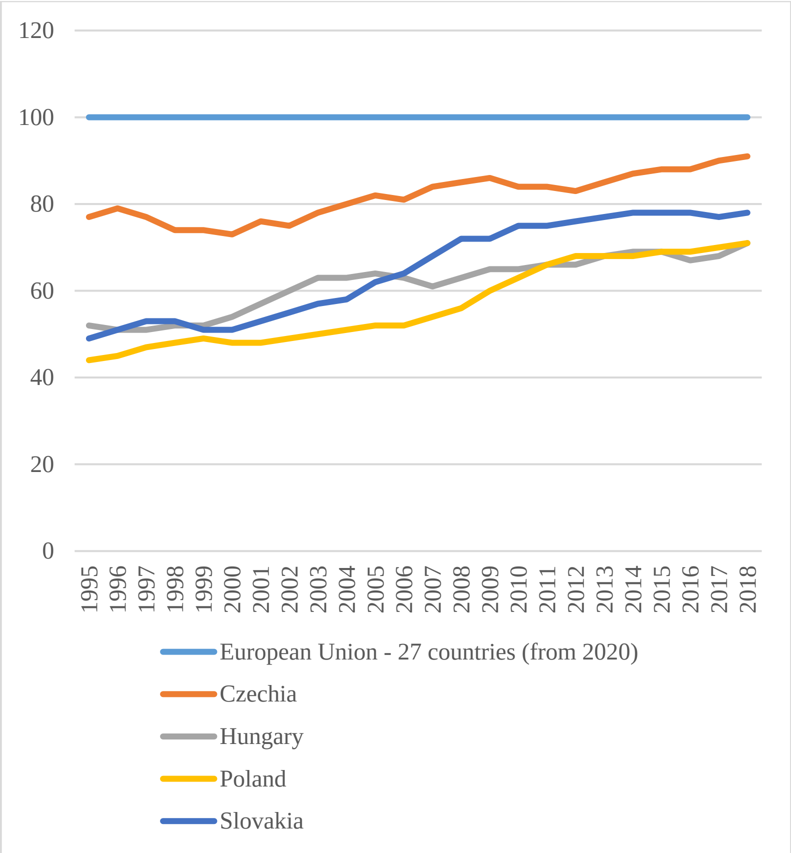
Table 1. Basic economic indicators of the V4 and reference countries

Country	**(1)** **Population** **(2018, million)**	**(2)** **GDP per capita in PPS** **(2018, EU27=100)**	**(3)** **GDP growth rate (2017/18, %)**	**(4)** **Labour productivity** **(2017, GDP per hour worked, EU28=100)**	**(5)** **Domestic value added in gross exports** **(2016, %)**
Czech Republic	10.6	91	2.8	74.6	62.3
Hungary	9.8	71	5.1	63.3	55.9
Poland	38.0	71	5.1	60.3	73.1
Slovakia	5.4	78	4.0	72.1	55.5
Austria	8.8	128	2.4	118.1	73.4
Finland	5.5	111	1.7	111.2	74.1
Netherlands	17.2	130	2.6	126.1	73.0

(1) https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_pjan&lang=en ; (2) https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00114&plugin=1 ; (3) https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00115&plugin=1 ; (4) https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tesem160&language=en ; (5) https://data.oecd.org/trade/domestic-value-added-in-gross-exports.htm

Data downloaded: Jan 30, 2020

Fig 1. GDP per capita in PPP (EU27 = 100)



https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00114&plugin=1. Data downloaded: Feb 10, 2020.

The Czech Republic is the most advanced member of the V4 group with its GDP per capita around 91% of the EU27 average in 2018, followed by Slovakia with 78%, and Hungary and Poland with 71%, respectively. Besides the conditional convergence story, the remarkable catching-up process has been supported by some important external forces like the benevolent economic environment unfolding in the second decade of this century, the steady growth of the most important trading partners and foreign investors, large EU transfers and subsidies, and remittances by V4 citizens working in more developed EU countries.[7]

Economic catching-up is a complex phenomenon. There have been a few success stories, e.g., that of Ireland at the end of the last century, where private sector jobs increased at a high rate, and annual GDP growth figures were close to 10% in the late '90s. Extensive growth was combined with structural changes: the focus shifted from agriculture to services and knowledge intensive high-tech industries. Although hard hit by the financial crisis in 2008, in terms of GDP per capita, the Republic of Ireland ranks as one of the wealthiest countries of the world now, well above (188%) the EU27 average. However, this position is not guaranteed. One of the victims of the financial crisis was higher education: the sector has suffered from a decade of underinvestment. Consequently, Ireland's best universities have been sliding in international

[7] The Economist (2019).

rankings. They are now trying to reverse that cycle, having realized that education is a cornerstone of both economic and social development and it may play an even greater role in the highly competitive global environment of the present and the future. The Irish government has declared that education must be a strategic priority.

