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THE INNOVATION LANDSCAPE AFTER THE COVID-19 CRISIS AND DURING THE ENERGY CRISIS

Abstract. The aim of this paper is finding an answer to a question how the current crises caused by the Covid-19 pandemic and changes in the energy sector have affected research and development and innovation? It seems likely that the COVID-19 crisis caused financial weakness for many actors, having the most significant impact on the willingness or ability of smaller firms to support R&D and innovation. However, where firms are able to sustain these investments, they will be more likely to survive, grow more strongly, and have higher profitability. A big challenge that companies face is energy changes. While the post-pandemic effects were slowly brought under control by enterprises, the energy crisis poses new challenges to companies. And here the most important challenge is not just financing, but sometimes a complete change in the line of products offered, by moving away from traditional energy sources based on oil and gas. The subjects of the analysis are companies in Poland engaged in continuous research and development activities and implementing innovations. This research was conducted by the Ayming Institute in several editions, starting in 2020, and the surveyed companies belonged to seven identified sectors: Chemical and Civil Engineering, IT & Telecoms, Energy & Biotech, Automotive & Industrial, Consumer Goods & Manufacturing, Healthcare & Pharmaceuticals and Finance & Capital.

Keywords: crisis, COVID-19, R&D, innovation, energy crisis.

The nature of the COVID-19 crisis

According to the business cycle theory, crisis follows periods prosperity is an inevitable event, what is surprising in the pandemic crisis Covid-19. Pandemic COVID-19, also known as the coronavirus pandemic, is a global disease outbreak. The pandemic has caused global economic disruption, including the largest global recession since the Great Depression [Protasiewicz, 2021, p. 486]. The crisis resulting from the COVID-19

pandemic shares two important similarities with the Great Financial Crisis of 2008–2010. First, in both cases there were or are acute exogenous shocks rather than business cycle fluctuations. Second, in both cases, firms suffered from sharp liquidity squeezes – in the case of the financial crisis a decade ago, from a sharp reduction in the availability of commercial financing, and in the case of the COVID-19 crisis, from a sharp reduction in turnover. In both cases, financial stringency will force companies to make quick strategic decisions on areas of spending and potential savings (Roper, Turner, 2020, p. 510–511). But the COVID-19 crisis differs from the previous collapse, including external shock affecting mainly market dynamics through a decline in demand. The direct supply-side effects of the 2007–2009 crisis were mainly confined to the financial and banking sectors. The disruptions at the industrial level were a consequence of the progressive recession rather than of the crisis itself. There was an economic shock that affected the economic system, but to a limited extent. In turn, a pandemic crisis differs in the scope of its consequences (physical and mental health, economic welfare, social changes), as well as in its geographical scope (global nature). Therefore, its impact on innovation or innovativeness is different – the importance of technology or technical and scientific knowledge is emphasized, as well as difficulties in accessing resources on a global scale (Dahlke et al., 2021, p. 3).

The pandemic crisis did not affect all entities in the same way. On the one hand, the consequences of the outbreak of the pandemic differed in differentneconomies of the world in terms of the number of infections in relationnto the number of people and the way in which the situation was dealt with.nCountries often applied different lockdown policies, which had an impactnon the economic situation. The sectors that were particularly affected were:ntourism, hotel industry, gastronomy, trade and entertainment and culturenindustry (Brem, Viardot, Nylund, 2021, p. 2).

The cessation of operations due to the COVID-19 pandemic had a tremendous impact on the financial position of companies, which deteriorated significantly overnight. Those entities that were not generating high financial surpluses lost liquidity very quickly. The onset of the crisis often means a reduction of financial resources for investment in enterprises. Long-term goals, which can be achieved by investing in research and development and developing innovative solutions, are put on the back burner. However, where companies are able to sustain these investments, evidence from the previous financial crisis of 2008–2010 suggests that they will have a better chance of survival, stronger growth and higher profitability. Innovative entities are less adversely affected by the economic crisis and have a higher

rate of growth. High-tech enterprises are characterized by highly developed adaptation abilities, which are crucial in case of sudden market changes (Spescha, Woerter, 2019, p. 324–330).

