# Future Prospects for Jumpstarting Technological Innovation in Enhancing the Competitiveness of Croatia Business Sector

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# FUTURE PROSPECTS FOR JUMPSTARTING TECHNOLOGICAL INNOVATION IN ENHANCING THE COMPETITIVENESS OF CROATIA BUSINESS SECTOR

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## ABSTRACT

Technology and innovation has always been among the major concerns of those striving to shape the future. Since decades, broadening the prospects for innovation directed discussion has been an imperative shaping public policy and company strategies. The pace of technological advances on world levels has recently been accelerating, which might be partly directed and inflated by COVID influences.

In terms of methodology, this paper presents a cross-section of (secondary) statistical data organized and interpreted in accordance to a list of issues identified by international bodies engaged in the research of R&D and innovation activity. Our original plan was to examine the likelihood of advancing the competitiveness of the Croatia economy for the future from the perspective of company level R&D activity. Instead, we were forced to rely on aggregate, national level, data. We review existing policy initiatives, draw some data and comment on the existing innovation supporting framework.

The paper is structured as follows: In the introductory part, we present expose some ideas we find encouraging for direction research into innovation activity at company and country level. The theoretical section defines the basic concepts and approaches dedicated to understanding innovation, particularly the discourse on the nature of "disruptive technologies". Under the third section we provide some context by highlighting some reports on recent innovative performance of Croatian firms in international, primarily European settings. This is followed by an exposition of data and by concluding remarks.

# 1. INTRODUCTION – THE RESEARCH AGENDA

The motivation for starting this research stems from the feeling that Croatia faces a moment in time that is likely to bend future prospects of economics and social development. In general, economic trends do not look bad; according to Eurostat GDP continues growing slowly, yet above the average rate of growth for EU and the Eurozone, while government debt remains bellow both averages and continues to decrease. If ever, now is the moment where assets may be available for investing in new developmental trajectories. On the other hand, the present moment is driven by unexpected developments. One crisis seems to follow another; a prompt application of measures to deal with this incidental occurrences of systemic crises, would be expected to direct the attention of policy makers to innovation and R&D in order to preserve sound socio-economic development (even though, as the Israeli-Palestinian war develops one wonders about the social cost involved). Recent developments add relevance to a point made by the Bar Am et al. (2020) stating that "understanding the state innovation is even more critical than ever".

Croatia has been enjoying a decade of generally positive macroeconomic performance that consequently led to closing up its developmental gap. (Srdelić, Davily-Fernadez, 2022). In terms of institutional support, Croatia has gained access to European funds and expertise, particularly since it joined the EU in 2013. Joining the EMU and becoming part of the Schengen area, which was accomplished in 2023, should additionally boost developmental prospects.

As to references to innovation activity, Srdelić, Davily-Fernadez (2022, p. 20) show that R&D is the most important explanatory factor of non-price competitiveness of Croatia.

Awareness concerning the importance of R&D also in Croatia exists, but apparently, there is need for a stronger and more articulated support by public authorities. Undergoing efforts remain poorly organized and lacking coordination. In 2013 a WB Country Series Paper reported that Croatia has undertaken steps to make its R&D sector more competitive and more effective in supporting economic growth, mostly from the part of the Croatian Ministry of Science, Technology and Higher Education. The effort, with some lag, was expected to reflect an overall increase of spending on R&D.

In terms of institutional support to innovation, either in the form of explicit policy or government contribution to developing supporting factors such as human capacity and financial endowments, it was noted that initiatives were taken at the national level:

- Public infrastructure is being established and integrated into supranational scientific networks (Croatian public academic institutions are part EHEA, ERA; reforms promote academic performance by providing research funding, establishing quality accreditation procedures and merit based system of academic advancement),

- Government agencies were established, such as BICRO, HABOR, technological parks and cluster initiatives are being promoted; but there also by tax reductions, tech-research and scientific-research equipment are exempt from import duties… (World Bank, 2013).

However, what remains underreported is activity by the private sector, i.e. initiatives at micro-level (company, group, individual). Apparently, this is not just the problem in Croatia.

The interest in technological developments has always been strong. At the beginning of the 2000, it was incurred that R&D activity was crucial for maintain sound economic growth and the OECD (2004, p. 5) was reporting on new "waves of innovation, notably in information and communications technology (ICT) and biotechnology going on. Interest for the topic pervaded over time and the number of international organizations and specialized teems systematically researching R&D and innovation has grown producing a string of annual reports such as the Global Innovation Index, a UN funded World Intellectual Property Organization (WIPO); the OECD Science, Technology and Industry Scoreboard; the European Innovation Scoreboard; national level projects and policy initiatives. All of them tried to establish and document trends producing a valuable stream of insights and supportive data.

Still, over the years, there have been some mild differences in the dominating rhetoric. Mainly, approaches at the turn of the century were prone to stress the importance of understanding contextual factors affecting innovation activity and stressing the importance of innovation activity at a micro level. Stern, Porter and Furman (2000) explicitly indicate that "ultimately, it is the microeconomic conditions associated with a nation's cluster which determine whether firms respond to technological opportunity and innovate at the global frontier" (p. 3).

In the early 2000's, the OECD (Patents and Innovation Trends and Policy Challenges, OECD, 2004, p. 15-18) will point out the notions of:

- Innovations being central to business strategy;
- Innovation processes becoming globalized, which lead to a review (strengthening) of patent rights;
- A growing awareness about the importance of "cross-fertilization" of public and private efforts;
- The sectoral structure recognized as important for understanding innovative activity.

The list above served to guide our choice of data to be used for understanding the patterns of R&D activity and innovation in Croatia. As more than ever innovations were being presented as a phenomenon evolving from company strategies, we initially attempted to review firm level data (ORBIS). However, as data on Croatian companies R&D was generally unavailable, we reverted to macro level data and tried establishing patterns that compare to globally identified trends and developments in other countries.

We are aware that most recently, some 20 years later after, the research agenda was expanded to include some new issues that affect the level and direction of R&D activity worldwide, namely:

- The importance of new investors (PE, VC) fueling R&D;
- The introduction of new concepts, such as „deep-tech" (Hodgson, 2023);
- A sensitivity to the efficiency and effectiveness of innovation promoting instruments, such as tax subsidies (reported to be on the rise according to Appelt at al. 2023, OECD, 2023);

- Innovation strategies designed as part of more complex policy platforms that target precise development goals, such as sustainability and digitalization (UN and EU strategies for period until 2030), and

- Increasing protectionism/nationalism in designing policies intended to support technology development (STI Outlook, 2023).

These new developments are certainly intriguing and worthy to be taken under consideration. Yet, it has been hard enough compiling evidence that will illustrate the first list of factors, so that we will attempt just to comment on them as we go along.

## 2. THEORETICAL PERSPECTIVES ON TECHNOLOGICAL CYCLES AND MARKET ENTRY

Since the 1970s, population-ecology theory has been considered the main theoretical strands dedicated to explaining the success rates (birth/death trends) of particular companies in particular industries. It focused on explaining strategic alternatives and issues related to individualized (company level) approach when it comes to market entry, market segmentation etc. It promoted the idea that companies should build capacities (resource composition, structural organizational arrangements) that help them achieve a strategic fit between company capabilities and market (environmental) opportunities.