The gap between the V4 group and the more advanced EU countries may certainly continue to be closing only with sustained higher growth rates. The average economic growth rate in the EU28 was 2.0% in 2018, while Hungary and Poland boasted 5.1% (see *Table 1).* The current strategic question from this point of view is how to avoid the 'middle income trap', i.e., the situation when up to a certain point the development of an emerging economy is fast, but is stuck at that level, unable to keep up with more developed countries in high value-added markets. All V4 countries started from a low base, and after their transition to market economy became low-cost outsourcing destinations for more developed countries. Early fast growth is usually based on adapted technologies, copying and FDI-led technology transfer. It is resource driven, dependent on cheap labour; competitive advantage is dwindling away when wages start to grow. The challenge is to move to growth, based on high productivity, high added value, cutting edge technology and innovation. This transition requires heavy investment in *scientific research* and *education*, and building structures encouraging creativity and innovation. In this paper, we intend to put forward some proposals to promote this transition.

Is the 'middle income trap' a real danger for the V4 countries? All are facing labour shortages, indicating the limits of extensive growth. While *labour productivity* has been well above the EU28 average in Austria, Finland and the Netherlands (see *Table 1*), the V4 economies are left behind. The gap is not uniform: the Czech Republic is the closest to the EU28 average, while Hungary and Poland are faring the worst. Domestic *value added* in gross exports is lowest in Hungary and Slovakia *(Table 1).* Together with Poland, all three countries are trailing behind on the *European Innovation Scoreboard* published by the European Commission in 2019,[8] while the Czech Republic is the closest to the scoreboard's Strong Innovators group.

Empirical evidence suggests that investment in R&D and the quality of higher education have a strong positive effect on GDP growth.[9] Through productivity, innovation can substantially raise living standards. The development of innovative high-tech products with high knowledge-based added value needs successful scientific research, and only a highly educated workforce can develop, use and maintain modern productive technologies. Weaknesses in scientific research and higher education certainly play an important role in the weakness of the V4 countries in productivity, added value and innovation.

R&D Intensity and Spending on Tertiary Education

The OECD's *Main Science and Technology Indicators*[10] show that R&D intensity (expenditure on R&D as a percentage of GDP) in the OECD area rose from 2.34% in 2016 to 2.37% in 2017 *(see Table 2).* This slight improvement was largely driven by growth in the United States, Japan, Germany and Korea, while the indicator was declining in Canada and several European countries, including France, Italy and the United Kingdom. South Korea and Israel had the

[8] https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en
[9] See, e.g., Guillemette and Turner (2018).
[10] https://www.oecd.org/sti/msti.htm

highest R&D intensity in 2017, at around 4.5% of their GDP. In the OECD, business enterprises accounted for more than 70% of all R&D expenditure in 2017. Business R&D is now 28% higher than ten years earlier, while the higher education and government sectors are 23% and 8% higher, respectively. The importance of tax-based support measures (corporate tax allowance in return for research funding) has been increasing in recent years, exceeding direct government support. The EU's declared R&D target of 3% of the GDP is still some distance away, while the group's indicator stagnated at around 2% between 2014 and 2017. In comparison, China's R&D expenditure was only 0.89% of the GDP in 2000, but reached 2.15% in 2017, a ratio higher than the EU28 average of 1.97%. Considering the size of its GDP as well, the Asian giant became a top research and innovation player continuously climbing in all rankings.