Numerous international studies show a strong pro-cyclicality of R&D and innovation investment in firms, meaning that investment rises during economic upturns and falls sharply in times of crisis. This procyclicality is due both to a firm's internal financial resources and to differences in market incentives to innovate (Rhaiem, Amara, 2019, p. 195–230).

According to OECD research, companies in Europe and the United States that invested heavily in R&D relatively quickly improved their product sales (OECD, 2012, p. 45–50). Similar conclusions are provided by research conducted by the Institute of Economics of the Polish Academy of Sciences (Instytut Nauk Ekonomicznych Polskiej Akademii Nauk, 2012, p. 13–19).

This correlation is primarily due to the fact that innovation allows you to gain a competitive advantage. This applies not only to individual enterprises, but also to entire branches of the economy, regions or countries. Innovations, especially in times of crisis, become the driving force of the economy and an important factor of modernization. At the same time, they build the foundations for sustainable economic growth. Despite the crisis in 2008, most European countries noted an increase in the innovative potential of their economies. One of the key success factors was a smoothly functioning system of links between the government, the scientific community and various sectors of industry. Pro-innovative countries also gave companies access to various sources of innovation financing, including public funds, tax breaks, loans, credit guarantees and offered support for micro and small enterprises (López-García, Montero Moral-Benito, 2013, p. 625–636).

Arguably, the effects of a pandemic will not be the same for all firms. Evidence in the aftermath of the Great Depression of 2008–2010 suggests that firms that entered the COVID-19 crisis with greater cash reserves may also emerge stronger from the crisis because tightening credit constraints during the crisis allowed these firms to gain a strategic advantage over financially constrained competitors. Continuing to invest during the crisis allowed companies to gain a competitive advantage that also persisted during the recovery. Having financial reserves at the onset of a crisis gives companies a significant advantage in both the short and long term (Joseph, Kneer, van Horen, 2020, p. 13–18).

Moreover, once the crisis has abated, firms with more financial backing may be able to undertake different types of innovation (more radical and risky) than more financially constrained firms (Latham, Braun, 2008,

p. 40–47). Entities with higher financial backing are more likely to engage in collaborative research activities that drive radical innovation, while firms with low financial backing are more likely to engage in short-term support and problem-solving activities that tend to lead to incremental innovation (La Rocca, Staglianò, 2019, pp. 1056–1068 oraz Bruneel, D'Este, Salter, 2016, p. 696–700).

Based on the post-crisis research conducted between 2008 and 2010, it has also been observed that companies that are able to sustain their research activities gain a significant advantage when the post-crisis recovery emerges. This is because those that continue to invest in R&D and innovation during the crisis tend to focus their efforts on: increasing productivity; better adapting to the changing needs and demands of suppliers, consumers and other stakeholders; and increasing organizational resilience (Flammer, Ioannou, 2015, p. 13–17). In addition, the experience of innovation during recessionary periods strengthens a company's ability to invest in R&D during a new crisis (Amore, 2015, p. 1574–1583).

Although it is not known what the post-pandemic world will look like, based on the analysis of the current situation, it is possible to outline the most likely economic phenomena that will shape the new reality. They may occur simultaneously or one of them will become the most dominant. Although nothing can be certain, the current situation already shows that companies are facing accelerated digital transformation and the need to invest in innovative solutions.

The Innovation Landscape after the COVID-19 crisis – analisys

Interest in R&D, and more broadly in innovation activity, is motivated by its importance, which is expressed in many dimensions. In particular, it is noted that innovation drives economic growth, increases employment and income, contributes to the quality of life and competitiveness of nations (Atkinson, Ezell, 2014, p. 130). Innovation activities have a measurable impact on the performance of firms. In this context, it is argued, among other things, that innovation has a positive impact on the probability of survival of firms (Cefis, Marsili, 2006, pp. 63), R&D intensity significantly increases the future profitability of companies (Grabińska, Grabiński, 2018, p. 58–59), and firms engaged in R&D have higher productivity growth than non-innovative firms (Medda, Piga, 2014, p. 428–429).

