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Boosting Effect of Startup Ecosystems through Next Generation Digital Technologies in Hungary[1]

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In time of crisis, developing Next Generation Digital Technologies in the innovation network, with special attention to startup companies, can be a key to economic thrive. This paper reviews the current and emerging technological trends and how they are connected to the hype surrounding startup companies and their ecosystem, with particular attention to the role of the state. The analyses use Ramstad's Expanded Triple Helix Model as a framework but with opening its workplace dimensions to subgroups.

In Hungary, digital or technology-led startups are relevant in their numerical and economic volume. Narrowing them further down to artificial intelligence-based companies, one can see that innovation-led cooperations are already state facilitated and could cover every aspect of the ecosystem model. Analysing its operation could lead to good practices for further usage in other technological fields. On the other hand, further qualitative research on their innovation partnership should be conducted to avoid any bias.

Keywords: *Next Generation Digital Technologies (NGDTs), emerging technologies, dual-use technologies, artificial intelligence, digital transformation, startup, innovation ecosystem, startup ecosystem, Expanded Triple Helix Model*

Introduction

Although – as countries face new economic and security challenges – the Covid-19 pandemic seems far behind, its impact on every aspect of our life with digital technologies remains. While lockdown-based economic challenges have become an everyday problem, the digital market has been accelerating, and its ongoing rise should be investigated further. Today, with the rise of a new crisis, ecological and wicked issues, lessons learned from the past could be favourable for policy-makers and further actors of the ecosystem, such as the

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usage of big data for adequate problem solving or the importance of cybersecurity due to the velocity of digitalisation.

As economies have not recovered from previous and ongoing shocks, the competitiveness of a region could be boosted by fast-growing, information and communication technology (ICT) based companies. On the other hand, rising technologies can have disruptive effects, causing not just opportunity but several challenges, too. Cho et al. (2023) refer to these new and emerging complementary digital technologies as Next Generation Digital Technologies (NGDTs). Their terminology includes: internet of things (IoT), mobile devices, big data, cloud computing, artificial intelligence (AI), blockchain, virtual/augmented reality, robotics and 3D printing, separating the definition from the undefined Industry 4.0 category, as the former is not explicitly focused on manufacturing while their definition does.[3]

Further insights about technological development prediction are available. The annual 2022 Gartner Hype Cycle for Emerging Technologies explores more than 2,000 technologies with high potential. It summarises 25 of them in three categories, potentially impacting the next 2 to 10 years. The categories are the following: 1. evolving/expanding immersive experiences; 2. accelerated artificial intelligence automation; and 3. optimised technologist delivery.[4]

Similar technologies got into the focus in the defence innovation industry. The North Atlantic Treaty Organization (NATO) focuses on the following areas: 1. AI; 2. data; 3. autonomy; 4. quantum-enabled technologies; 5. biotechnology; 6. hypersonic technologies; 7. space; 8. novel materials and manufacturing; 9. energy and propulsion.[5] NATO's Defence Innovation Accelerator for the North Atlantic (DIANA) accelerates further the investment into boosting these areas. An obvious consequence of the NATO directions is that the National Military Strategy of Hungary is in line with it, listing likewise key technologies from AI to nanotechnology.[6] Nowadays, these dual-use technologies are not just spinning from military to civilian use,[7] but market-based innovations can be found useful in the defence sector.[8] Innovation researches and cooperations are interoperable, with actors often overlapping.

Change in technology use also demands "a more inclusive approach to digital transformation",[9] as its society-shifting effects are remarkable. In parallel, social transition can be a precondition for further growth, and an interrelated connection is apparent again.

Technology innovation is also an opportunity for countries without significant natural resources. It allows for building a (continuously) learning[10] economy and learning

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3 Cho et al. 2023: 1.
4 Perri 2022.
5 NATO 2022.
6 Government Decree 1393/2021 (VI.24.) on the National Military Strategy of Hungary.
7 For example, when the U.S. Department of Defense set out in the 1960s to create a decentralised postal service so that the traditional mail system would not collapse in the event of the centre's destruction. The research they funded led to the birth of email, an innovation that truly decentralised communication (Kornai 2010: 2).
8 Like facial biometrics, where GaussianFace facial identification algorithm – developed at the Chinese University of Hong Kong in 2014 – reached scores of 98.52% (Lu–Tang 2015: 1–13).
9 OECD 2020: 13.
10 Lundvall 2016.

society.[11] To do so, boosting the economy through supporting startup companies is a trending tool. States have space for manoeuvre, regardless of whether it has a liberal or an entrepreneurial, mission-oriented view of the responsibilities that they follow. They can – with strategies, regulation, policies, direct and indirect incentives by their choice and opportunities – orient the move of the market and every relevant actor with it.