Table 2. Gross domestic expenditure on research and development (GERD) as a percentage of GDP

Country / region	2011	2012	2013	2014	2015	2016	2017
United States	2.77	2.68	2.71	2.72	2.72	2.76	2.79
EU28	1.87	1.91	1.92	1.94	1.96	1.94	1.97
China	1.78	1.91	2.00	2.03	2.07	2.12	2.15
Israel	4.01	4.16	4.09	4.18	4.26	4.39	4.54
Korea	3.74	4.03	4.15	4.29	4.22	4.23	4.55
Germany	2.80	2.87	2.82	2.87	2.91	2.92	3.04
OECD total	2.31	2.31	2.33	2.35	2.34	2.34	2.37

https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB. Data downloaded: Feb 17, 2020

Compared with Austria, Finland and the Netherlands, gross domestic expenditure on R&D is rather low in all V4 countries (see *Table 3)*. As far as R&D intensity is concerned, each V4 country is below the OECD and EU averages. It is highest in the Czech Republic (1.80% in 2017), and lowest in Slovakia (0.88%). In real terms, the Czech Republic spends more than twice as much on R&D as Poland, a country with a four times larger population. Poland has more researchers than the Netherlands, but its R&D expenditure was only 16% of the latter.

As far as the higher education sector is concerned, it can be safely concluded that public expenditure on tertiary education in the V4 countries *(Table 3)* is highly inadequate.

Table 3. Main science and higher education indicators

Country	(1) R&D expenditure (GERD) (2018, Euro/capita)	(2) Gross domestic spending on R&D (2017, % of GDP)	(3) Total number of researchers (2018, FTE)	(4) Public expenditure on tertiary education (2016, % of GDP)	(5) Number of doctoral students (2017, thousands)
Czech Republic	377.6	1.80	41198	0.70	23.5
Hungary	209.8	1.35	31430	0.76	7.4
Poland	158.5	1.03	117789	1.06	43.2
Slovakia	138.0	0.88	16337	1.39	7.4
Austria	1388.1	3.16	50975	1.79	22.9
Finland	1167.7	2.76	37891	1.83	18.9
Netherlands	974.8	1.99	95611	1.75	15.1

(1) https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdtot&lang=en ;

(2) https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm#indicator-chart ;

(3) https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsc00004&plugin=1 ;

(4) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tertiary_education_statistics#Finance

(5) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Number_of_tertiary_education_students_by_sex_and_level_of_education,_2017_(thousands)_ET19.png

There is no break-through in research, innovation and technology without first-class education, primarily in higher education. Without it, masses of talented youths will leave the country to look for better education. The earlier they leave the less likely they are to return to their countries of origin, making any economic leapfrog almost impossible. The European Union has created a unique setup in economic history, making migration, including student migration, so easy within the EU that it has a considerable negative impact on the economic outlook of many countries that are on the EU periphery. This is one of the reasons why higher education is of paramount importance in the future development of the V4 economies. Talents can only be kept home if a country is offering them outstanding education followed by exciting and rewarding job opportunities.

The migration of students and scientists is a complex, multi-faceted and highly debated phenomenon.[11] Unfortunately, statistical data are vague and sometimes misleading because there is no consistent tracking, using the same methodology across countries, in addition to which record keeping of immigrants and emigrants varies from country to country.[12] When tracking human flows, many countries put scientists into the basket of 'highly educated migrants'. Even within the EU we do not have completely reliable data on student and scientist migration. Anyway, available data of tertiary student migration (see *Tables 4 and 5*) show a steady growth in numbers. It is certain that the V4 countries are losing a very large pool of talented young people if graduates studying abroad do not return home.

Table 4. Total outbound internationally mobile tertiary students studying abroad

Country	2013	2014	2015	2016	2017
Czech Republic	12592	12373	12526	12542	13159
Hungary	8842	9566	10643	11632	12275
Poland	23287	23821	23866	24231	24918
Slovakia	33206	32057	31514	31963	32404
Austria	15781	16476	17313	18072	19170
Finland	8295	8839	9339	10185	10899
Netherlands	13648	14831	15217	17028	18438

http://data.uis.unesco.org/Index.aspx?queryid=172. Data downloaded: Feb 19, 2020

Table 5. Total inbound internationally mobile tertiary students

Country	2013	2014	2015	2016	2017
Czech Republic	40138	41149	41715	42812	44261
Hungary	20694	23208	21707	26155	28628
Poland	27767	34664	43988	54734	63925
Slovakia	10183	11107	10876	10072	10764
Austria	70852	65164	67691	70483	73964
Finland	21859	22757	23142	23197	24168
Netherlands	68943	70692	86189	89920	96289