As originally exposed by Aldrich and Pfeffer (1976), the population-ecology model explains the logic of natural survival to companies operating on the same market. The model assumes there is a strategic fit between the strategies and structures chosen by the firm and the conditions in its market environment, mainly the availability (whether scarcity of abundance) of critical resources that are contested by market competitors. It is more recent, as well as more broadly oriented ramification, considers the concept of market ecology can be defined/modeled as a state of market structure likely to promote efficient behavior by market actors. This line of reasoning latter evolved into the concept of business ecosystems, which are being using to develop a general theory of factors influencing innovation. The perspective of business ecosystems explicitly includes regulatory/ governmental involvement in the creation and further developments of market conditions.

Their interest lies in understanding factors that drive changes and the way existing ecosystems coevolve. The idea of ecosystem attracted much researchers' attention in recent year. By Adner (2016, pp. 40) it was explained as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize", while Granstrand and Holgersson (2020) "the evolving set of actors, activities, and artefacts, and the institutions and relations, including complimentary and substitute relations that are important for the innovative performance of an actor or a population of actors".

The idea of ecosystems can be interpreted as a more contemporarily "version" of the population-ecology/resource dependency metaphor. The contemporary approach to interpreting and developing science, technology and innovation policy; to quote the OECD, relies on the "system ecology" approach develop in the business literature. Its important feature is that it proposed looking at trends as a result of multiple interrelated factors (co-determination of causal effects) acting in a complex network of firm/institutional interdependencies. A model of an innovation ecosystem, such as Passi et al. (2023) will point to a number of co-evolving elements (some 20 of them) includes: Market size, Ecosystem attractiveness, Hype, Ideas, Social benefits, Regulators, Finance…

Another enlightening narrative that stands out is that of disruptive innovation.[1] Disruptive innovations appear to be a promising path (loophole) capable of promoting latecomers/marginal into the front light. The term disruptive technology was promoted by Bower and Christensen in 1995.[2] Here firm behavior on markets has been developing around the idea that different technologies coexist on the same market and that innovation, at least at its beginnings is not necessarily superior in performance when compared to technologies that are more traditional.

According to Christensen:

> *…When introduced, disruptive innovations are initially inferior on accepted performance dimensions relative to incumbent products, but offer a novel mix of attributes that appeal to fringe customer groups such as those near the bottom of the market…Consequently, incumbents are typically not motivated to develop their own disruptive innovations that promise lower margins, target smaller markets, and introduce inferior products and services that their existing customers.*

What the theory is really about are the different development trajectories of firms serving the same market, such that once marginal firms (the entrant(s) outperform strong incumbents basically by adopting technology that appeared inferior (for being underdeveloped) at the time. This approach will not so much focus on the proper time of entry, but rather on the expectation that the success of a potentially disruptive technology will require some complacency from the incumbents, providing incumbents are likely to develop products that serve the needs of the most demanding and most profitable market segment. Neglect of marginal market segments allows for a time window that can be exploit alternative technology that may eventually make new-entrants overtake major incumbents.

As stressed by Adner (2002) this is again a demand-based view of technology competition. Market dynamics requires a certain state of demand conditions to trigger the development of disruptive technologies. The market structure is presented by a segmentation of consumers according to particular preference trade-offs s regarding the functional performance of goods and services. As put by Adner, market opportunities arise when consumer preferences are met with consumer willingness to pay for performance improvements. Requirements of some market segments may be met by non-standard/disruptive technologies. If over time, preferences of two consumer groups overlap (or, preference symmetry occurs), decreasing willingness to pay for high end products will increase the importance of price differentiation and demand will shift between competitors.

The theory has been supported by case studies. Such studies (for example, Coccia and Wang, 2015 on anticancer drugs, Yang, Kim and Choi, 2022 on Korean on-line retail platforms), even though they might be demeaned and considered anecdotal confirmations, demonstrate the only ***some* firms** in **specific sectors** (with dynamic technological developments) have managed to follow the growth trajectory envisaged by theory.

Both narratives help understand technology development trajectories but in a perspective that leans on the role of consumer behavior (preferences) in driving incentives of companies to

[1] The DT theory is a bit restrictive as it addresses product innovations; id does not speak of other types of innovation such as process, organizational, market communication and other forms on innovation. See Gault (2016) on the evolution of the Oslo definition of innovation, its scope and implications for measurement.

[2] As suggested by the author himself, the concept has often been misunderstood. So 20 years later Christensen et al. (2015) make an effort to point out the main ideas.

innovate. Consequently, they focus on the private sector and neglect public investments and policy. In addition, they are more appropriate for understand specific markets and specific company strategic efforts. (Again, this can be seen as another limitation to the approach.) On the positive side, these theories advocate that those that can develop a strategy that captures the right moment and right pathway to success, can actually advance their competitiveness. (We hope Croatia is in a position to do so in the near future; as long as we do not rock the boat.)

Population-ecology narratives point to the importance of firms establishing a strategy. This strategy can work of a firm is capable of spotting the state of resources; or, abundance or scarcity of resources existing in a proper moment in time (an opportunity window). It is similar with disruptive technologies narratives. But coming from a time in history when once strong companies (incumbent firms) were unable to maintain dominancy, the disruptive technology paradigm additionally requires certain market conditions (complacency by incumbents) and a long enough evolution period for news entrants to evolve and displace incumbents. Another apparent distinction between the two narratives stems from the fact that the size of entry-level investments does not seem to be particularly important for the success of DT.

The critical issue demanding some stand is: can a paradigm of entrants outperforming incumbents, as a theory of *industrial structure* transformation, be extended to "predict" repositioning of national industry sectors in international settings… (Note that such a thesis will imply that a larger numbers of firms in multiple industries should demonstrate substantial innovative capacity)[3]

Even though at first sight focusing on individual firm behavior and performance does not appear very suitable for macro-level analysis, it is a fact that the industry approach logic is being employed also at the macro level in developing public policy. Policy researchers and policy makers are more than ever talking of (technological) competition, securing resources and building capabilities… These can be seen in the ever more comprehensive approach to explaining innovation and R&D investment trends on national and regional levels.

These authors (the paper) is also important because it set the standards for measuring factors affecting R&D productivity at country level and establishing the measurement of R&D outputs as: scientific outputs, innovative outputs and productivity (gains). (Today the approach can be found in the WIPO yearly report employing seven pillars: five groups for contributors/inputs and two groups of outcomes/outputs, one being "more visible" (knowledge and technology), and the other being more complex to report (creative outputs).

As an example, the OECD newest Science, technology and Innovation Outlook 2023, subtitled "enabling transition in times of disruption", demonstrates the contemporary sensitivity to business environments and an "embeddedness" of explanations of trends in the rhetoric of competition. In the introductory abstract, the STI Outlook points out that the contemporary crises with COVID, called attention to "insufficient funding, wealthier-country hoarding and logistical challenges..." have triggered "Vaccine nationalism" and "diplomacy".

