Sistem nauke-faktor poticaja ili ograničavanja razvoja: Science system-a Factor of Stimulation or Limitation in Development

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Financing research and development around the world, in Southeast Europe and in Bosnia and Herzegovina

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Abstract: This paper analyses the financing of research and development, starting from the global and regional contexts and moving on to the specifics of such investment in Bosnia and Herzegovina. The first section presents an analysis of the global context and of the 10 highest-investing countries, as well as a breakdown of the sources of such financing by sector. Based on the most recent data from UNESCO, which were for 2018 at the time of writing, South Korea and Japan invested most in research and development in relative terms, while the US and China did so in absolute terms. The second section contains a comparative analysis of investment in research and development by the countries of Central and Southeast Europe. This group is led by Slovenia, followed by the Czech Republic and Hungary. The third section is dedicated to the case of Bosnia and Herzegovina and certain factors affecting the country's very low level of spending on research and development. The fourth section presents a number of successful examples of investment by Bosnian companies in key branches of industry where the country has achieved above-average results for the Southeast European region, as well as very good export results, as measured by the Economic Complexity and the Product Complexity indices.

Key words: research and development (R&D), financing, world, Southeast Europe, Bosnia and Herzegovina, Economic Complexity Index.

JEL Classification: O30, O39

1. Global context

According to the UNESCO Institute for Statistics' (UIS) data for 2018 (the latest available), total research and development (R&D) spending worldwide, expressed in terms of purchasing power parity of USD ($PPP), was $1.7 trillion. As Table 1 shows, just ten countries accounted between them for GDP of $76.86 trillion ($PPP) or 59.5% of the global total calculated in terms of $PPP, but also for 84% of R&D spending in absolute terms. These were the USA,

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China, Japan, Germany, South Korea, France, India, Great Britain, Brazil and the Russian Federation, providing 1.5 times more of global research and development expenditures than their share in global GDP (in $PPP) would have warranted.

Table 1 – The top ten spenders on R&D in $PPP – 2018

Country	Total R&D expenditures in billions of $PPP	Shares of sectors in R&D expenditures (in %)		
		Business sector	Government	Universities
1. USA	476.5	71.5	11.4	13.1
2. China	372.3	77.3	15.8	6.9
3. Japan	169.6	77.7	8.3	12.6
4. Germany	109.6	67.6	14.6	17.7
5. South Korea	73.1	78.2	11.2	9.0
6. France	60.6	63.7	12.7	22.3
7. India	51.7	37.1	56.5	6.4
8. UK	43.8	65.1	7.3	25.8
9. Brazil	42.2	---	---	---
10. Russian Fed.	40.3	59.6	30.5	9.9

Source: UIS – UNESCO Institute for Statistics, at: http://uis.unesco.org/apps/visualisations/research-and-development-spending/ - accessed on 10/01/2021.

Taking each in turn, we see that the world's leading economic and technological power, the United States, had a share in global R&D spending that was considerably higher than its share in global GDP (28% compared to 15.9%). The same was true of China, the world's second-largest economy (21.9% compared to 16.8%).[1] The differences recorded for Japan and South Korea were even bigger, with shares in R&D spending 2.5 times their corresponding shares in global GDP (Japan: 10%, against 4%; South Korea: 4.3%, against 1.7%). These two countries were also the world leaders in relative investment in research and development (R&D expenditures as a % of GDP).

In South Korea, Japan, China, and the US, most R&D spending came from the business sector (on average close to 75% of all R&D expenditures in these four economies). In India, it was from government (56.5%). The United

[1] In 2018, China was the largest economy in the world in terms of GDP $PPP. To prevent any potential misunderstandings from the shares of world GDP assigned to the US (15.9%) and China (16.8%), please note that these shares are derived from GDP presented in terms of the purchasing power parity of the US dollar. On the other hand, when the countries' GDP are given in current prices and current US dollars for 2018, the US is the largest world economy (with a share of close to 21.2% of global GDP), and China the second largest (with a share of about 14.3% of global GDP).

Kingdom and France were the two countries with the highest university share in R&D spending. The most recent data (2019) indicates that the top ten corporate spenders on R&D were: Samsung (South Korea), Alphabet (USA), Volkswagen (Germany), Microsoft (USA), Huawei (China), Intel (USA), Apple (USA), Roche (Switzerland), Johnson & Johnson (USA), and Daimler (Germany),[2] investing a total of $122.2 billion (in USD from 2019) between them. This is approximately equal to the combined GDP of Slovenia, Bosnia and Herzegovina, and Serbia that year or almost a quarter of the combined GDP of all the low-income countries (the 28 poorest countries in the world).[3]

Table 2 shows the top ten spending countries in relative terms (R&D expenditures as % of GDP). It includes four countries from Table 1 (the largest spenders in absolute terms): South Korea, Japan, Germany, and the United States. The other members of the group are Finland, Switzerland, Sweden, Austria, Denmark, and Belgium. Slovenia is included in Table 2 as number 11, because although it is tied with Belgium for relative R&D spending, it nonetheless has fewer researchers per million inhabitants.