After the Covid-19 pandemic, most bussiness have faced circumstances that have demanded rapid adaptation. And as you know, it is how businesses

have reacted that will determine their future success. History tells that it's vital to innovate through a period of significant change. However, did most enterprises intensify or maintain the level of research and development work during and after the crisis?

The Ayming Institute conducted Innovation Barometer research in most European countries, before and after the crisis. The Ayming Institute's research on the "International Innovation Barometer" has been conducted every year since 2020. The report presents a detailed and comprehensive look at research and development activities in several countries around the world, including Poland. Wyniki tych analiz otrzymano na podstawie szczegółowych ankiet, które zostały przeprowadzone w poszczególnych państwach, na grupie kilkuset podmiotów należących do sektorów: Chemical and Civil Engineering, IT & Telecoms, Energy & Biotech, Automotive & Industrial, Consumer Goods & Manufacturing, Healthcare & Pharmaceuticals and Finance & Capital.

Unfortunately, the results in Poland differ in many aspects compared to the above-mentioned theory. Importantly, most of the surveyed sectors showed that the amount of work in the field of innovation/research and development increased compared to 2022, when large declines in this aspect were observed (Table 1).

Table 1

Does organisations undertake enough innovation/reasearch and development (R&D) work? (%)

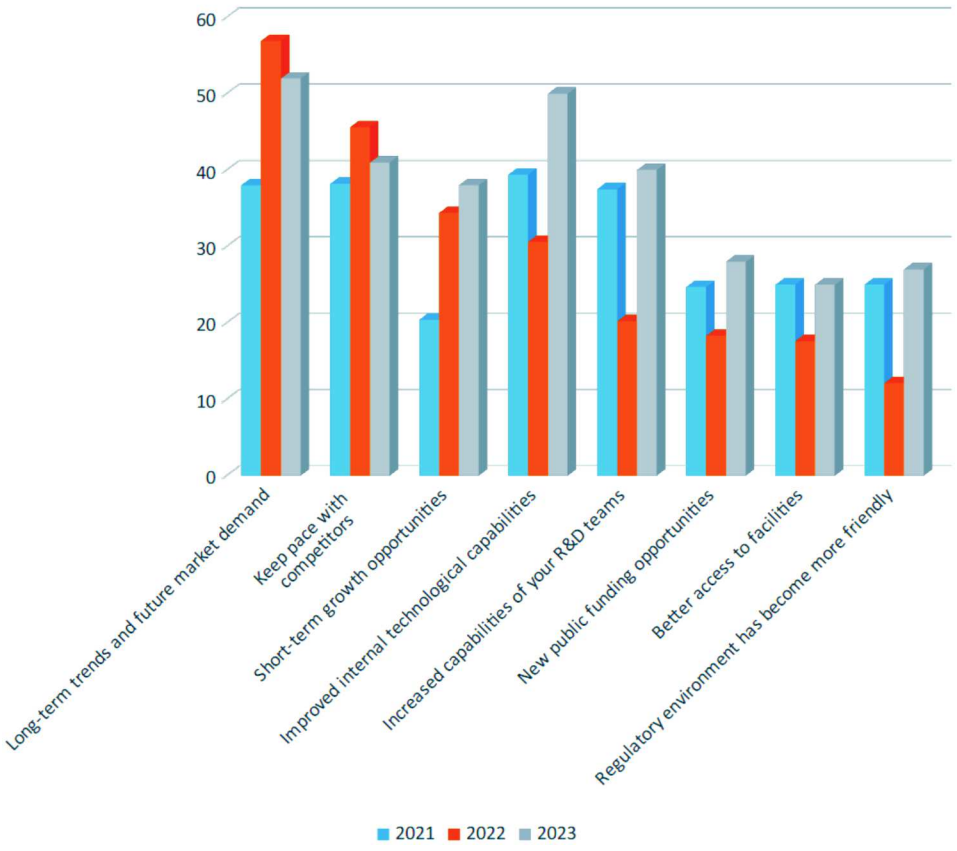
Does your organisation undertake enough innovation/ reasearch and development (R&D) work? (%)	2021			2022			2023		
	Yes	No	Don't know	Yes	No	Don't know	Yes	No	Don't know
Chemical and Civil Engineering	86,70	13,30	0,00	68,40	26,30	5,30	62,00	32,00	6,00
IT & Telecoms	92,30	7,70	0,00	75,80	17,70	6,50	68,00	25,00	7,00
Energy & Biotech	100,00	0,00	0,00	77,40	22,60	0,00	82,00	18,00	0,00
Automotive & Industrial	81,80	18,20	0,00	64,00	28,00	8,00	73,00	16,00	11,00
Consumer Goods & Manufacturing	87,00	5,60	7,40	69,80	24,40	5,80	78,00	19,00	3,00
Healthcare & Pharmaceuticals	78,20	18,00	3,80	63,60	27,30	9,10	76,00	19,00	5,00
Finance & Capital	90,10	8,80	1,10	74,30	20,10	5,60	79,00	16,00	5,00