Conceptual background

Innovation has become a selling buzzword on the market, although it has a well-defined theoretical background. Related concepts are invention as well as research and development. However, these two do not necessarily appear in the market, while one can only talk about innovation if they reach the customer. At the same time, innovation does not always necessarily root in R&D activities. According to the widely used definition of the European Commission, innovation is "the successful production, assimilation and exploitation of novelty in the economic and social spheres. It offers new solutions to problems and thus makes it possible to meet the needs of both the individual and society."[12] Technology-based innovation has social innovation as a precondition. Workplace innovations are also necessary for introducing new tools in a company, although it is a common default to avoid dealing with organisational learning and its longer timeframe.[13] Innovation varies in several forms; there are several clustering options. Based on the latest Organisation for Economic Co-operation and Development (OECD) Oslo Manual, "innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by unit (process)".[14] To the extent of change, one can distinguish between incremental and radical innovation.

Radical economy and society revolutionising innovation have cyclicality; the most well-known approach to this is technological revolutions. Perez (2002) makes a difference between the two phases of these revolutions. The techno-economic paradigm, "which breaks the existing organizational habits in technology, the economy, management and social institutions" and a significant surge of development, "which represents the process of installation and deployment of each revolution and its paradigm in the economic and social system", aka diffusion in every sphere in the society. They together are the steps of a technological revolution, which "can be defined as a powerful and highly visible cluster of new and dynamic technologies, products and industries, capable of bringing about an upheaval in the whole fabric of the economy and of propelling a long-term upsurge

[11] On the other hand, previously the concept of the knowledge economy was connected to the Triple Helix Model in literature. Meanwhile, knowledge society and knowledge democracy came from Quadruple Helix Model, and the socio-ecological transition was linked to the theory of the Quintuple Helix Model (Carayannis et al. 2012: 1–12).

[12] European Commission 1995: 1.

[13] Makó–Illéssy 2014: 4–20.

[14] OECD 2018: 20.

of development". Techno-economic paradigms have a strong connection with technical innovations.[15]

Perez specifies five technological revolutions (Figure 1), where the latest is the age of information and telecommunication. At the time of the paradigm's rise, we do not yet know which might be the determining technologies of the next revolution, but its development might already be ongoing; therefore, one can just predict what the sixth will be. Still, long-term growth assumes the creation of future-oriented policies, which – even with uncertainty – lead to support technologies listed before.

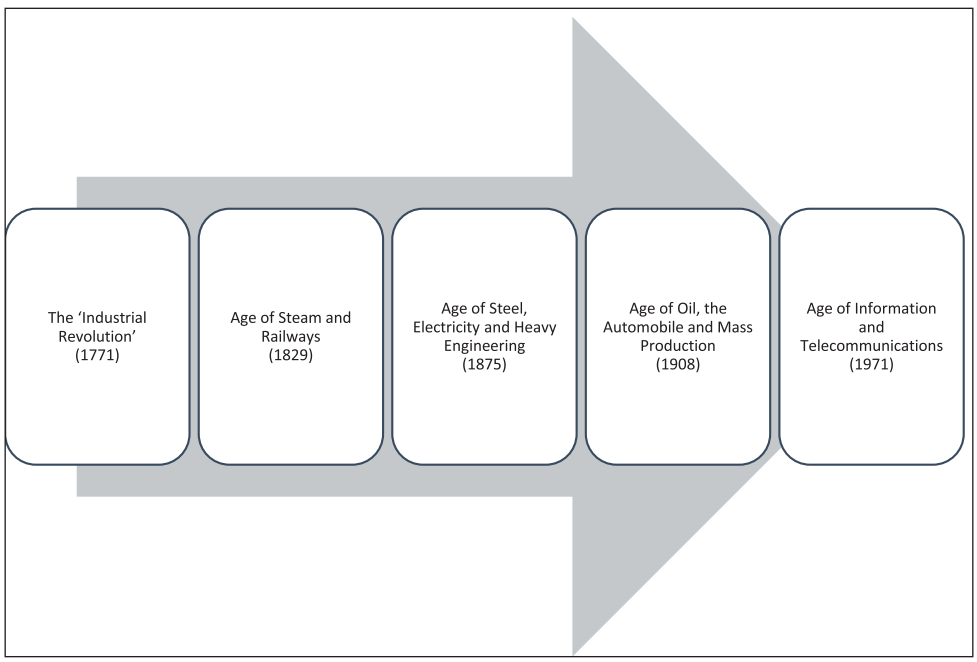

Figure 1: Technological revolutions

Source: Compiled by the author based on Perez 2002: 11.

Including future-oriented policies, the role of the state in these turbulent times appears in many aspects. The most obvious of those related to the topic – research institutions – can support technological development. Furthermore, at the time of crisis, the double role of the state appeared: it provides stability of everyday operations and agility with new challenges simultaneously. With various tools available, bureaucracies can drive innovation,[16] shape markets and define future goals.[17]

[15] Perez 2002: 7–8.
[16] Kattel et al. 2022.
[17] Mazzucato 2016: 140–156.