Table 2 - Top eleven spenders on R&D in relative terms – 2018

Country	R&D expenditures in % GDP	Number of researchers per million inhabitants
1. South Korea	4.3	6826
2. Japan	3.4	5328
3. Finland	3.2	7009
4. Switzerland	3.2	4468
5. Sweden	3.1	6875
6. Austria	3.1	4947
7. Denmark	2.9	7310
8. Germany	2.9	4320
9. USA	2.7	4205
10. Belgium	2.4	4528
11. Slovenia	2.4	4147

Source: UIS – UNESCO Institute for Statistics, available at: http://uis.unesco.org/apps/visualisations/research-and-development-spending/ - accessed on 10/01/2021.

World average R&D spending is 1.35% (as a % of GDP). The data in Table 2 show that South Korea is spending three times and the US twice the world average. Denmark leads by number of researchers per million inhabitants, followed by Finland, Sweden, and then South Korea. Slovenia is the leading

[2] Available at https://spendmenot.com/blog/top-rd-spenders/ (accessed on 26/12/2020).
[3] Data from the World Bank database website: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD (accessed on 26/12/2020).

country in transition by GDP per capita and was the first to become a member of the euro area. It is also the leading country in transition for R&D spending.

2. Regional context: Central and Southeast Europe

With R&D spending 1.9 times the world average, Slovenia leads the group of central and southeast European countries. Next is the Czech Republic, with approximately 1.5 times the world average, and then third-ranked Hungary, whose spending is close to the world average. Serbia heads the countries with R&D spending less than half the world average. The data on number of researchers per million inhabitants shows that Slovenia has 14 times more than Bosnia and Herzegovina (BiH) and 4.5 times more than Romania.

Table 3 - Countries of Central and Southeast Europe by R&D spending, in relative terms – 2018

Country	Spending on R&D as % GDP	No. of researchers per million inhabitants
1. Slovenia	2.4	4147
2. Czech R.	2.0	3402
3. Hungary	1.4	2673
4. Slovak R.	0.9	2715
5. Poland	0.9	2064
6. Bulgaria	0.8	1821
7. Croatia	0.8	1437
8. Serbia	0.7	1830
9. Romania	0.6	903
10. North Macedonia	0.5	837
11. Montenegro	0.4	671
12. Bosnia and Herzegovina	0.3	292
13. Albania	0.2	155

Source: UIS – UNESCO Institute for Statistics, available at: http://uis.unesco.org/apps/visualisations/research-and-development-spending/ - accessed 10/01/2021.

Ranking the central European and former Yugoslav countries by total R&D spending in $PPP puts Poland, the most populous country, in the lead (see Table 4). In 2018, its total spending on R&D was six times that of Slovenia. But Poland's population is 19 times Slovenia's, so the balance shifts back considerably in Slovenia's favour once we look at spending on a per capita basis, with Slovenia spending 3.1 times more per capita than Poland (753 compared to 241 $PPP). As already mentioned, the southeast European countries investing less than half of the world average are headed by Serbia (see Table 3). In

2018, Serbia's R&D per capita spending was 108 $PPP. This was 35% less than Croatia, but 48% more than Romania. It was still 3.1 and 3.2 times what BiH or Montenegro invested, respectively (on a per capita basis).

Table 4 – Total spending on R&D in Central European and former Yugoslav countries in $PPP – 2018.

Country	Total R&D spending in millions $PPP	Sectoral share in total spending (in %)		
		Business sector	Government	Universities
1. Poland	9,149	46.6	23.9	29.2
2. Czech R.	6,699	55.2	19.0	25.4
3. Hungary	3,408	71.5	13.7	13.5
4. Slovenia	1,506	77.4	12.2	10.4
5. Slovak R.	1,380	36.8	28.3	34.4
6. Serbia	756	29.6	24.5	45.9
7. Croatia	732	48.2	26.1	25.7
8. N. Macedonia	143	10.5	15.4	73.4
9. BiH	102	19.6	19.0	60.4
10. Montenegro	35	38.3	21.3	37.5

Source: UIS – UNESCO Institute for Statistics, available at: http://uis.unesco.org/apps/visualisations/research-and-development-spending/ - accessed on 10/01/2021.