Source: [based on Amar and others, 2021, p. 6; Amar and others, 2022, p. 6; Amar and others, 2023, p. 12]

In 2023 year, some sectors are marginally more confident, saying they are doing enough innovation and up eleven per cent from last year (average for sectors that increased the level of innovation). These are the sectors: Energy & Biotech, Automotive & Industrial, Consumer Goods & Manufacturing, Healthcare & Pharmaceuticals and Finance & Capital. However, this is still down 10–20 per cent from prior to the pandemic and 20–30 per cent of firms say they are not doing enough innovation. For comparison, in 2021 there were approximately 5–18% of such enterprises.

What has also changed is the main approach to strategy in conducting research and development (Figure 1).

Figure 1. What are the main drivers for R&D strategy? (%)

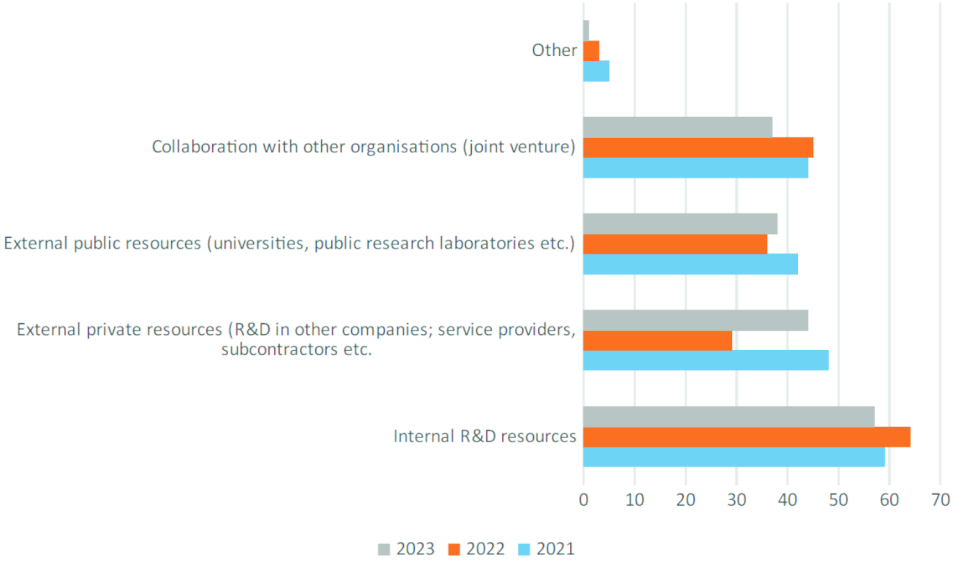


Source: [based on Amar and others, 2021, p. 8; Amar and others, 2022, p. 8; Amar and others, 2023, p. 14].