[3] Post WWII Japan appears to offer confirmation. According to Tetsuji (2015), the Japanese miracle has been an "*extension of the national catch-up effort that began in the late nineteenth century. There are constant features underlying the economic dynamism of the prewar and postwar eras. But there are also differences. The basic growth factor common to the prewar and postwar economies was the "backwardness" of the Japanese economy relative to the world's advanced industrial economies…"* (see the catching up chart at: https://www.nippon.com/en/in-depth/a04003/

This raised "concerns about strategic competition in other technology areas, as well as the prospects of future STI co-operation on global challenges such as climate change" As a result, as COVID combined with challenges related to the war in Ukraine the technology innovation arena become a matter of high public interest. Several OECD countries are developing STI policies in order to "make economies and societies more resilient, and are aware that keeping up requires "long-term investments in R&D, skills and infrastructures".[4]

## 3. SOME CONTEXTUAL REFERENCES ON INNOVATION ACTIVITY

Nowadays, according to the European Innovation Scoreboard 2022, Croatia is an "Emerging Innovator" with innovation performance at 66.5% of the EU average. It also means that Croatian performance is above the average of the Emerging Innovators (indicated by the 50.0% threshold). Innovation performance is increasing (15.5%-points) at a rate higher than that of the EU (9.9%-points).

On world levels, it was noted that "After a boom in 2021, investments in innovation showed a mixed performance in 2022. Scientific publications, R&D, venture capital (VC) deals and patents continued to increase to higher than ever. However, growth rates were lower than the exceptional increases seen in 2021. In addition, the value of VC investment declined and international patent filings stagnated in 2022." (GII, 2023, p. 21.)

Following the trajectory of historical changes in (the more empirical) policy perspective. During the 2000s OECD (OECD, 2004, p. 15-18) policy was pointing out that innovation activity is related to the business sector ("Innovation is central to business strategy"); and, as innovation processes were becoming globalized, there was a movement towards a review strengthening) of patent rights. It also stressed the role of the parallel system of public institutions (the academic world) in maintain innovation activity.

Now, 20 years later, the overall perspective did not change much; the methodology (pillars) used to report contributors and results from innovative activity remained more or less the same. Yet some new issues/concerns come forward, such as:

- Higher sensitivity to efficiency and effectiveness of innovation promoting instruments; for example, tax subsidies (on the rise according to Appelt at al. 2023);

- Innovation strategies designed as part of more complex platforms that target precise development goals, such as sustainability and digitalization (UN and EU strategies for period until 2030); and

- New investors looking for opportunities (PE, VC) introducing new concepts and measures for tracking innovation performance (see how deep-tech is being defined by Hodgson, 2023)[5]. Some argue that Europe is falling behind because its financial system is inferior to the US when it comes to financing innovation and particularly in scaling new promising business models (ibid);

[4] OECD STI Outlook 2023 QUOTE: „Governments are putting in place measures to (i) reduce STI interdependency risks and restrict international technology flows; (ii) enhance industrial performance through STI investments; and (iii) strengthen international STI alliances among like-minded economies. These measures could disrupt integrated global value chains and the deep and extensive international science linkages that have built up over the last 30 years. "

[5] According to Hodgson the concept (deep tech) was coined in 2014 to refer to technology based on tangible engineering innovation and scientific advances with the ability to disrupt several industries.

- Increasing protectionism/nationalism in designing policies intended to support technology development.

3.1. **Some empirical evidence of contemporary R&D trends**

Going back to world levels, look at the data by WII Report OECD (2022) indicates that the importance of R&D spending by the business sector has been correlated with GDP growth (Figure 1).

*Figure 1. R&D trends follow GDP*


Source: WIPO, 2022

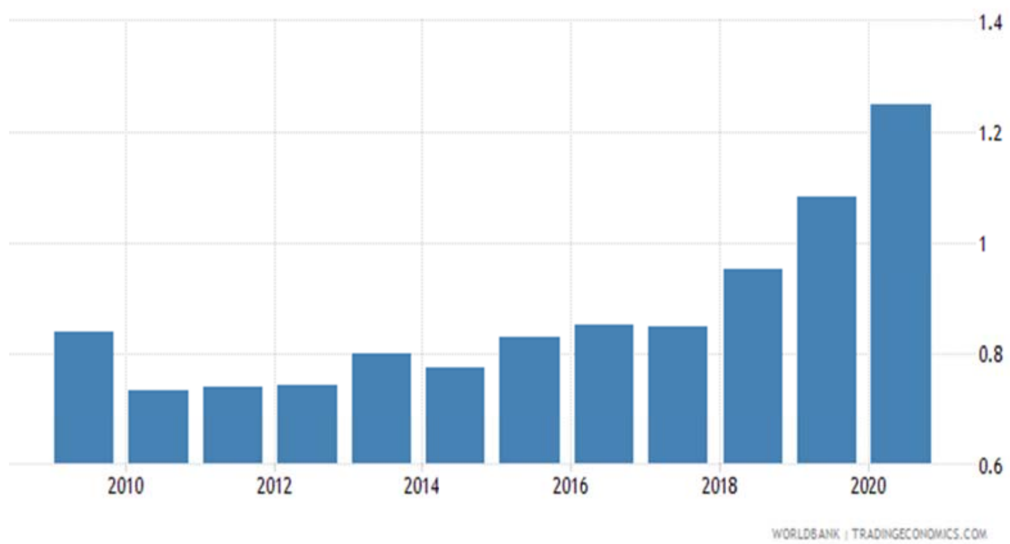
The graph clearly illustrates a close relationship between R&D investment and GDP growth. This is most visible during crises periods. A way out of the 2008 crises was marked by path of "constant growth of R&D spending by both the public and the private sector. (The worldwide recovery of business enterprise expenditure on R&D (BERD) was quick, reaching 3.2% growth in 2010 and gaining at the faster pace of 7.2% in 2011 and 6.6% in 2012. WIPO, GII, 2015). Another point to be made is that the "rest of the world" appears to be more "sensible" to drop in GDP. Finally, as it will show later as we look at Croatian figures, it is interesting to note that the authors chose to plot levels of business R&D.

With Croatia trends "work" a bit different; economic activity mirrors worldwide trends, but R&D investments have a somewhat different trajectory as is shown by Figure 2(a) and Figure 2(b). Peaks and troughs in GDP follow world patterns. When it comes to R&D expenditures, the picture changes (Figure 2b). Even during recession, R&D was sustained and has even shown some growth.

*Figure 2(a). Croatian GDP growth trends*


Source: https://www.theglobaleconomy.com/compare-countries/

*Figure 2b. R&D activity in Croatia*




Source. https://tradingeconomics.com/croatia/research-and-development-expenditure-percent-of-gdp-wb-data.html

R&D spending in Croatia is modest in absolute figures. After all, Croatia is a small economy (population of 3.9 million, 60 billion euros GDP); however, with rates of R&D spending to GDP lower than the European average.[6]

In the decade 2010-2020 R&D expenditures as % of GDP for Croatia have remained in the positive, even in times when GDP growth was (slightly) in the negative (Figure 3). However, the trend was much smoother and the investment rates were generally low (source WB).[7]

[6] It should also be noted that Europe (as the most important macro environment influencing the economic performance of Croatia) has been less active than its main competitive rivals. According to a study produced by McKinsey Global Institute, Europe30 patent activity is lagging behind the US in a whole range technological areas. (Smit et al. 2022., p. 24)

Perhaps standing on the positive side of the "0-line" may be attributed to Croatia joining the EU in 2013. Still, already at the time Croatia was preparing to enter EU, it was acknowledged that Croatian investments in R&D are insufficient and lagging behind countries with similar income levels (World Bank, 2013. p. 11). According to it, at the national level (government) institutions have provided support for "improving the legal environment… and creating programs to support innovating private sector companies." But the report also advised that the level of expenditures in R&D should rise to an average of 3% of GDP and that additional efforts are needed to stimulate private sector R&D and innovation (European Commission 2023 Country Report – Croatia, p. 49).