Comparative spending on R&D in Central and Southeast Europe must be considered in the context of gross and per capita public debt and total and per capita GDP, with reference to the countries' respective starting positions on entering transition, given the impact all these variables have had, and continue to have on their overall capacity to finance, including to finance R&D funding opportunities. Slovenia was the only country of the former Yugoslavia to be fully spared direct involvement in the conflicts associated with the country's disintegration. It suffered no war damage and no break in production during the last decade of the last century. By contrast, BiH saw losses in human capital that, just in terms of the number of persons killed, were four times higher than the combined losses of all the other successor states.[4] What is more, the GDP BiH lost because of impeded production between 1992 and 1995 was equivalent to three times the country's total output in 1990, when its GDP was approximately DEM17 billion or $10.7 billion.[5] BiH's lost GDP during the 1992-1995 war for independence was thus $32 billion in 1990 US

[4] Available at https://hr.wikipedia.org/wiki/Raspad_SFRJ

[5] According to the Federal Bureau of Statistics of SFRY Yearbook for 1992. The data on GDP for 1990 in USD and DEM calculated according to the official and stable exchange rate of the Yugoslav dinar against the German mark (1DEM=7YUD).

dollars. The war left BiH with approximately 270,000 civilians and veterans with disabilities,[6] which has given rise to 25 years of total annual fiscal spending on them (from both entity budgets, i.e., the Federation of BiH and the Republika Srpska) of some 4.3% of GDP. This is approximately four times the corresponding fiscal burden to Croatia, the second most affected country by the break-up of the SFRY. In fact, no other country in transition has been burdened with anything like this type of expenditure, which has naturally improved their baseline for structuring budget expenditures, including for funding R&D activities.

Figure 1 – Comparative levels of per capita GDP and public debt for Central and Southeast European countries and Bosnia and Herzegovina (BiH=1.0; the left bar represents a country's level of GDP per capita, the right bar its level of public debt per capita)

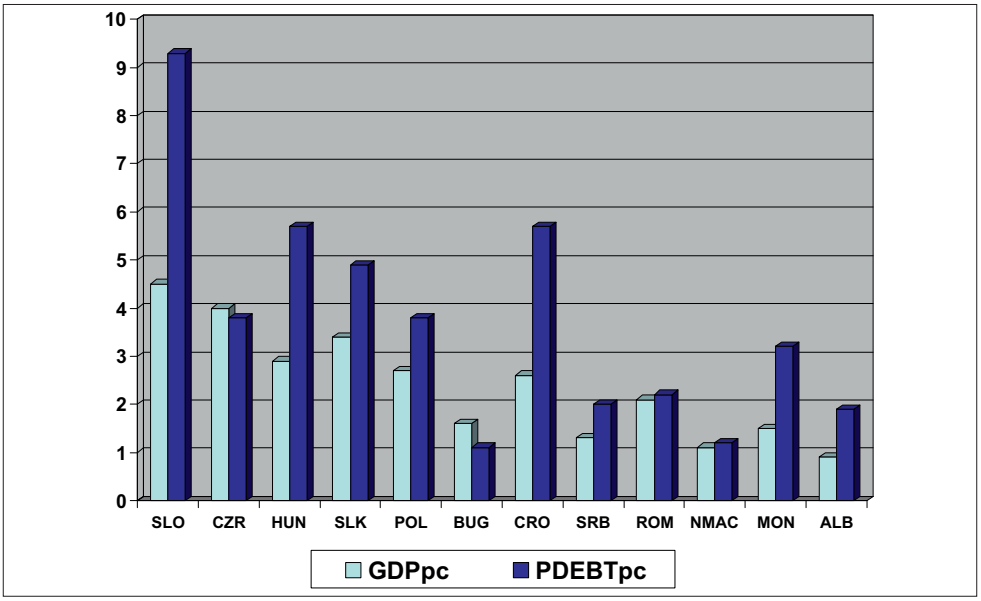

Figure 1 presents differences (for 2018) between central and southeast European countries and BiH in per capita GDP and per capita public debt. The only two countries with lower levels of public debt than BiH were the Czech Republic and Bulgaria. All the others have significantly higher levels of per

[6] Source: Žarko Papić (2008) "Socijalna inkluzija i filozofija razvoja," in Ž Papić and F. Čaušević, (eds) *Ekonomija ubrzanog razvoja*, Forum Bosnae 43/08, International Forum Bosnia, Sarajevo, pp. 256-283.

capita public debt, especially Croatia, Slovenia, Montenegro, and Albania, with levels compared to BiH that were 2.1 times the differences in per capita GDP.

3. Financing research and development in Bosnia and Herzegovina

How R&D in BiH has been financed since its independence has been directly determined by the administrative structure and, more particularly, the structure of fiscal federalism, set out in, or derived from the Dayton and Paris peace agreements (November/December 1995, respectively). The signing of the Paris Treaty (14 December 1995) was followed by confirmation of BiH's formal membership in the International Monetary Fund (on 14 December 1992), allowing the country to become a member of the World Bank Group (on 23 March 1996 the country's formal membership obtained on 23 February 1993 was confirmed). Eight days after accession to the World Bank Group, the BiH Priority Reconstruction Program began. It lasted four years. During 1996, the structure of fiscal federalism and, based on it, the powers and responsibilities of different levels of government to finance all three levels of education, science, research, and culture, were defined, as an integral part of the administrative restructuring package for BiH.