In 2021, the most important factor influencing the strategy of R&D activities was the improvement of internal technological capabilities. After the pandemic, this factor is no longer considered the most important, because now the key factor is to focus on long-term trends and future market demand. Nevertheless, both factors mentioned are crucial today when adopting an R&D strategy. Moreover, post-pandemic, short-term growth opportunities are an important factor influencing the choice of R&D strategy. This seems understandable, due to the fact that today's crises teach entrepreneurs to build not only long-term innovation policies, but also short-term ones, in order to flexibly adapt to dynamically changing conditions.

Post-pandemic, there are also some changes in R&D funding (Figure 2).

Figure 2. What resources rely on for innovation/R&D?



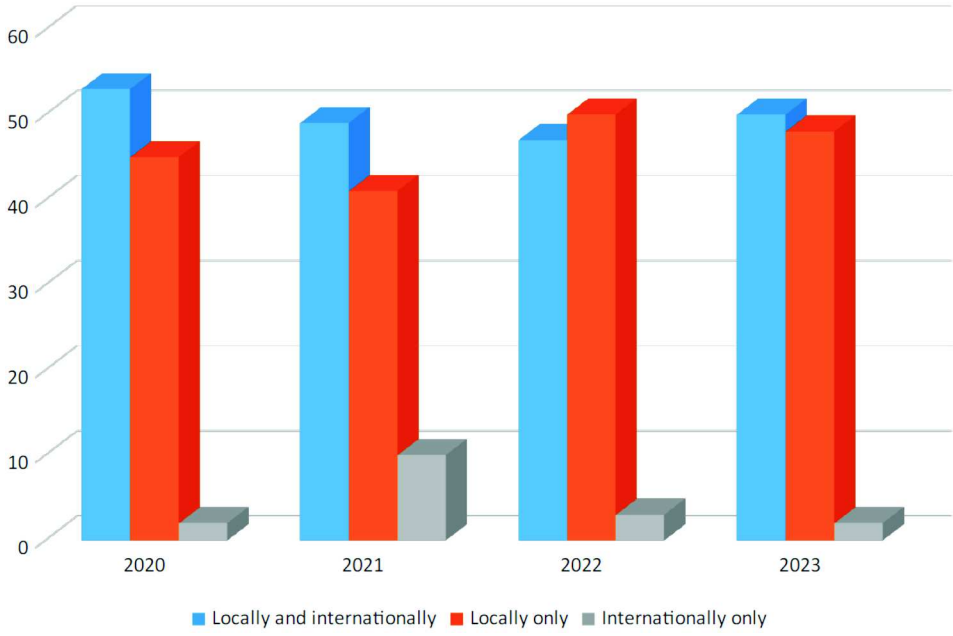
Source: [based on Amar and others, 2021, p. 10; Amar and others, 2022, p. 9; Amar and others, 2023, p. 16]

When it comes to the resources firms rely on for innovation, the overall picture is one of growing dependence on internal R&D resources, because firms stuck with the trusted and familiar resources over the past months. Why? Because there is a certain reliability and agility that comes with internal resources, something that will have been and will be very important in the in the following years. However, the biggest increase has been among external private resources, which has shot up 15 per cent on last year from 29 per cent to 44 per cent, almost at prepandemic levels.