A more recent evaluation of Croatian innovation performance (WIPO, 2022) will find that Croatian performance matches expectations by being in accordance with its income level. In fact, the score of innovation output to innovation input in 2022 is better than average. However, Croatian overall performance is below the high-income country group average. Of all GII pillars and at its worst when it comes to institutions (particularly its business environment). [8]

*Table 1. Croatia – GII Croatia country ranking*

| Year | GII | Innovation inputs | Innovation outputs |
|---|---|---|---|
| 2015 | 40 | - | - |
| 2016 | 47 | - | - |
| 2017 | 41 | - | - |
| 2018 | 41 | 42 | 42 |
| 2019 | 44 | 46 | 52 |
| 2020 | 41 | 44 | 43 |
| 2021 | 42 | 41 | 48 |
| 2022 | 42 | 45 | 40 |

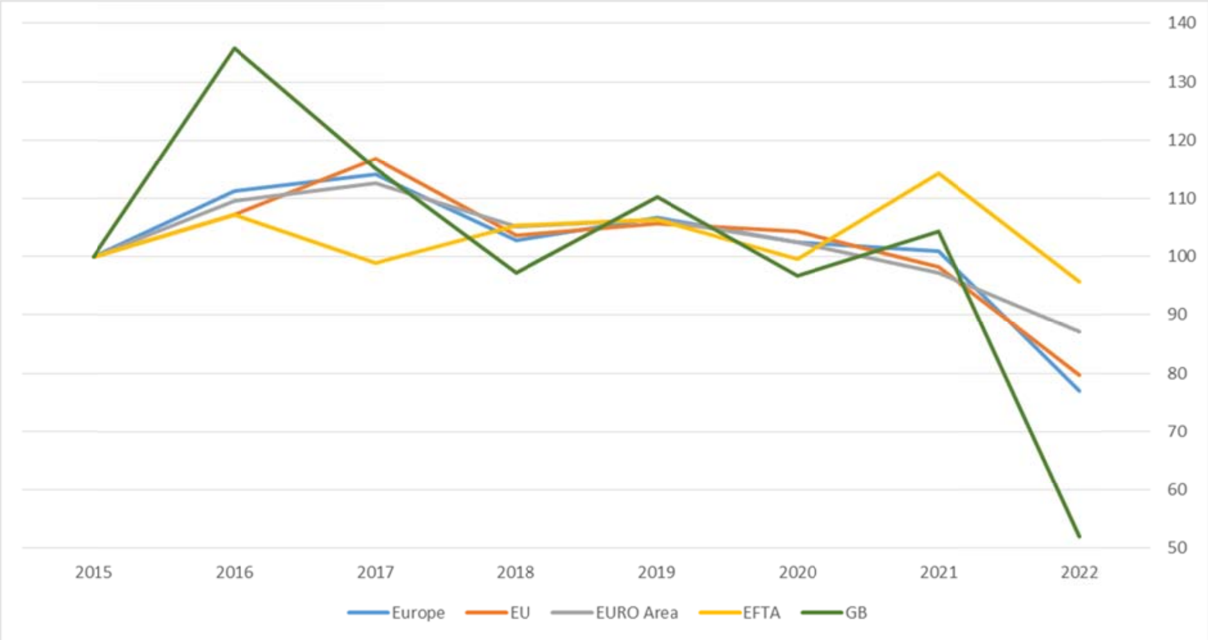
Source: WIPO – GII

Employing a different data source (ORBIS company level data) will demonstrate that European R&D spending has been generally decreasing (Figure 3).

[7] WB methodology: "Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development" (https://tradingeconomics.com/croatia/research-and-development-expenditure-percent-of-gdp-wb-data.html)

[8] The Global Innovations Index (GII) is calculated on yearly basis by the World Intellectual Property Organization (WIPO). Croatia has been a member since 1991. The GII rests on 7 pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, Business sophistication, **Knowledge and technology outputs, Creative outputs**. Institutions include: the political environment, the regulatory environment and the business environment. In 2020 its worst ranking was for market sophistication. By items, the worst rankings were attributed to state of cluster development, university/industry collaboration, and intensity of local competition…

*Figure 3. R&D expenditures by company sector 2015-2022 (billions of Euros)*




Source: created by authors with data from ORBIS database

Unfortunately, data on R&D for Croatia could not be found in the ORBIS database; so we could not verify was is primarily public spending being reported in national level statistics.

## 3.2. **The analysis of Eurostat data**

To measure the strength of the relationship between R&D activity and variables thought to be significant for R&D activity, we retrieved data from Eurostat and performed Pearson correlation tests. The two indicators chosen for R&D activity are R&D as a percentage of GDP and patent applications per million inhabitants. The indicators for which we expected a possible relationship with R&D activity included: the overall level of GDP, the average number of employees in manufacturing firms, the turnover of SMEs in manufacturing, direct investment flows, the share of manufacturing in GDP, the share of computer programming, consulting, and information services in gross value added, the share of HGE (high growth enterprises) in the total number of firms, the share of firms with more than 250 employees in the total number of firms, their share in turnover, and the share of persons employed in these firms in the total number. The information whether the country is a former communist country was used as an additional dummy variable.

We found no strong significant relationships with R&D in GDP and other variables. Modest significant correlations, however, are found for the size indicators: share of employees in firms with more than 250 employees [r(28) = 0.484, p = 0.011] and a share of turnover in these firms [r(26) = 0.426, p = 0.030]. As expected, there is also a moderate relationship between the share of R&D in GDP and the number of patent applications [r(30) = 0.490, p = 0.006]. We also found a negative relationship of moderate significance with post-communist country status [r(30) = -0.466, p = 0.010]. Several other variables that showed moderate relationships with R&D in GDP were not statistically significant.

A comparison of the relationships between the selected indicators and patent applications per million inhabitants showed a strong positive correlation with the indicators of firm size:

number of employees per firm in manufacturing [r(28) = 0.709, p = 0.000], share (%) of firms with more than 250 employees [r(28) = 0.693, p = 0.000], and share (%) of employees in firms with more than 250 employees [r(27) = 0.616, p = 0.001]. Again, post-communist countries showed a negative correlation with our R&D indicator, and in the case of patents this correlation is strong [r(30) = -0.529, p = 0.003]. Another strong negative correlation was found with direct investment flows [r(27) = -0.572, p = 0.002].