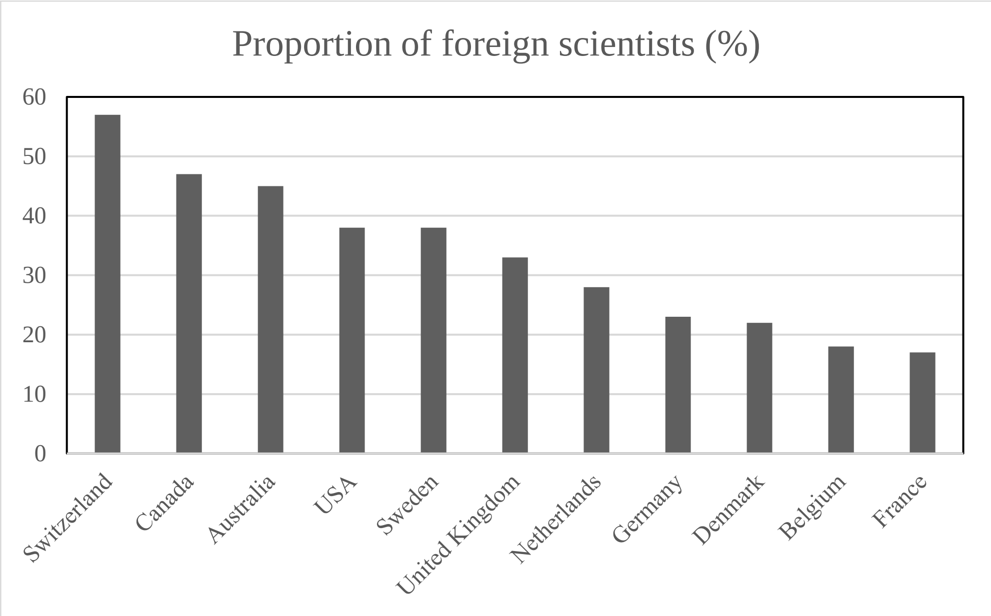
http://data.uis.unesco.org/Index.aspx?queryid=172. Data downloaded: Feb 19, 2020

Scientists'' regular geographic relocation is a world-wide social and political problem. In some countries, governments try to legally control the emigration of scientists but that kind of legislation clashes with scientific and personal freedom. One thing is obvious: scientific talent likes 'smart' places (countries, towns, and organizations) where money, facilities and the company of other prominent scientists are available. The *GlobSci* survey conducted in 2012

[11] See, e.g., Florida (2005).
[12] The study of student and scientist migration would by itself merit a separate Horizon Europe call.

found big geographic disparities: a few well-developed countries had very high proportions of foreign scientists *(Fig 2).*[13] Research on scientific citations confirms that the geography of scientific publications is highly concentrated (or 'spiky'): the vast majority of the world's most influential scientists in fact reside in a small number of U.S. and European cities, while some new 'spikes' are starting to emerge in Asia.

Figure 2. Countries with the highest proportions of foreign scientists according to the 2012 GlobSci survey



Source: Noorden R.: Science on the Move. Nature, Vol 490, 18 October 2012, p. 327

V4 Universities in Global University Rankings

Unfortunately, quality higher education is struggling in all V4 countries, a problem highlighted by the global university rankings. But why are university rankings so important?

Although in many countries, including some developed ones, the 18-25 year-old population is expected to shrink in the forthcoming decades, the demand for quality higher education is growing. The return on higher education is especially high in poorer countries. While demand is growing, supply has become global. University rankings are a typical phenomenon of globalization. Although international university rankings have their methodological problems,[14] they matter because of their strong signalling value. As such, they have a significant impact on students' orientation and on their subsequent job market perspectives. In addition, they also signal the competitiveness and development of a country or region. Knowledge-producing and talent-catching capabilities are vital indicators of a country's ability

[13] GlobSci data is presented and discussed in Franzoni et al. (2012).
[14] See, e.g., Hazelkorn (2015); Stack (2016).

to successfully participate in the global economic competition, technological progress and innovation.

Countries and institutions are eager to climb higher on the lists. Governments want top-class universities. As leading high-tech companies know that a modern economy is driven by knowledge, they set up shop where these are available. Also, an internationally competitive educational sector may make a significant contribution to the GDP and high added value export income. Governments and educational decision makers use various strategies for moving upwards in the rankings.[15] Some, especially the wealthy ones, try to build universities from scratch or persuade top institutions to set up campuses on their soil. Others work with their legacy institutions and try to boost their quality. Since top universities need excellent faculty, competition for the best professors and researchers has increased, together with the fight for the most talented students.