One consequence of the two entities having different administrative structures has been the different distribution of responsibilities for financing education and R&D. In the FBiH, for 25 years, funding for education and science has come largely from cantonal budgets (there are ten cantons in the FBiH). The cantonal budgets have therefore been responsible for financing all three levels of education, as well as for a certain proportion of R&D projects. The entity-level of government (the Budget of the FBiH) has also played a role in financing R&D, but not for financing any level of education in the FBiH. By contrast, in the RS, key responsibility for financing education and research lies with the entity government (the RS Budget) in cooperation with municipal/city authorities. In the "third part" of BiH, Brčko District, where approximately 3% of the population of the country lives, the District Budget is responsible for financing both.

According to the Federal Statistics Bureau (FBS), an average of 37 R&D projects were implemented each year between 2016 and 2018 at universities in the FBiH (i.e., not including the RS).[7] Of that number, most (20) were

[7] Academy of Sciences and Arts of Bosnia and Herzegovina, "Harmonizacija sistema nauke u Bosni i Hercegovini" –Federal Statistics Bureau, "Rezultati statističkog istraživanja,"

funded at a level of less than BAM 100,000. The state or BiH-level of government financed four R&D projects on average, while the cantonal level also funded four up to that value, while two more were on average financed by domestic or foreign non-governmental organizations and foundations. Of the R&D projects attracting funding of BAM 100,000 to 300,000, three were financed by the FBiH Budget and international organizations. There were on average two R&D projects each year with funding of between BAM 300,000 and 500,000 during the period, one funded from the FBiH Budget, the other by international organizations. There are a further three projects with funding of more than BAM 500,000 during these three years, one of them financed by the entity budget, one by the Sarajevo Canton budget, and one from international funds. Of the total of 37 projects in any given year, 31 were implemented at public universities, with six at private universities.

Thirty-nine research institutes were contacted for the FBS Survey. 18 responded. 134 of their 410 employees are researchers, implementing a total of 209 projects (approximately 70 per year), between 2016 and 2018. The largest block of those 209 projects, 103, involved providing consulting services/projects. Their R&D projects most relevant to developing BiH's export competitiveness and import substitution related to applied research and improving existing technology in the business sector. There were 52 such projects at the surveyed institutes, but the survey does not state the amounts spent on them.

The low value of R&D spending in BiH is clearly reflected in a document prepared for the RS Government by the RS Ministry for Scientific and Technological Development, Higher Education, and the Information Society, entitled *A Roadmap of Research Infrastructure in Republika Srpska (Bosnia and Herzegovina)*.[8] It contains data on investment in equipment, according to which, a total of BAM 1,212,600 in funds for equipment was transferred from the RS Budget to 16 research institutions (institutes or university or faculty departments or research units in the RS) between 2010 and 2018. The average annual amount invested in research infrastructure (equipment) at all 16 institutions during that period was therefore BAM 134,733, which is BAM 8,420 per year per institution.[9]

Sarajevo, 2020, p. 19.

[8] Document available at: https://www.vladars.net/sr-SP-Cyrl/Vlada/Ministarstva/mnk/Documents/RIRS-RoadMap-SR.PDF

[9] Source: Ibid, p. 13. The data for the entire period (2010-2018) and yearly data are calculated using data from Table 1, p. 13 of the original document.

In September 2016, the BiH Council of Ministers prepared a strategic document on science development in BiH.[10] In the section that deals with financing R&D and covers 2017 to 2020, the plan was to increase investment for these purposes from BAM 101.2 to 189.6 million, followed by a further hike to BAM 268.2 million by 2022, with the entities contributing more or less in line with their share in overall GDP creation, 66.1% and 32.9% respectively, with the remaining 1% to come from Brčko District. For this to happen, spending on R&D would have to increase from BAM 66.9 to 177.4 million in the FBiH and from BAM 33.3 to 88.1 million in the RS between 2017 and 2022. Expressed as a percentage of national GDP, the planned increase in R&D expenditures was to have been from 0.35% (2017) to 0.80% (2022).[11] Effective spending on R&D in 2018 was lower than planned, with total spending in 2018, according to the UIS-UNESCO data presented above, just 0.3% of GDP. Planned expenditures in the entity budgets prepared at the end of 2020 for 2021 make it clear that total spending on R&D in BiH will not reach even 0.5% of GDP in 2021 or 2022, never mind the 0.75% planned.