In last year (2022), firms took activity in-house, this year has seen a reduction in internal resources and a rise in external public and private resources as have opened up from the pandemic. However, own funds still significantly dominate. Financing R&D activities mostly with own funds is very risky, especially when the world is in crisis. Due to the outbreak of the COVID-19 pandemic, many entrepreneurs were forced to revise their plans and minimize spending on R&D. Before the pandemic, most entities planned to increase their R&D budgets over the next three years. In the current situation, a large percentage of research entities limit this type of spending, due to cost-cutting in other areas of business activity, although in full awareness that the resulting innovations (the effect of R&D activity) could contribute to faster growth in subsequent periods. Therefore, reaching for external financing may turn out to be not only an additional factor intensifying innovative activity in a company, but in many cases, even a way to sustain R&D activity in the times of the economic slowdown (PFR, 2021, p. 1).

What is very surprising, as a result of the analysis, is that innovations are more local, rather than international, after the pandemic (Figure 3).

Figure 3. Is innovation locally, internationally, or both?



Source: [based on Amar and others, 2020, p. 16; Amar and others, 2021, p. 12; Amar and others, 2022, p. 10; Amar and others, 2023, p. 18]

In 2020, by far more innovations were mixed (local and international). Now, in 2023, companies still prefer this style of innovation, but the local nature of innovation has become very important. Arguably, this was influenced not only by the timing of the pandemic itself, but also by the subsequent war in Ukraine and the increase in energy commodity prices.

However, it should be emphasized that the Covid-19 pandemic has had an unequal impact on innovation in all industries, which is an obvious conclusion. However, it may come as a surprise that innovations have accelerated dramatically not only in the Healthcare & Pharmaceuticals sector, but also in the following sectors: IT & Telecoms, Finance & Capital and Energy & Biotech. The sectors that suffered the most in terms of innovation after the pandemic are: Automotive & Industrial, Consumer Goods & Manufacturing (Table 2).

Table 2

How has the Covid-19 crisis impacted innovation in market?

How has the Covid-19 crisis impacted innovation in market?	Innovation stalled	Innovation has remained the same	Innovation accelerated a little	Innovation drastically accelerated	Don't know
Chemical and Civil Engineering	14,7	26,3	35,9	16,8	6,3
IT & Telecoms	12,1	15,3	37,9	32,3	2,4
Energy & Biotech	19,4	22,6	32,3	25,7	0,0
Automotive & Industrial	24,0	34,0	22,0	18,0	2,0
Consumer Goods & Manufacturing	20,9	37,2	23,3	15,1	3,5
Healthcare & Pharmaceuticals	9,1	20,0	40,0	27,3	3,6
Finance & Capital	11,1	22,9	33,3	27,8	4,9

Source: [based on Amar and others, 2022, p. 28]

It should be noted, however, that while some industries have been more affected by the pandemic, all sectors are showing an increase in R&D activity, to a greater or lesser extent, in 2023. If anything, the pandemic has proved that necessity is indeed the mother of invention. Already, have seen the emergence of pandemic-induced innovation, and there is surely plenty more in development.

Kinga Karpińska

Impact of crises (Covid-19 pandemic, energy crisis) on R&D activities – recommendations for the future

As it turns out, the Covid-19 pandemic is just one of the causes, hampering the innovation activities of companies. Another important factor for companies to consider in the coming years is the energy crisis, sparked by the war in Ukraine. The energy crisis has spread across Europe at an alarming rate. Economies that were and still are dependent on fossil fuels and obtain energy from foreign sources, without ensuring internal energy diversification, were particularly severely hit. The pandemic and its consequences determine the experience with which companies entered the current energy crisis. The energy crisis also has a geopolitical dimension and has posed new challenges for the entire world: ensuring economic, energy and food security. The greatest effects in the case of such shocks are visible in open economies that have been strongly impacted by the globalization process, and broken supply chains have shown how important it is to diversify supply sources and choose local and predictable contractors. Economies that base their production on energy from fossil fuels and are dependent on energy sources from Russia have been particularly hit by the problem of lack of diversification and security of supplies during the energy crisis. These are undoubtedly the consequences of many years of policy of the governments of individual countries and the chosen geopolitical directions (Lewiatan, 2023, p. 2–4).