The two most frequently cited rankings these days are the *Shanghai Jiao Tong Academic Ranking of World Universities (ARWU),* which mostly focuses on research, while the *Times Higher Education World University Rankings (THE)* also looks at other factors such as reputation or staff-to-student ratio. It is striking that while Austria, Finland and the Netherlands have altogether 11 institutions in the Top200 of ARWU, the V4 countries have none (see *Table 6*). There are three V4 universities in the Top500, while Austria, Finland and the Netherlands boast 21. The Czech Republic and Poland are represented in that group with one and two institutions respectively, while the first Hungarian and Slovak universities appear only within the 501-1000 range.

Table 6. Number of universities in the top leagues of the ARWU ranking

Country	Top20	Top 100	Top200	Top300	Top400	Top500	501-1000
Czech Republic				1	1	1	6
Hungary							5
Poland					1	2	10
Slovakia							2
Austria			1	3	4	6	5
Finland		1	1	1	3	4	5
Netherlands		4	9	10	11	11	2

http://www.shanghairanking.com/arwu2019.html. Data downloaded: January 20, 2020

The Times (THE) ranking does not change the picture significantly. Austria has one and Finland two in the Top200 group, and have 6 and 5 respectively in the Top400. The Netherlands is a star performer of THE with 13 institutions in Top250. The V4 countries appear in the 401-500 range first (see *Table 7*), where the Czech Republic and Hungary are

[15] See, e.g., the recommendations in Salmi (2009). According to this much referenced study, a top university needs the following: (a) a high concentration of talent (faculty and students), (b) abundant resources to offer a rich learning environment and to conduct advanced research, and (c) favourable governance structures that encourage strategic vision, innovation, and flexibility (pp. 19-20).

represented by one of their universities, while all the other V4 institutions are beyond the 600 mark.

Table 7. Number of V4 universities in the THE ranking

Country	401-500	601-800	801-1000
Czech Republic	1	2	2
Hungary	1	1	3
Poland	0	2	2
Slovakia	0	0	0

https://www.timeshighereducation.com/opinion/world-university-rankings-2020-work-many-hands . Data downloaded: January 20, 2020

Research Performance

Research performance is a key factor in global university rankings. Cutting edge scientific research attracts prominent professors, talented students, more research grants, and improves the institution's image. Research generates new knowledge, supports the development of new products and technologies and, through education and innovation, may lead to enormous returns in the whole economy.

Measuring scientific output is not an easy task, especially in the short term, but is essential for evaluating institutions, laboratories, research teams and individual scientists.[16] Measuring and analysing scientific literature has become a special field of study with a sophisticated methodology using special statistical and computational tools. Although indicators and measurement techniques are widely debated by the scientific community and other stakeholders, it is obvious that the number and quality of publications is of high importance and the main statistical indicator are often based on the number of citations.[17]

Similarly to university rankings, publication rankings are also publicly available. One of the most respected ones is the public portal of the *SCImago Journal & Country Rank,*[18] based on Elsevier's Scopus® database. Citation data are drawn from over *34,000 titles,* and performance metrics are available for *239 countries* worldwide.

The key *Scimago* indicators of the V4 and the three reference countries are presented in *Table 8*. The number of citable documents purely represents quantity, while the number of citations and especially the citations-per-document ratio reflects quality more. The Hirsch index[19] in the last column is a combined indicator that measures both productivity and citation impact. Country differences in quantity data (number of documents and citations) can be compared

[16] Abbot (2010) discusses how scientific output metrics are used for different purposes at scientific institutions.
[17] On the evolution of metrics, see, e.g., Garfield (2007).
[18] https://www.scimagojr.com/
[19] The *Hirsch index* is defined as the maximum value of *h* such that the given author/journal has published *h* papers that have each been cited at least *h* times. Similarly, the Hirsch index of a country can be calculated. See Hirsch (2005).

with population size *(Table 1)* and data on the number of scientists and PhD students *(Table 3).*

Regarding the citations-per-document indicator and the Hirsch index, the Netherlands is the top performer, while all V4 countries are behind Austria and Finland as well.[20]

Table 8. Scimago indicators of scientific output

Country	Citable documents	Citations	Self-citations	Citations per document	Hirsch index
Czech Republic	313365	3681392	798131	11.28	427
Hungary	181716	2952020	438879	15.33	419
Poland	627632	6683506	1685997	10.2	519
Slovakia	107531	1084641	205831	9.74	263
Austria	353818	7959145	994419	20.57	620
Finland	311398	7553739	1078823	22.56	609
Netherlands	872993	25586850	3854314	26.46	957

https://www.scimagojr.com/countryrank.php. Data downloaded on November 13, 2019.