As one can see from its roles, the state is an inevitable actor, but its activity is interdependent with further actors' behaviour. When one looks at it from a research, development and innovation perspective, innovation models can help to draw the necessary connections.

The first innovation models analysed the path between an idea/R&D result and the market (linear models, within the factory),[18] later systemic approach was unfolded, which included non-technological innovations and every relevant actor outside of the company (organisations, institutions) to be further highlighted as a relevant factor. They could perceive how different performance appears in two companies that operate in the same way. The answer lay in their out-of-the-factory connections.[19]

One feedback-based, systemic innovation model is the Triple Helix Model, which lists states, universities and industries as part of the network. Their cooperation is capable of formulating an innovation-boosting space. Cooperation includes knowledge transfer, interactions, motivating each other for development, and even taking each other's role. This equal partnership is a delicate balance; moving away from this cooperation can lead to inefficiency.[20] Extended versions are the Quadruple Helix (adding media-based, culture-based public and civil society)[21] and the Quintuple Helix Model (adding to the latter natural environment system).[22]

Ramstad (2009) expanded the Triple Helix Model within its dimensions to reach joint knowledge creation, use and dissemination. Actors are policy-makers, workplaces and R&D units. The cooperation happens through policy-making, research, consulting, education and development. The outcome of the different actors turns out to be:

- Workplaces: "comprehensive development, better practices and routines, increased expertise on development, improvement of performance" and quality of working life (QWL)
- R&D units: "improved expertise, education and regional activities, new methods and tools, publications, scientific research"
- Policy-makers: "infrastructure improvement, improved expertise on the R&D field, new roles"
- Society: "generative knowledge and practices created, databanks, national, regional and sectoral infrastructures"[23]

Not explicitly stated in the innovation models but focusing on technology development inevitable factors, the newly formed innovative companies often appear as so-called startup companies. By definition, they are 1. younger than 10 years; 2. have (highly) innovative technologies and/or business models used; and 3. reach or strive for great employee and/or sales growth.[24] Also important that they are preparing for the international market from the start.

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18 Marinova–Phillimore 2003: 44–53.
19 Makó et al. 2020: 96–123.
20 Etzkowitz 2008: 1–8.
21 Carayannis–Campbell 2009: 201–234.
22 Carayannis–Campbell 2010: 41–69.
23 Ramstad 2009: 186.
24 Kollmann et al. 2016.

Lányi (2017) summarises why one is formulating policies around startup companies, whereas a learning society can grow through innovation. She states that startups can introduce new competition into the existing economic system, bringing dynamism and vitality to the market, stimulate a research-based innovation system, especially in applied and high-technology research; promote proactivity as a social value alongside the values of expertise, creativity and responsibility.[25] Therefore, dedicated courtesy goes to startups when an analysis searches for a technological growth catalysator.

It leads this paper to the next concept of bringing together startups and the innovation ecosystem. The term startup ecosystem has not been as thoroughly elaborated as the innovation one. Jáki et al. (2019) state that the Hungarian startup ecosystem's most important actors are startup companies with their support organisations.[26] In this case, where a specific aspect, the technological development of the Hungarian economy is analysed, the two approaches – the startup and innovation ecosystem – are not needed to differ strictly. The reason is that normally startup companies can be formed on R&D or without, but in case of Next Generation Digital Technologies using startups, almost exclusively R&D-based ideas go to market. Based on the definition of innovation above, one can realise that the investigated market segment's framework is the innovation ecosystem, with special attention to startups in its economic dimensions.

Therefore, this paper works with the approach of Ramstad's (2009) Expanded Triple Helix Model, opening up the workplace dimension and analysing it as a multisegmented network of economic actors, putting startup companies at the centre of the research (Figure 2).