How major scientific institutions of national importance have been financed is a remarkable paradox in R&D financing in post-war BiH. This paradox is a direct consequence of political fragmentation and unwillingness or, more correctly, obstruction on the part of the government (or part of the government) at entity and state levels to agree on financing national-level scientific and cultural institutions. There is no better example than how the Academy of Sciences and Arts of Bosnia and Herzegovina (ANUBIH) has itself been funded over the past 25 years. Namely, its survival is thanks exclusively to financing from the Sarajevo Canton budget. At no point in the past four years did the Academy's total annual revenues exceed BAM 1.8 million, and even this represented an increase on the twenty years previous to that. In fact, the ANUBIH's revenues peaked in 2019 at BAM 1.769 million, with planned revenues for 2020 of BAM 1.639 million.[12] This compares to total planned revenues for the Croatian Academy of Sciences and Arts of BAM

[10] The Council of Ministers of Bosnia and Herzegovina, "Strategija razvoja nauke u Bosni i Hercegovini – Revidirani dokument," Sarajevo, September 2016. At https://ekonsultacije.gov.ba/legislativeactivities/details/14-prijedlog-revidiranog-dokumenta-strategije

[11] Source: Ibid., p.62.

[12] The Academy of Sciences and Arts of Bosnia and Herzegovina. "Izvještaj o radu Akademije nauka i umjetnosti Bosne i Hercegovine za period od 1.jula 2017. do 31. decembra 2020. godine," Sarajevo, December 2020, p. 32.

19.79 million (HRK 76.192 million[13]) for 2020. Of this, 83% comes from the Budget of the Republic of Croatia.

The Annual Report of the Czech Academy of Sciences (CAS) for 2019 says it had 9672 employees, 3926 of them researchers, with a further 2014 employees in research institutes within the CAS holding university degrees.[14] The average monthly salary of these 9672 employees was $1,947, while researchers received $2,495 on average.[15] The average monthly salary for academics at the ANUBIH that year was $385. Per capita GDP was 300% more in the Czech Republic than in BiH, but the monthly salary of CAS researchers was 550% more than that of ANUBIH academics. Total CAS revenues for 2019 were $681.13 million, or CZK 15,461.74 million.[16]

4. Financing R&D in BiH and the country's economic complexity

According to UIS-UNESCO data, R&D spending in BiH was $PPP 102 million in 2018. Universities accounted for slightly more than 60% and the business sector for close to 20%, with the remainder (19%) funded by different levels of governments. University financing of R&D thus represented a greater share in Northern Macedonia and BiH than in the other former Yugoslav countries, while business sector funding was highest in Slovenia (above 77%) and Croatia (close to 50%). In BiH, the business sector accounted for just 19.6% of R&D expenditures in 2018, but, thanks partly to R&D investment and innovation by BiH companies in mechanical engineering and the automotive, metal processing, and wood processing industries, business results for 2015-2020 were nonetheless better than for neighbouring countries whose R&D expenditures were higher and, in some cases, significantly so.

At this point, we should look at how Western Balkan countries are ranked for business competitiveness purposes by the economic complexity and product complexity indices, a major measure of the effects of R&D spending and especially of applied research efficiency. According to the Observatory

[13] Source: The Croatian Academy of Sciences and Arts – available at: http://info.hazu.hr/upload/File/2020/ODLUKE-2020/PRORA%C4%8CUN-2021.pdf (accessed on 08/01/2021)
[14] Source: The Czech Academy of Sciences. "2019 Annual Report of the Czech Academy of Sciences", Prague, 2019, p. 45. Available at: https://www.avcr.cz/opencms/export/sites/avcr.cz/.content/galerie-souboru/vyrocni-zpravy/VZ-AV-CR-ENG.pdf
[15] Source: Ibid, p. 45 (amounts converted from CZK to USD at average USD/CZK exchange rate for 2019).
[16] Source: Ibid, p.48.

of Economic Complexity (OEC),[17] BiH's ranking under the Economic Complexity Index improved three places, from 44 in 2015 to 41 in 2019. Over the same period, Serbia's ranking improved two places (from 41 to 39), while Croatia stayed put at 37. This index is calculated on the basis of specialization in production and the complexity of production processes and indicated that there is very little difference between these three former Yugoslav countries in their ranking. Given the funds invested in R&D, whether overall or on a per capita basis, the BiH business sector's results in manufacturing have been above-average, not just for Southeast Europe but also for some countries of the southern EU (e.g., Greece, Portugal, Cyprus).

The most complex products made in and exported from BiH, as ranked by the OEC-published product complexity index, mostly come from the metal-working industries, the production of machinery and tools, and the automotive industry. More concretely, the product groups with the highest product complexity index include:

- the production of screws, bolts, nuts, rivets, and washers,
- interchangeable tools and dies for hand or power tools,
- gaskets and similar joints of metal sheets,
- parts and accessories for machine tools,
- knives, cutting blades, for machines and appliances,
- electrical machinery and equipment,
- machinery and appliances,
- vehicles and their parts.[18]