Besides publication data, scientific performance can also be evaluated by access to competitive research funding: high performance brings more research grants and vice versa. Based on scientific excellence, the *European Research Council* (ERC) provides internationally competitive funding for pioneering frontier research across all scientific fields in the European Union, but application may come also from outside the union. The ERC was established by the European Commission and has a total budget of over 13 billion Euros under the Horizon 2020 program and offers grants in five different categories. Applications are evaluated by qualified experts, whose sole criterion for selection is scientific excellence. The process is highly competitive and selective.

The ERC regularly publishes grant data on its website.[21] *Table 9* shows that Austria, Finland and especially the Netherlands have managed to obtain far more ERC grants than the V4 countries, but there are obvious differences within the V4 group as well: while Hungary has 71 grants Slovakia has only two, and considering its size, Poland's performance is pathetic. Also, Hungary's success rate is higher than that of Finland, which is somewhat surprising. It is also worth noting that the successful ERC grants in the V4 countries are concentrated in a handful institutions and laboratories. For example, in Hungary by the end of 2019 more than 60% of the grants were awarded to only four institutions. We can observe a similar pattern in the other V4 countries as well.

[20] Jurajda et al. (2017) analyse the publication performance of six post-communist EU member states using Web of Science (Wos) data. The authors conclude that, as of 2010–2014, these countries were still lagging far behind more developed ones of comparable size, with the exception of a few narrow subject areas.
[21] https://erc.europa.eu/

As we evaluate scientific performance, we should recall the trend that the number and size of business-funded research projects is growing in many countries, including the V4 ones.[22] However, business-funded projects are less visible because business is more interested in innovation than publication. The growth of business funding is impressive in Hungary, Poland and Austria, but Finland's trend is declining (perhaps due to the 'Nokia effect', see *Table 10*).

Table 9. Number of ERC funded projects by category and success rate

Country	Starting	Consolidator	Advanced	Proof of Concept	Synergy	Total	Success rate (2007-2019, %)
Czech Republic	18	13	8	0	0	39	6
Hungary	29	15	21	4	2	71	9
Poland	24	5	4	2	0	35	3
Slovakia	1	0	0	1	0	2	1
Austria	140	51	74	21	3	289	16
Finland	78	42	45	26	2	193	7
Netherlands	437	188	229	123	6	983	16

https://erc.europa.eu/projects-figures/erc-funded-projects. Data downloaded on Jan 31, 2020; success rates are calculated for 2007-2019.

Table 10. Business-financed GERD as a percentage of GDP

Country	2011	2012	2013	2014	2015	2016	2017
Czech Republic	0.59	0.65	0.71	0.71	0.67	0.66	0.70
Hungary	0.56	0.59	0.65	0.65	0.68	0.68	0.71
Poland	0.21	0.28	0.32	0.37	0.39	0.51	..
Slovakia	0.22	0.30	0.33	0.28	0.29	0.36	0.43
Austria	1.23	1.33	1.44	1.47	1.52	1.66	1.70
Finland	2.44	2.16	2.00	1.70	1.58	1.56	1.60
Netherlands	0.96	0.99	0.99	1.01	0.97	1.04	..

https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB. Data downloaded on Feb 21, 2020

Policy Implications and Recommendations

As shown in this paper, despite relatively successful convergence in the past 30 years, the bulk of economic improvement has mostly been driven by external, FDI-led technology transfer from more developed EU countries. Time is ripe for a completely new growth model in Central and Eastern Europe, based on domestic research and innovation. To put it differently, the V4

[22] https://www.oecd.org/sti/msti.htm

countries should move from simply copying existing technologies towards creating new ones. The bad news is that preconditions for such a change are almost non-existent. The tertiary education sector is in disarray and investment in R&D is low compared to international best practices.

There is a real danger for the V4 countries to be stuck in the 'middle-income trap'. We emphasize that this should not only be viewed through the lens of lost output or welfare loss. Lack of further catch-up with the West may have serious political and social implications. It may strengthen the anti-EU populist forces, alienate these countries as they may start feeling second class citizens inside a successful European club. It is therefore of paramount importance for 'club members' to promote the transition of the V4 (and other peripheral) countries to a developed, and high added value economic path.