We also found some moderately strong significant correlations with patent applications: a positive correlation with the share of HGE [r(27) = 0.385, p = 0.047] and a negative one with SME manufacturing turnover [r(29) = -0.418, p = 0.024], the latter being another indicator of firm size. The detailed results of the analysis are presented in two correlation matrix tables and are available in the appendix to this document.

The dummy variable indicating whether the country is a former communist country was included because research shows that post-communist countries often lag behind in terms of their ability to innovate. Zawalińska et al. (2018) argue that the technological backwardness of CEE countries is the result of half a century of neglect of technological progress, insufficient investment, and low productivity, while others (Ženka et al., 2017) point out that post-communist CEE countries have a pattern of locating their knowledge-intensive business services mainly in the capital city, while manufacturing is scattered in smaller towns, which may also be a reason for the R&D lag, or that innovation capacity is determined by the ability to retain a highly skilled workforce (Bernard et al. 2014).

The relationship between firm size and R&D has been well analyzed and documented since Arrow (1983) made the theoretical assumption that larger firms have an advantage because of their ability to raise capital and generate more internal funds. Recent empirical research tends to confirm the assumption that larger firms have an advantage (Yang, 2023; Peng et al. 2018; Choi and Lee, 2018; Dindaroglu, 2013). Small and medium-sized companies rely more on venture capital funding to achieve innovation. If successful, they can become HGEs or Gazelas, i.e., high-growth companies (Flachenecker, 2020).

## 4. A LOOK AT SOME OF THE POSSIBLE EXPLANATIONS OF DIFFERENCES IN R&D AND INNOVATION ACTIVITY OF CROATIA COMPARED TO WORLD TRENDS

Explanations of differences in GDP and R&D may come various factors, such as:

- Differences in sources of R&D financing (ratio of public to private financing),
- Economic structure (sectoral composition of the economy),
- Historical trajectories (technology cycles, path dependency),
- Cultural factors (attitudes...).

The underlying question is what motivates investments in R&D. Is it the perspective of future profits[9] or are these primarily "political" goals. Since the main provider of funding seems to be state, apparently political motivation prevails.

By the already mentioned GII and the European Innovation Scoreboard 2022 (Eurostat), Croatia is doing well, even a bit above expectations; but still is very much in the catch up phase. (For the EIS the average performance of emerging innovators is set at 50% of the European average and over the past years, Croatian performance gap to the EU is becoming smaller.)

On the negative side, the European Innovation Scoreboard also indicated that when it comes to R&D investments by the business sector, Croatia's position is at 40%, the percentage of spending by the business sector in Croatia is among the lowest in comparisons to most of the countries presented (compare to EU average at 57 and Euro Area at 58%). Similar findings were produced by a survey conducted by Aralica, Račić and Radić (2008). It confirmed that the private sector in Croatia has been rather inactive when it comes to R&D.

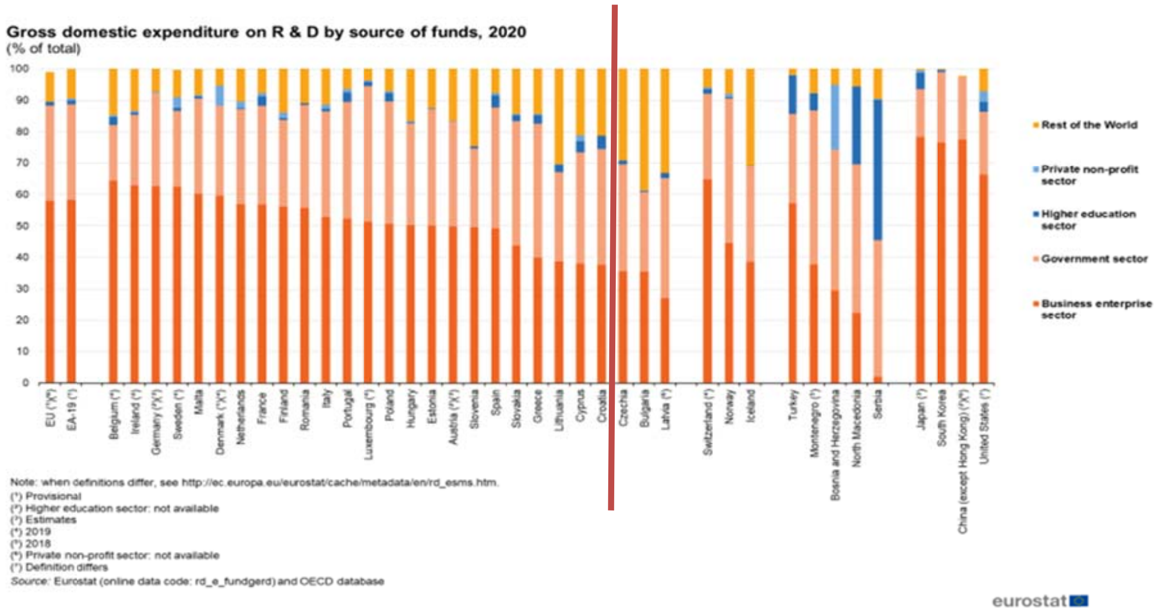
### 4.1. **Economic structure**

It is expected that the country's economic structure reflects of the structure of R&D spending. The OECD STI Scoreboard (2015, Chapter 5 - Competing in the Global Economy, pp. 188-189) stresses that intensity of R&D greatly varies across industrial sectors, and that adjusted business R&D intensity should be observed to draw the right conclusions on country performance. They also mention that, at the time, the economic structure of South and Eastern Europe countries is close to the OECD average; while countries like Germany, Belgium, France should be considered as countries that have some dominant industrial sectors that account for large parts of the country's R&D investments, or countries with specialized R&D activity.

A comparison of Croatian R&D spending to that of other European countries indicates that Croatian business sector share in R&D spending is one of the lowest in the EU (Figure 4).

[9] As we are trying to observe country level performance, profit seeking motivation would be tied to reliable incentives, or profit prospects generated by market trends and eventual institutional support (subsidies, tax incentives?) So, there a correlation of public and private R&D related spending is expected.

*Figure 4. Composition of R&D spending by sector*




Source: Eurostat

Since 2015, they fell by 36%. In fact, in terms of contribution to the overall country ranking, firm investments have deteriorated and aggregate rankings and come at 40% of the European average (Innovation Scoreboard, EIS Country profile, 2022). These are about the same figures as in 2013 (OECD, 2015), meaning past efforts by public authorities did not provide intended outcomes. The issue of who will finance innovation was elaborated recently by the WII report of 2020. One of the points stressed in the report concerns the role of venture capital for pursuing technological development and economic growth.

The figures also imply that it is governmental spending that makes up for the next 40% share of total national R&D spending. This puts the government in position to strongly affect the innovation behavior and performance in Croatia. However, it is doubtful whether the government can have a deep understanding of industry dynamics. We believe it would be preferable to have large business entities planning the investment in R&D; and that those might bring product and process innovation.