For a particularly good example of very successful and fruitful cooperation between universities, institutes, and the business sector related to improving the Bosnian economy's competitiveness and exports of more demanding products or indeed producing such products for domestic export-oriented companies, we may turn to Thermal Process Solutions (TPS) from Zenica. This company is owned by Jusuf Duraković, a lecturer at the Metallurgy Faculty of the University in Zenica. In 2019, TPS designed and produced devices for use in chemical and thermic processes in the automotive industry for the production of very high performance vehicles (Ferrari and Maserati).[19] TPS is in fact the only company making such equipment anywhere in what

[17] Data on OEC website: https://oec.world/en/rankings/eci/hs6/hs96 and https://oec.world/en/profile/country/bih

[18] Source: https://oec.world/en/profile/country/bih

[19] See https://www.bljesak.info/gospodarstvo/tvrtke/Zenicki-TPS-Proizveli-uredaje-za-obradu-dijelova-za-Ferrari-i-Maserati/290228

was once Yugoslavia and has sold its machinery to a Slovenian company making parts for the brands in question. TPS also produces an endogenerator for its Slovenian partner, a flow-through production line to harden paper fans, a key component in making filters, for Mann+Hummel BA, a company from Tešanj (again the automotive industry), and a chamber cementation furnace for SIM Technik, a company from Kotor Varoš. The company also cooperates very actively with NN and Graewe Tadiv, both from Konjic.

Procassa-Fischer from Jelah, near Tešanj, have also shown how, thanks to their accumulation and development of know-how, Bosnian companies can achieve excellent results based on their own investment in R&D, by integrating and deploying new technologies, within the branches of business they belong to. The company's director Mehmed Husaković, has achieved excellent results in just three years, working with engineering colleagues from BiH and business partners from Germany. In 2018, the company produced the first CNC machine in BiH, and in 2019 the first PLC press. Even if 2020 was overshadowed by the Covid crisis, the company nonetheless managed to promote its new product in late September of that year.[20] The product in question is a six-axle CNC machine.[21] The fact that this product integrates the "old" and "new" economies, viz. machinery with IT, only makes it even more significant for BiH's competitiveness. The newly minted six-axle CNC machine has been exported to Germany for use in the German automotive industry.

In late December 2020, a Sarajevo-based company Dizart promoted its own new five-axle CNC machine. The company applied for financial support for R&D projects provided by USAID WHAM. The machine will be used for training, as well as to finish materials for the European market. Dizart enjoys successful cooperation with the Sarajevo University's Mechanical Engineering Faculty, as well as with the Metalworking High Technical School in Sarajevo.[22] According to the director, the company exports more than three quarters of its total production to markets in England, Ireland, and Australia. Dizart is an exceptional example of a small company that has achieved outstanding results on the basis of modest financial resources and of excellent cooperation with the University of Sarajevo, and thus of the direct link possible between theory and practice.

[20] See Procassa-Fischer webpage, https://www.akta.ba/Firma/procassa-fischer-doo/279490

[21] Available on https://www.akta.ba/vijesti/novi-uspjeh-bh-pameti-nova-cnc-masina-najveca-na-balkanu/124096

[22] See BiznisInfo portal, https://www.biznisinfo.ba/sarajevska-kompanija-predstavila-novu-cnc-masinu-vlastite-proizvodnje/

During 2020, one of the "more unusual" examples illustrating Bosnian companies' flexibility and capacity was the news published in mid-December that a ventilator produced by the TMD Group from Gradačac had received MD-TEC certification in London.[23] The TMD Group had developed the prototype for this ventilator in cooperation with the University Hospital in Tuzla. During the 1970s and 80s, this company was part of the pre-war Famos group from Sarajevo and produced parts for vehicles and transport equipment. At the beginning of the present century, it was privatised by tender and began to focus again on producing parts for the automotive industry (for initial build), mostly for companies in Western Europe. The decades of experience and tradition in metalworking and metallurgy represented by such companies in BiH mean it is still possible to achieve excellent results on the basis of modest investment in innovation and adapt production for branches where they previously had no presence.

A particularly good example of successful cooperation between academic institutions and industry in the areas of innovative product development and more particularly of industrial design is how lecturers/teachers at the Academy of Fine Arts of the University of Sarajevo have been working together with Yield and MS&Wood, furniture manufacturing companies based in Sarajevo. Zlatko Tanović established Yield in 2007 and in 2013 began working closely with one of the most respected designers in furniture production in Southeast Europe, Salih Teskeredžić,[24] who teaches at the Academy. It was within the framework offered by Yield that Teskeredžić developed his own product and design brand called Gazzda. He has received a number of prestigious international awards for furniture design for these products. Nataša Perković,[25] a professor at the same Academy, designed a chair for MS&Wood which was awarded at a furniture trade fair in Germany. Avdo Avdagić won the highly prestigious German Design Award at the same trade fair for a sideboard he designed, also produced by MS&Wood.[2627] Avdo Avdagić and Salih Teskeredžić work together closely on product development at one of the most successful companies in the furniture industry in Southeast Europe – Artisan