Based on the evidence presented above, it seems inevitable that more financial resources should be injected into higher education, research and development. This is true not only for Central European countries, but for the EU in general. The V4 countries should support every initiative which changes the structure of the European budget in favour of more investment in technology and innovation. Until now the focus of the V4 countries has been mainly on agriculture spending and infrastructure investments (brick and mortar); or put it differently, building the economy of the 20th century. With the help of better targeted EU funds and beefed up national initiatives, the goal to reach at least the EU average in R&D and higher education spending seems attainable.

However, throwing more money at the problem is unlikely to solve it. Substantial *differentiation* based on transparent and outcome-based incentive schemes is also inevitable. The starting point is obvious. There are already a few centres of excellence in the V4 group which produce high quality internationally recognized research. Publication and ERC grant data show that e.g., the Institute of Experimental Medicine of Hungary is a frontrunner in brain research, and the country has a high potential in developing and commercializing high-tech tools for medical diagnostics and imaging. The Institute of Organic Chemistry and Biochemistry of the Czech Academy of Sciences is internationally well-known in medicine chemistry, biochemistry and photochemistry. Their most significant contributions are the acyclic nucleotide phosphonate antivirals – anti-HIV and anti-HBV drugs. In Slovakia, the Institute of Chemistry of the Slovak Academy of Sciences – the only successful recipient of ERC grants – is a good example to build on. Poland's Jagellonian University is the sole V4 institution on Reuters' Europe's 'Most Innovative Universities' ranking for 2019 (91st); successful research groups there are developing, among others, a new generation of catalytic converters and a real-time holographic imaging technology for heart surgery.[23]

Besides supporting the bright spots, a completely new *incentive scheme* is needed to raise the effectiveness of public grants in general. First of all, financing should be less institution-based and more project-oriented. Second, international cooperation and public-private research initiatives should receive higher funding. Third, projects with high quality output (based on internationally developed criteria) should qualify for more support. On the other hand, locally relevant projects of dubious quality should receive significantly less public money. Fourth, the quality of proposals should be evaluated with the help of external experts. However, the current practice of cross-evaluation inside a small group of local elites is a hard Gordian knot to cut.

[23] https://graphics.reuters.com/EUROPE-UNIVERSITY-INNOVATION/010091N02HR/index.html

Selecting research based on global recognition does not necessarily mean supporting only *applied research* in technology-related areas. It would be a mistake, in our view, to neglect, for example, *basic research* or *social sciences*. Let us take the example of the internet, the poster child of the recent technological revolution. It was not created by some global private corporate giant, but is a direct outcome of a government financed basic research program. And then why not technology projects only? There are at least two good reasons to consider other areas as well. First, with the development of machine learning and AI, more and more human skills can be automated. It is well known that soft skills are much less prone to robotization and less likely to be substituted by technologies. From an economic success, income distribution or labour market perspective, social or more human-like skills will be assets in the near future. Moreover, policymakers should also consider these broader trends when managing their economies. Second, research areas are not isolated compartments. There are a large number of scientific advances happening at the borderline between two (or more) fields.

Governments should also recognize their role in creating a supportive environment for *innovation*. The private sector has been gradually increasing its R&D expenditures in the recent past, but clearly more is needed to approach the global technology frontier. As we highlighted earlier, scientific talent likes 'smart' places (countries, towns, and organizations) where money, facilities and the community of other prominent scientists are available. Therefore, successful research centres are geographically concentrated in *clusters*. Unfortunately, none of the V4 countries has any innovation cluster in the Top100 centres of inventive activity on the list compiled by the World Intellectual Property Organization (WIPO),[24] while the equally large Finland and Austria each have one, and the Netherlands has three.

Top clusters with leading universities, research institutions, world-class companies, a lively entrepreneurial community, modern infrastructure and attractive living conditions are especially strong magnets for talent. We see an important role for governments to facilitate the creation of such clusters. Here we can think of three avenues to pursue. First, from a national perspective, the strategy should be broad-based, covering most of aspects of scientists' lives. A good salary, the proximity of talented students and researchers, high quality health services, green cities, and a rich cultural life are all important ingredients for a happy life. Second, from a regional perspective, cooperation between the four V4 countries might also be considered. Geographical distances are relatively short, and the group might benefit from economies of scale in research. Third, in the 21st century we should not exclude the possibility of *pan-European virtual clusters*.