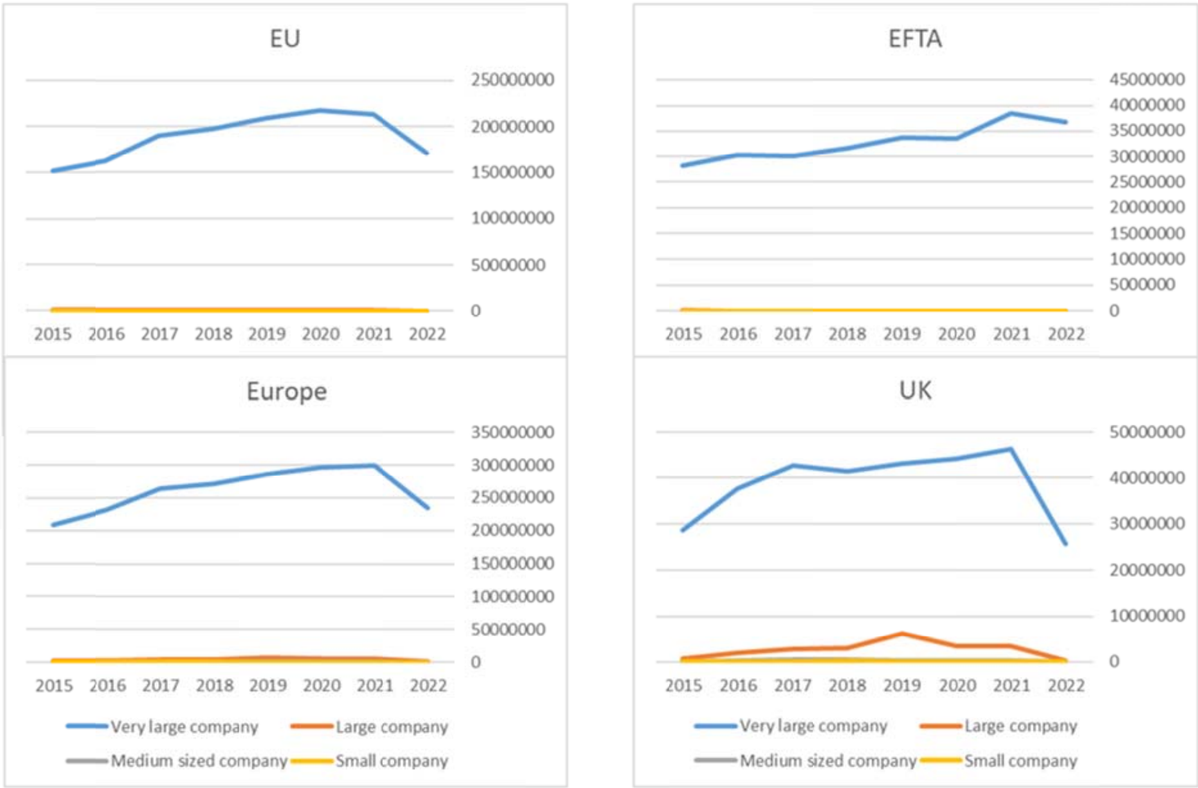
As a final note on the influence of the sectoral structure on R&D activity: Empirical data will suggest that some industry sectors are more technologically innovative than others. Such dynamism has recently been in the biotech industry, pharmaceutical industry, and financial industry with its “fintech” solution. In addition, some industries may attract more investor (or government) attention in specific circumstances or times. Such is the case of the pharma industry in recent years. For example, COVID related investments of private companies motivated by willingness of public authorities to increase health related spending increasing profit expectations, so the pharma industry was willing to activate their own resources. Concentrating on specific industries makes it easier to understand specific factors that drive innovation in particular moments in time.

4.2. **Size composition of the economy**

Another issue is size[10] along with the relative investment capacity of business entities.

Figure 5 reports on R&D intensity figures compiled by using the ORBID database. It clearly illustrates the dominance of large firms.

*Figure 5. R&D intensity in relation to size composition of the economy (by number of employees)*




Source: created by authors using ORBIS data

When it comes to sources of financing, it should be assumed that companies devoting funds to R&D are generally those making a profit. Often those are larger companies, likely to establish a more significant market presence making them more likely to make R&D commitments and enforce market strategies that will help them secure future profits.[11] Croatian companies do not enjoy size advantages on either European, or world markets. Therefore, it is unlikely they would be able likely to provide substantial investments in technological innovations, and protect profit margins from competitors even in the event of gaining patent protection.

[10] We are aware that the size composition of a national economy addresses questions broader than the issues of investment capacity or resource availability that again relies on competitive strategies, or the primary reasons that companies to invest in R&D.

[11] a dominant market position towards competitors and strong bargaining power with wholesalers, government funds…

*Table 2. Innovation profiles: Croatia compared to EU average*

| Innovation profiles | Croatia % | EU % |
|---|---|---|
| In-house innovators with market novelties | 9.7 | 10.7 |
| In-house product innovators without market novelties | 13.0 | 12.3 |
| In-house business process innovators | 7.8 | 11.0 |
| Innovators that do not develop innovations themselves | 7.1 | 11.6 |
| Innovation active non-innovators | 0.3 | 3.3 |
| Non-innovators with potential to innovate | 25.3 | 19.9 |
| Non-innovators without disposition to innovate | 36.9 | 31.5 |

Source: EIS (2022)

Going back to the sectoral (industry) structure, the EIS 2022 also provides a comparison of Croatia and the EU average. (Table 3- selected items).

*Table 3. Economic structure and performance*

| Selected items | Croatia % | EU % |
|---|---|---|
| GDP/c (ppp) | 20,900 | 31,200 |
| Employment share in Manufacturing | 17.8 | 16.4 |
| Turnover share of SMEs (%) | 42.6 | 34.8 |
| Turnover share of large enterprises (%) | 37.6 | 48.2 |
| Foreign controlled enterprises | 14.0* | 11.7 |
| Enterprise births (10+ employees) (%) | 2.5 | 1.0 |
| Total Entrepreneurial Activity (%) | 11.8 | 7.3 |
| FDI net inflows (%GDP) | 3.5 | 1.0 |
| Top R&D spending enterprises | 0.0 | 18.3 |
| Government procurement of advanced tech products | 2.5** | 3.5 |

* note that they contribute to 30% of R&D investment according to Figure 4 (rest of the world)
** It is likely that shares of government spending on R&D are related to defense, but we did not look at these figures

Source: EIS (2022)

A final note taken by looking at EI Scoreboard 2022 (time series 2015-2022) is that overall firm investment activity has been deteriorating year upon year. On the positive side, Innovating activity has increased, and so did intellectual assets.