[23] See TMD Group webpage, https://tmd-group.ba/respirator-proizveden-u-gradaccu-certificiran-u-britaniji/

[24] Available on https://bigsee.eu/salih-teskeredzic-bosnia-and-herzegovina-big-see-visionary-2019/

[25] Available on https://www.archiproducts.com/en/designers/natasa-perkovic

[26] See: https://www.artisan.ba/en/designers/ado-avdagic

[27] Available on https://www.sarajevotimes.com/company-ms-wood-won-2-prestigious-german-design-awards-2018/

from Tešanj.[28] Another lecturer at the Academy to have achieved a regional and indeed European reputation over the past two decades, in his case in the field of graphic design, at his Sarajevo-based company Fabrika, is Bojan Hadžihalilović.

Nor have Bosnian companies in the fields of the "new economy,"[29] "the intangible economy", or the ICT-based economy, fallen behind their peers in the Western Balkans or, in some cases, even IT companies from Central and Eastern Europe more broadly. When Deloitte Central Europe published its 2019 list of the 50 fastest growing technology companies from Central and Southeast Europe (based on the growth rate in total revenues), the only company from the Western Balkans was a Bosnian company, the Ministry of Programming, whose revenues rose 813% during 2019. Founded in 2015, the company specialises in developing first-rate start-up companies in the sector. According to Deloitte, they have developed first-class services and products in data gathering and analysis, social networks, market development software, and software for discovering viruses. Google, McKinsey, and Rocket Internet have recognised three of the 35 start-up companies in which the Ministry of Programming has invested between 2015 and 2019 as world-class start-ups.[30]

Other highly significant companies from the IT sector to achieve regional and European reputations on the basis of years and indeed decades of investment in R&D include Lanaco and BS Telecom Solutions. In 2016, Lanaco became the first Bosnian company listed on the London Stock Exchange's ELITE programme, amongst the 50 most successful companies in Europe. The following year (2017), the company received a bronze medal at the SAP Quality Awards – SAP ERP for business transformation in central and eastern Europe.[31] Lanaco opened the Lanaco technology centre in Banja Luka in 2016 to promote investment and development of the sector, founding the ITivity Software Academy the following year. Lanaco has a presence throughout BiH, with offices in both Banja Luka and Sarajevo, and is first-rate example of an integrative economic approach to a knowledge-based Bosnian economy. BS Telecom Solutions is another example of an IT sector company

[28] See https://www.dnb.com/business-directory/company-profiles.artisan_doo_tesanj.f79f8c48dde194e74c0f035898df9cde.html

[29] For a recent discussion of the impact of the "new economy" (October 2020), see https://www.brookings.edu/research/whats-new-about-the-new-economy-it-economic-growth-and-productivity/

[30] Deloitte Central Europe: Deloitte Central Europe, "Deloitte Technology Fast 50 Central Europe", at https://www2.deloitte.com/ce/en/pages/about-deloitte/topics/technology-fast-50.html

[31] See LANACO web site - https://www.lanaco.com/nasa-prica/

with good references in the development of IT business solutions and a record of highly successful projects in the Czech Republic, Russian Federation, both entities of Bosnia and Herzegovina, and more recently, in neighbouring Serbia, who have shown that continuous investment in knowledge and innovation is the best path to a European reputation in the contemporary business world. Infobip BH Ltd Sarajevo, a subsidiary of the Croatian company Infobip from Vodnjan, is one of the most successful IT companies in BiH. The company has started the construction of a development campus, which should be completed in 2022 and will serve as the centre for MENA region.

According to the data set out in table 2 (see part two of the text above), in 2018, relative spending on R&D in the four industrially strongest economies of the former Yugoslavia, as a percentage of GDP, was: 2.4% in Slovenia, 0.8% in Croatia, 0.7% in Serbia, and 0.3% in BiH. In table 3, we presented the relative prominence of three sectors in the financing of R&D. The results for the business sector were: 77% for Slovenia, 48% for Croatia, 30% for Serbia, and 20% for BiH. Based on this data, we might conclude that business sector spending in these four countries, expressed as a percentage of GDP, for 2018, was: 1.86% for Slovenia, 0.38% for Croatia, 0.21% for Serbia, and 0.06% for BiH. Consequently, business sector spending on R&D in Slovenia was 35 times higher than in BiH, 8.9 times higher than in Serbia, and 4.9 times higher than Croatia. Total relative investment in R&D in Slovenia that year was eight times higher than in BiH, 3.4 times higher than in Serbia, and three times higher than in Croatia. These highly significant differences between Croatia, Serbia, and BiH in terms of business sector investment in R&D did not result in any major differences in their economic complexity indices or ranking, however. According to the latest rankings, BiH comes just two places after Serbia and only four places behind Croatia.