Businesses across all sectors are feeling the squeeze. This growth is so significant that it has made some business models unprofitable and therefore unnecessary. Inevitably, these ripple effects affect some companies more than others. For most businesses the energy cost increase is affecting profitability. Predictably, the manufacturing sector is most at risk and at least the technology sector. Technology firms and other professional services are definitely less dependent on energy consumption, especially considering the recent transition to remote working. But it's possible some of these companies are underestimating the risk they face from energy (Anandan, Muthusubramanian, Ramaswamy, 2022, p. 807–809).

It is currently accepted that if one of largest costs doubles, absolutely going to be looking to innovate around that, either to reduce your reliance on it or remove it altogether. Just not going to rely upon that cost potentially going down in the future and losing money in the short to medium term. It's a severe shock to your business and something needs to change. These pressures have jolted companies into action, to make more radical changes. There is a shift away from traditional new product-oriented inno-

vation, and changes across the entire product lines are increasingly being observed (Shtunder, Kushnir, Perevozova, Kalinina, Savchenko, Nitsenko, 2022, p. 156–161).

Without any doubt, the energy crisis is threatening the survival of countless companies. Now, in attempts to weather the storm, companies are deploying a range of cost-cutting strategies, with sustainability being the core beneficiary. But the huge upfront costs involved in making the necessary changes means governments would do well to expand funding and use the biggest range of incentives possible, with a combination of subsidies, grants, credits and other initiatives. This brings to the all-important silver lining: sustainability. The energy crisis and the rise in fossil fuel prices is a natural catalyst for the transition towards greener energy. There's already a drive to reduce carbon footprints and many businesses declare intentions to reduce their carbon footprint. But progress has been slow. Businesses were previously working with more generous timelines, such as becoming carbon neutral by 2030. Now, the increase in costs has made change a necessity (Prokopowicz, 2022, p. 7–9).

However, certain resources are also needed to make these changes. First, increasing the role of external funding for innovation. The key barriers to developing innovation in companies are high costs and lack of sufficient funding. Before the coronavirus pandemic, most of the surveyed entities planned to increase their R&D budgets over the next three years. Unfortunately, due to the COVID-19 crisis and the energy crisis, many entrepreneurs were forced to revise their plans and minimize spending. In this situation reaching for external financing may turn out to be not only an additional factor intensifying innovative activity in a company, but in many cases even a way to sustain R&D activity in times of economic slowdown. Governments need to step up and support companies to navigate the energy crisis. Although lots of incentives are linked to decarbonisation already, governments must think carefully about their method of financing and ensure they have a range of support mechanisms to stimulate the energy transition. Grants are most commonly associated with funding sustainability. These are a very valuable funding mechanism, but the funding looks to solve a specific problem, is not available to everyone, and applications are onerous. Therefore, businesses cannot rely on them solely. Tax credits are a guaranteed way to secure funding for green innovation. However, tax credits are also restricted to some extent. To be eligible, the activity has to resolve a technical issue, meaning a lot of straightforward but potentially expensive changes businesses make to reduce energy use are not eligible for R&D tax credits. As a solution and to stimulate action, governments can expand funding to any

and all projects that reduce a company's carbon footprint. This would be a much broader criteria than the tax credit and include changes outside of technical R&D – simple but valuable actions like localising manufacturing (Piotrowski, 2021, p. 60–63).

Secondly, creating a culture of innovation, with particular emphasis on sustainable development. This means a much higher level of this culture, because in addition to the sheer focus on innovation, solutions to reduce energy consumption should be considered first and foremost. For some companies, these solutions will lead to radical changes, such as a complete shift away from oil and gas-based production. Another of the options is to look for alternative energy sources or changing energy supplier. The idea is to get the most energy for the best price. There are potentially big savings to be made through changing Tariff schemes, reviewing tax, implementing efficiencies plans or even planning energy use at times of year where there is less strain on the national network (Shtunder, Kushnir, Perevozova, Kalinina, Savchenko, Nitsenko, 2022, p. 156–161).