## 4.3. Technology cycles and path dependency – when is the right moment and how much are we constrained by historical developments

It must be noted that best performing economies that are at the same time the economies growing at the fastest pace, such as China, or S. Korea (Japan included, have close to 80% of R&D spending being financed by the business sector.[12]

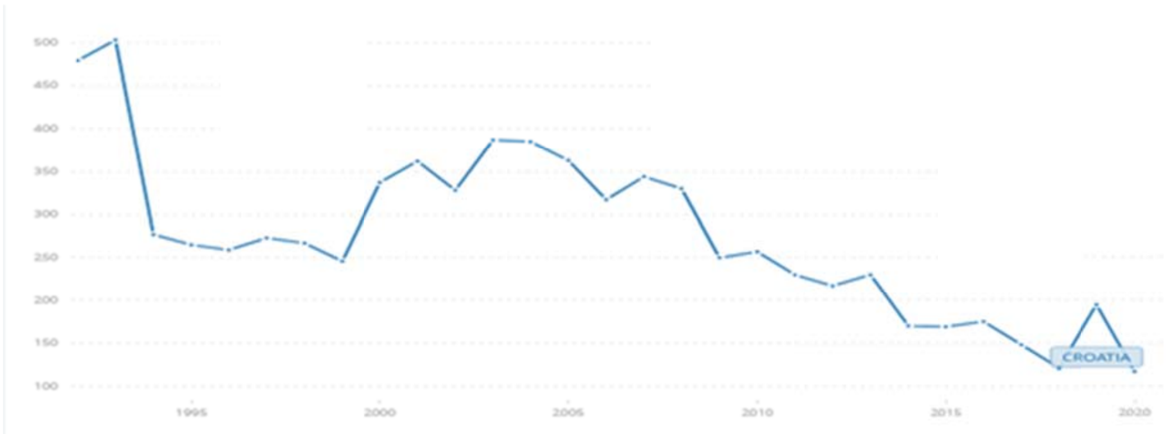
A possible indicating of the importance of historical trends can be found when looking at patent activity. The already mentioned Stern, Porter, Furman (2000) examined the patenting activity of 17 OECD countries in the period 1973-1996. Patents were considered as a "visible innovative activity". When technological development is measured by numbers of patents being issued, the US and Japan have been witnessing a surge of patents since the nineties.

[12] A question that comes to mind is whether it is structure of the economy, particularly the dominance of more "traditional" business sector in GDP formation, the main reason for small contribution to national R&D spending. Alternatively, is the structure just a reflection of historical developments, and (still) an "overgrown" governmental role in the economy.

Innovation activity was also growing in EU but at a slower pace. In term of number of patents, Croatia is doing worse than before.[13]

Figure 6 show the decrease in patent activity by Croatia resident companies in the past decades.

*Figure 6. Patent applications – residents - Croatia*




Source: WIPO

Some explanations for Croatian performance in GDP terms may be found in expectations that "The potential impact of investments in research and innovation on productivity growth is even higher for developing countries, given the opportunity for catching up…", as stressed by Lederman and Maloney (2003, p. 9).

However, if no policy efforts exist, there is little ground for expecting that things will change in the future. Historical examples will suggest that those countries that led an active policy were capable of achieving progress; if not in technology creation (high-tech), than at least at technology adoption.

## 5. CONCLUSIONS

It is indicative observation concerning Croatia is that R&D spending does not shadow GDP trends. R&D investment rates are low: The business sector has little participation in country R&D. Its already minor contribution has been declining.

Economic structure can be treated in different ways: by analyzing the national business sector by its composition in terms of economic classification of activities (technological dynamism, more or less innovative sectors), by looking at company size (resource endowment, investment capacity), by referent to particular industries and markets (bargaining positions). However, all these comparisons suggest that the situation will not be improving "spontaneously". Today, understanding the reasons for insufficient innovatory activity of Croatia is essential. The lag is particularly evident when R&D is observed by sectors; with the public sector research attracts funds and produces (academic) results, while the private sector remains less productive. During the past decade, when world level business R&D seems to be leading the race, the Croatia business sector investments have been declining.

[13] Nonresident applications have been even poorer. https://data.worldbank.org/indicator/IP.PAT.NRES?locations=HR

Relying on the Stern, Porter and Furman (2000) perspective it may be argued that not taking a micro perspective is one of the main explanations for why public policy and governments spending in R&D have failed to make a more profound impact on business sector innovativeness, as seems to be the case in Croatia. If industry structure is "weak" in terms of shares of technologically dynamic sectors; if companies do not stand out in terms of size and R&D investments capacity; if links between private and public STI are lacking or dysfunctional, negative trends will continue despite of rising of comparative macroeconomic indicators.

The only "unrestricted" force capable of breaking the circle of inertia can be provided through prompt governmental engagement in a way that will introduce incentives for applicative research and strengthen the support form of innovation of a lower profile, i.e. process innovations and strategic repositioning of firms on European, if not global markets. Basically, we rest on the premise that times of substantial unrest concerning the economic future are often open to new trajectories for developing technologies and business models. Consequently, national innovation policy should address issues concerning conditions of doing business (market settings, consumer expectations, policy measures) and support business sector resilience, so that companies themselves can advance their market position and dilute historical power asymmetries between small and companies and traditional industrial towards the new dynamic industrial sectors.

At this moment, we do NOT have much more that a compilation of theoretical elaborations of technology development, some insights on technology policies and some (illustrative) data gathered by consulting the literature and searching the internet. In the future, we plan to explore the situation/capabilities/prospects of Croatia concerning the preset state of R&D momentum and the availability of institutional support.