An ERC research grant provides a fantastic opportunity for European *researchers* to engage in cutting-edge research and to attract outstanding researchers from around the world. It is a truly outstanding EU instrument. However, on the flip side, it helps to preserve the current status quo. Talent is leaving the peripheral V4 countries towards the scientifically better established centres. To stop or mitigate this outflow, we suggest creating an additional ERC grant category (let us call it 'research incubator grant'), based on some proven research record and on potential research excellence. This would help establish small research labs, centres which can serve as seeds on the periphery, which could then fertilize the research and higher education sector. This concept is close to the highly successful business incubator idea.

[24] See Bergquist et al. (2017). WIPO's analysis is based mainly on international patent data.

Besides efficient national research structures, the V4 countries should promote the international mobility of researchers and the exchange of scientific and technological know-how. The development of the joint European Research Area opens new networking opportunities for establishing a ‘critical mass’ of scientific activities. For example, the Network of European Institutes for Advanced Studies hosts more than 500 researchers every year, but has a partner institution only in one V4 country. The V4 countries should have a clear strategy for networking, which may include a ‘Visegrad IAS’ type initiative with joint centres in different research fields located in different member countries. The present centers of excellence may serve as the building blocks of this network.

Turning to the recommendations for the tertiary education sector, moving from quantity towards quality cannot be overemphasized. Visegrad countries cannot afford to finance universities or faculties disconnected from global standards. There is no point in having colleges in every larger city; it is much more important to have at least one or two high quality *research universities*. Therefore, scoring higher in international university rankings has to be one of the main objectives of every reform. This can be achieved only via a comprehensive reform package covering finances, human resources, teaching and incentive schemes.

Building a globally recognized university is impossible without adequate human resources. Faculties and students should be international. Selection criteria should follow *international good practices*. Professorships should be awarded based on research output rather than obscure formal requirements as is the current practice. Salaries should be competitive enough to attract high quality foreign researchers. Policymakers should understand that the tertiary education market is truly global. In our view, English should be the primary language at most of the universities (maybe with the exception of teaching colleges). At the beginning of the reform process, it makes sense to create joint PhD programs with the participation of foreign professors (like in Finland or Switzerland).

Financing should be based mainly on the quality of research output: journal rankings, citations and participation in international projects. Governments might also consider creating special programs in areas with clear links to the supply side of their economies (for example, the automotive sector in Slovakia). In some cases, regulatory exemptions or fiscal benefits might attract foreign research and innovation? for example, providing a `real’ testing site for autonomous vehicles or drone research, a program Hungary has already embraced.

No country can build a successful university without good students. Currently, *student mobility* in the V4 countries seems to be a one-way street. Therefore, we propose to establish student loan programs, with friendly repayment conditions (somewhat similar to the current UK student loans) to cover reasonable tuition fees and living expenses:

- for students from the EU periphery to study in the EU’s top universities, attached to a `go back’ requirement string,

- for students from the developed EU countries to study in some selected periphery universities and/or degree programs (which satisfy some pre-set conditions),

- for students from non-member states (e.g., developing countries) to study in these selected periphery universities and/or degree programs.

Similarly to student mobility, promote the *mobility of researchers*, helping in building research excellence. A fellowship scheme should be created to incentivize established researchers with a proven track record to move (temporarily, e.g. for sabbatical) from research institutions and universities in the centre to the periphery, and vice-versa.

The move towards a more *knowledge-based society* would benefit also from the broad support of citizens. The change in the growth model should be clearly communicated by politicians and policy makers. The public recognition of teachers and researchers should be raised together with their salaries. Good examples or substantial achievements should be more widely communicated also on official forums.

Lastly, we list four important *policy questions* which beg for further exploration in this area. First, we need to better understand the evolution of research clusters. What factors contribute to the attraction of 'smart' places and what kind of policies can accelerate such a process? Second, the mechanics of creative destruction should also be high on our agenda. How are successful ideas 'flowing' through the economy? What determines the speed and penetration of innovations? How are international innovation chains created? Third, brain drain is the Achilles heel of the V4 countries. Is it really only about wage differentials? What kind of policies can help to keep the brains at home or attract talents from Eastern European countries? And fourth, economists have only limited knowledge about the innovation needs in the private sector. What are the determinants and preconditions for successful public-private cooperation?

It seems fair to say that keeping pace with the 21^{st} century requires profound but doable changes of the V4 (as well as also of other peripheral) countries. These changes are rendered even more pressing and unavoidable by the corona 19 pandemic. Unless quick and assertive action is taken, these economies will be left behind for a very long time, with serious economic, social and political implications.

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