In other words, the effectiveness of R&D spending and innovative activities at the company level indicates that Bosnian companies achieved very good results with considerably less investment, which may be partially explained by capable management within the metalworking industry, mechanical engineering, the production of car parts, and the woodworking industry, and by the IT sector succeeding to innovate and commercially exploit their products and services, thus capitalising on a stock of knowledge and a tradition developed over decades in the first four industries and on being rather quick learners in the IT sector. A key element for explaining the significant achievement of dozens of Bosnian companies and Bosnia's high-ranking in terms of the Economic Complexity Index (among the top 28% of economies

in the world), given the low degree of investment in R&D, on the one hand, and the effectiveness of resources invested in the business sector, on the other, is offered by the analysis given by Radošević of the sources of innovation in his paper.[32] Radošević points out, with reference to an earlier paper by Lorenz and Lundvall, that innovation doesn't just happen as a result of public sector investment in R&D, because it is essentially a consequence of "doing-using-interacting" work that draws on the productive and business experience of entrepreneurs and innovators. This aspect of the analysis of innovation and the relatively high degree of product complexity helps to explain the high ranking of Serbia, Croatia, and in particular Bosnia and Herzegovina, given their actual levels of public sector spending on R&D activities.

5. Conclusion

The analysis of global and regional experiences in financing R&D indicates that the world economies with the highest GDP or the highest GDP per capita account for more of global spending on R&D than of global GDP. South Korea is a very good example of a small open economy that has achieved exceptional technological results and global competitiveness across several industrial branches over the past three decades. The country is proof that targeted and effectively controlled planned investment in research and development can result in technological breakthrough onto global markets. The two largest economies in the world by GDP, the US and China, are also the two largest investors in research and development in absolute terms. The Scandinavian countries and the major Western European countries also offer good examples of the payoff from investment in research and development, but also the seeming need for such investment to be above-average vis-à-vis share in world GDP.

Global experiences and trends in financing research and development have been most successfully mirrored and applied in Central and Southeast Europe by Slovenia, the best performing country in transition in terms of per capita GDP. This country in transition and former member of the Socialist Federative Republic of Yugoslavia is not just the regional leader in relative investment in research and development, but number 11 in the world overall.

[32] Slavo Radoševič (2021) "Public R&D and Science – Industry Links in Economic Development: Implications for Bosnia and Herzegovina," London (June). Paper prepared for ANUBIH conference "System of R&D in Bosnia and Herzegovina" to be held on 5 November 2021, pp.8-9.

The approach taken by Slovenia and her national and economic policymakers and so the creators of her scientific and research development strategy has pushed this small country into 12th place worldwide in terms of the economic complexity index and into the group of countries with a very high human development index. The other central or south-eastern European countries with high levels of investment in research and development include the Czech Republic and Hungary, whose economies have experienced significant successes in the past decade.

Slovenia, of course, was the best placed of the former Yugoslav countries, while the other former Yugoslav countries have and continue to invest considerably less in R&D. Croatia and Serbia are well below the world average in investment for these purposes, while Bosnia and Herzegovina is the country with the second lowest level of investment in R&D in Central and Southeast Europe, after Albania, This very low level of investment in Bosnia and Herzegovina is at least in part a consequence of objective factors, but also in part due to the extremely misguided approach of government to organised investment in R&D and its importance for the future development of society, competitiveness, and export capacity. The most significant objective factor is Bosnia and Herzegovina's very different starting position on entering transition compared to the other countries in transition, and particularly the other countries of the former Yugoslavia, given the extremely heavy war-related destruction the country suffered, which was a multiple of the damages suffered by all other members of the former Yugoslavia combined. One consequence is that the BiH entities spend four times more on social security for civil victims of the war and disabled veterans than the other worst affected member of that former state.

On the other hand, there is really no excuse for a government that was unwilling to make room in the structure of available and, up until the Covid crisis, growing tax revenues for the goals of financing R&D which those same authorities set themselves in their own key development documents, ratified at all the various levels of government. One direct consequence of this approach has been the continued outflow of the best young scientists and researchers, generally to the countries of Western Europe, the UK, and the US. While the business sector in Bosnia and Herzegovina has not invested much in R&D, the business results achieved by companies in the metalworking industry, mechanical engineering, the automotive and woodworking industries, and in the ICT sector have helped put Bosnia and Herzegovina amongst the top 28% of countries in terms of the Economic Complexity Index. The

talent, production-oriented knowledge, and capacity learned by employees in these industries by working or rather by innovating offer major scope for significantly improving the quality of life and of the economy in Bosnia and Herzegovina, but this proven potential may in the coming years and decades equally and with relative ease cease to be such a leading contributory factor to the Bosnian economy's surprisingly high-ranking in terms of the Economic Complexity Index, given the overall very modest level of investment in R&D, if those authorities and the economic-policy makers in Bosnia and Herzegovina do not radically change their attitude regarding the universal truism that investment in R&D is an extremely important precondition for improving both quality-of-life and the structure of the economy.

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