Another option is to look at supply chains, whether that's assessing where you source materials or how you transport it. On par with alternative materials, a lot of businesses are trying to source materials more locally. The last few years and the supply chain disruption from Covid-19 and the energy crisis encourag the localisation of supplies. The increase in the cost of importing goods has made locally sourced goods more affordable (Prokopowicz, 2022, p. 6–7).

Conclusions

In conclusion, both after the COVID-19 crisis and during the energy crisis, the innovation landscape is being transformed. The new challenges posed by these crises are prompting the search for innovative solutions, changes in approaches to technology, and the adaptation of business to new conditions.

Given the upheaval faced over the 2020–2021 years, it is perhaps not surprising that many businesses have struggled to innovate as much as they might like. They are in fact dependent on, among others, on the level of financial liquidity of enterprises and the level of general economic risk during their implementation. Investing in research and development is therefore pro-cyclical, just like most of the company's investment activities.

This is reflected in the general shape of R&D activity. Companies are more likely than in the past to depend on their own internal resources

to innovate and slightly less likely to look to international innovation efforts to drive progression. Why? Because there is a certain reliability and agility that comes with internal resources, something that will have been and will be very important in the in the following years. Financing R&D activities mostly with own funds is very risky, especially when the world is in crisis. Due to the outbreak of the COVID-19 pandemic, many entrepreneurs were forced to revise their plans and minimize spending on R&D. Before the pandemic, most entities planned to increase their R&D budgets over the next three years. In the current situation, a large percentage of research entities limit this type of spending, due to cost-cutting in other areas of business activity.

Before and during the pandemic, the most important factor influencing the strategy of R&D activities was the improvement of internal technological capabilities. After the pandemic, this factor is no longer considered the most important, because now the key factor is to focus on long-term trends and future market demand. Nevertheless, both factors mentioned are crucial today when adopting an R&D strategy. Moreover, post-pandemic, short-term growth opportunities are an important factor influencing the choice of R&D strategy. This seems understandable, due to the fact that today's crises teach entrepreneurs to build not only long-term innovation policies, but also short-term ones, in order to flexibly adapt to dynamically changing conditions.

However, it should be emphasized that the Covid-19 pandemic has had an unequal impact on innovation in all industries, which is an obvious conclusion. However, it may come as a surprise that innovations have accelerated dramatically not only in the Healthcare & Pharmaceuticals sector (for obvious reasons), but also in the following sectors: IT & Telecoms, Finance & Capital and Energy & Biotech. The sectors that suffered the most in terms of innovation after the pandemic are: Automotive & Industrial, Consumer Goods & Manufacturing. It should be noted, however, that while some industries have been more affected by the pandemic, all sectors are showing an increase in R&D activity, to a greater or lesser extent, in 2023.

Currently, the energy crisis is a major obstacle to conducting innovative activities. This crisis followed two years of restrictions on economic activity, which in turn were a response to the coronavirus pandemic. The crises have led to significant increases in energy prices and uncertainty over energy security, as well as concerns about further increases in consumer prices and rising costs of living.

As a result, many companies, especially those that depend on heavy energy consumption, are struggling with higher bills, which greatly affects

their profitability. So companies are being forced to adjust their business models to minimize the impact of the energy crisis. This may include seeking alternative energy sources, optimizing energy processes and developing energy efficiency strategies. At the same time, the energy crisis can stimulate energy innovation. Companies can engage in research and development of new technologies that are more efficient, sustainable and less dependent on traditional energy sources.

Undoubtedly, these could be good developments, as interest in renewable energy sources is growing, but it should be remembered that these types of solutions are primarily more costly. Undoubtedly, these could be good developments, as interest in renewable energy sources is growing, but it should be remembered that these types of solutions are primarily more costly. And with a large percentage of companies funding R&D from their own resources, this may be the most important barrier to further funding. Therefore, it would be appropriate to think about systemic solutions that would support this type of innovative activity more intensively than at present.

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