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## APPENDIX 1. PEARSON CORRELATION MATRIX FOR R&D IN GDP

| | | R&D in GDP | Post communist country | GDP | Employees per enterprise - manufacturing | SME turnover in manufacturing | Direct investment flows - Million ECU/EUR | Manufacturing / GDP | Computer programming, consultancy, and information service activities / Value added gross | HGE % | % Enterprises more than 250 | % Person employed im more than 250 | % of Turnover in more than 250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **R&D in GDP** | Pearson Correlation | 1 | | | | | | | | | | | |
| | Sig. (2-tailed) | | | | | | | | | | | | |
| | N | 30 | | | | | | | | | | | |
| Post communist country | Pearson Correlation | -.466** | 1 | | | | | | | | | | |
| | Sig. (2-tailed) | ,010 | | | | | | | | | | | |
| | N | 30 | 30 | | | | | | | | | | |
| GDP | Pearson Correlation | **,335** | -.363* | 1 | | | | | | | | | |
| | Sig. (2-tailed) | ,070 | ,049 | | | | | | | | | | |
| | N | 30 | 30 | 30 | | | | | | | | | |
| Employees per enterprise - manufacturing | Pearson Correlation | **,333** | -,289 | .374* | 1 | | | | | | | | |
| | Sig. (2-tailed) | ,083 | ,136 | ,050 | | | | | | | | | |
| | N | 28 | 28 | 28 | 28 | | | | | | | | |
| SME turnover in manufacturing | Pearson Correlation | **-,314** | ,134 | -,336 | -.409* | 1 | | | | | | | |
| | Sig. (2-tailed) | ,098 | ,490 | ,075 | ,034 | | | | | | | | |
| | N | 29 | 29 | 29 | 27 | 29 | | | | | | | |
| Direct investment | Pearson Correlation | **,167** | ,218 | ,152 | -.447* | -,017 | 1 | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| flows - Million ECU/EUR | Sig. (2-tailed) | ,405 | ,274 | ,450 | ,022 | ,932 | | | | | | | |
| | N | 27 | 27 | 27 | 26 | 27 | 27 | | | | | | |
| Manufacturing / GDP | Pearson Correlation | **,086** | ,307 | ,090 | -,011 | -.418* | ,358 | 1 | | | | | |
| | Sig. (2-tailed) | ,650 | ,099 | ,635 | ,955 | ,024 | ,067 | | | | | | |
| | N | 30 | 30 | 30 | 28 | 29 | 27 | 30 | | | | | |
| Computer programming, consultancy, and information service activities / Value added gross | Pearson Correlation | **-,149** | .403* | -,177 | ,075 | ,037 | -,044 | ,011 | 1 | | | | |
| | Sig. (2-tailed) | ,476 | ,046 | ,398 | ,727 | ,865 | ,841 | ,958 | | | | | |
| | N | 25 | 25 | 25 | 24 | 24 | 23 | 25 | 25 | | | | |
| HGE % | Pearson Correlation | **,228** | -,116 | -,022 | ,026 | -,252 | -,141 | ,042 | -,113 | 1 | | | |
| | Sig. (2-tailed) | ,252 | ,565 | ,913 | ,901 | ,206 | ,502 | ,834 | ,608 | | | | |
| | N | 27 | 27 | 27 | 26 | 27 | 25 | 27 | 23 | 27 | | | |
| % Enterprises more than 250 | Pearson Correlation | **,148** | -,264 | ,284 | .944** | -.424* | -.473* | -,049 | ,258 | ,032 | 1 | | |
| | Sig. (2-tailed) | ,453 | ,174 | ,143 | ,000 | ,025 | ,015 | ,804 | ,235 | ,877 | | | |
| | N | 28 | 28 | 28 | 26 | 28 | 26 | 28 | 23 | 26 | 28 | | |
| % Person employed im more than 250 | Pearson Correlation | .484* | -.440* | .515** | .423* | -.747** | -,150 | ,143 | ,141 | ,170 | .437* | 1 | |
| | Sig. (2-tailed) | ,011 | ,022 | ,006 | ,035 | ,000 | ,475 | ,476 | ,532 | ,416 | ,023 | | |
| | N | 27 | 27 | 27 | 25 | 27 | 25 | 27 | 22 | 25 | 27 | 27 | |
| % of Turnover in more than 250 | Pearson Correlation | .426* | -,312 | .661** | ,317 | -.850** | ,148 | ,245 | -,120 | ,022 | ,269 | .831** | 1 |
| | Sig. (2-tailed) | ,030 | ,121 | ,000 | ,123 | ,000 | ,491 | ,228 | ,595 | ,916 | ,184 | ,000 | |
| | N | 26 | 26 | 26 | 25 | 26 | 24 | 26 | 22 | 25 | 26 | 26 | 26 |

## APPENDIX 2. PEARSON CORRELATION MATRIX FOR PATENTS APPLICATIONS PER MILLION INHABITANTS

| | | Patents appli. per milion inhabitants | Post communist country | GDP | Employees per enterprise - manufacturing | SME turnover in manufacturing | Direct investment flows - Million ECU/EUR | Manufacturing / GDP | Computer programming, consultancy, and information service activities / Value added gross | HGE % | % Enterprises more than 250 | % Person employed im more than 250 | % of Turnover in more than 250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patents appications per milion inhabitants | Pearson Correlation | 1 | | | | | | | | | | | |
| | Sig. (2-tailed) | | | | | | | | | | | | |
| | N | 30 | | | | | | | | | | | |
| Post communist country | Pearson Correlation | -.529** | 1 | | | | | | | | | | |
| | Sig. (2-tailed) | ,003 | | | | | | | | | | | |
| | N | 30 | 30 | | | | | | | | | | |
| GDP | Pearson Correlation | ,163 | -.363* | 1 | | | | | | | | | |
| | Sig. (2-tailed) | ,390 | ,049 | | | | | | | | | | |
| | N | 30 | 30 | 30 | | | | | | | | | |
| Employees per enterprise - manufacturing | Pearson Correlation | .709** | -,289 | .374* | 1 | | | | | | | | |
| | Sig. (2-tailed) | ,000 | ,136 | ,050 | | | | | | | | | |
| | N | 28 | 28 | 28 | 28 | | | | | | | | |
| SME turnover in manufacturing | Pearson Correlation | -.418* | ,134 | -,336 | -.409* | 1 | | | | | | | |
| | Sig. (2-tailed) | ,024 | ,490 | ,075 | ,034 | | | | | | | | |
| | N | 29 | 29 | 29 | 27 | 29 | | | | | | | |
| Direct investment flows - Million ECU/EUR | Pearson Correlation | -.572** | ,218 | ,152 | -.447* | -,017 | 1 | | | | | | |
| | Sig. (2-tailed) | ,002 | ,274 | ,450 | ,022 | ,932 | | | | | | | |
| | N | 27 | 27 | 27 | 26 | 27 | 27 | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing / GDP | Pearson Correlation | -,042 | ,307 | ,090 | -,011 | -.418* | ,358 | 1 | | | | | |
| | Sig. (2-tailed) | ,824 | ,099 | ,635 | ,955 | ,024 | ,067 | | | | | | |
| | N | 30 | 30 | 30 | 28 | 29 | 27 | 30 | | | | | |
| Computer programming, consultancy, and information service activities / Value added gross | Pearson Correlation | ,014 | .403* | -,177 | ,075 | ,037 | -,044 | ,011 | 1 | | | | |
| | Sig. (2-tailed) | ,946 | ,046 | ,398 | ,727 | ,865 | ,841 | ,958 | | | | | |
| | N | 25 | 25 | 25 | 24 | 24 | 23 | 25 | 25 | | | | |
| HGEs % | Pearson Correlation | .385* | -,116 | -,022 | ,026 | -,252 | -,141 | ,042 | -,113 | 1 | | | |
| | Sig. (2-tailed) | ,047 | ,565 | ,913 | ,901 | ,206 | ,502 | ,834 | ,608 | | | | |
| | N | 27 | 27 | 27 | 26 | 27 | 25 | 27 | 23 | 27 | | | |
| % Enterprises more than 250 | Pearson Correlation | .693** | -,264 | ,284 | .944** | -.424* | -.473* | -,049 | ,258 | ,032 | 1 | | |
| | Sig. (2-tailed) | ,000 | ,174 | ,143 | ,000 | ,025 | ,015 | ,804 | ,235 | ,877 | | | |
| | N | 28 | 28 | 28 | 26 | 28 | 26 | 28 | 23 | 26 | 28 | | |
| % Person employed im more than 250 | Pearson Correlation | .616** | -.440* | .515** | .423* | -.747** | -,150 | ,143 | ,141 | ,170 | .437* | 1 | |
| | Sig. (2-tailed) | ,001 | ,022 | ,006 | ,035 | ,000 | ,475 | ,476 | ,532 | ,416 | ,023 | | |
| | N | 27 | 27 | 27 | 25 | 27 | 25 | 27 | 22 | 25 | 27 | 27 | |
| % of Turnover in more than 250 | Pearson Correlation | ,327 | -,312 | .661** | ,317 | -.850** | ,148 | ,245 | -,120 | ,022 | ,269 | .831** | 1 |
| | Sig. (2-tailed) | ,103 | ,121 | ,000 | ,123 | ,000 | ,491 | ,228 | ,595 | ,916 | ,184 | ,000 | |
| | N | 26 | 26 | 26 | 25 | 26 | 24 | 26 | 22 | 25 | 26 | 26 | 26 |