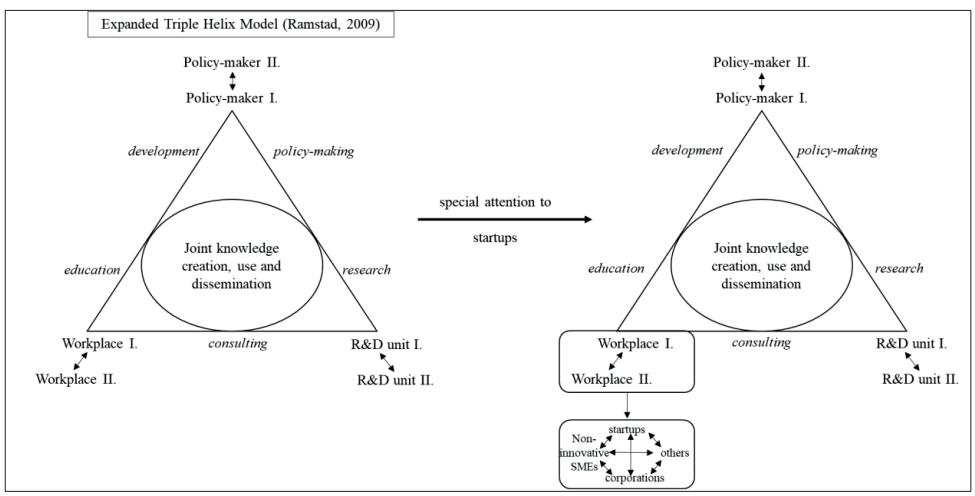

Figure 2: Expanded Triple Helix Model based on Ramstad 2009: 186 and its rethought view with special attention to startups, as one of the "problem owner" and knowledge creators

Source: Compiled by the author.

[25] Lányi 2017: 79.
[26] Jáki et al. 2019: 2–12.

Methodology

The research question of this paper: How does new technology (AI) implementation/ development appears in the Hungarian innovation (startup) ecosystem level, focusing on synergies?

To answer this question, the paper concentrates first on the broadly defined startups, followed by narrowly classified technology-based startups and their attributes available. Data comes from the Hungarian Central Statistical Office (available between 2019–2021), the Startup Hungary organisation's publications and the Dealroom.co startup database. International statistics are available in the latter, completed by a detailed collection of operating companies at the "Hungarian Ecosystem at a Glance" subpage, powered by Dealroom.co and Express Innovation Agency (Hungary). Used data is based on the latest available update (28 October 2022). A comprehensive source of knowledge about the ecosystem is the Hungarian Startup Report, which the Startup Hungary organisation releases for the previous year since 2021.

To see the whole ecosystem, further related actors are investigated. Information is available specifically to the AI boosting network; therefore, the AI ecosystem will be the deeply analysed case of the study. It will be tested whether all roles of the rethought version of the expanded Triple Helix Model are covered in the Hungarian AI network.

The Hungarian (technological) startup landscape

The number of startups in Hungary differs in each source as a direct consequence of ambiguous and unregulated business forms, causing difficulties in a thorough investigation. Additionally, idea stage startups have not even had a legal form yet. The further point is that failed startups are not necessarily motivated or dedicate time to delete themselves from databases after closure.

As an orientation, the Hungarian Startup Report for the year 2021 assumes that the number of active startups is about 1,000.[27] In contrast, the Dealroom.co database counts 1,470 and presents the lack of unicorns.[28] The numbers are presenting again that lack of proper definition and data complicates the analysis.

The Hungarian Central Statistical Office has collected data about startups since 2019. Available information is limited: founders, financial sources and net income are presented.

[27] Startup Hungary 2022: 6.

[28] Startups with a $1 billion valuation are called unicorns. 2 potential unicorns are listed in Hungary: Seon and bitrise. (Data last checked at the Dealroom.co webpage: 30 December 2022.)

Table 1: Hungarian Central Statistical Office: Distribution of startup founders and companies by their main characteristics

Name	Ratio (%)		
	2019	2020	2021
Distribution of startup founders by age group			
Younger than 25 years old	5.8	7.9	9.4
25–34 years old	29.7	30.8	31.4
35–44 years old	35.7	34.8	31.2
45–54 years old	15.8	17.2	18.1
55–64 years old	7.7	6.9	7.0
65 years old and older	5.3	2.5	2.9
Sum	100	100	100
Of which: women	26.6	24.8	23.7
Distribution of startup founders by education			
Academic degree (PhD)	4.0	6.2	6.8
University degree	57.5	61.5	63.0
High school degree	36.9	30.2	27.2
Other/no data	1.6	2.2	3.0
Sum	100	100	100
Distribution of startups by number of founders			
1 founder	42.3	41.2	37.8
2 or 3 founders	50.4	50.6	51.6
More than 3 founders	7.4	8.2	10.6
Sum	100	100	100
Of which: companies with foreign founder	8.5	9.4	7.8

Source: Hungarian Central Statistical Office 2022a.

Table 1 shows that the 25–34 age group (31.4% in 2021) and the 35–44 age group (34.8% in 2021) are the most active in startup creation. This contrasts with the stereotype that startup founders are typically university students. Two-thirds of the founders have a tertiary education: 63% had a university degree in 2021, plus 6.8% also have a science degree. The slow rise in the number of PhD holders could also herald a revival in the market roll-out of research. Furthermore, scientific knowledge can be a boost for emerging technology-based startups. Unfortunately, disciplinary distribution between degrees is not available (Table 1).

Funding sources are mostly based on the founders' own assets (in 2021: 76.8%), but every internationally recognised option is available, as Table 2 presents.

Table 2: Hungarian Central Statistical Office: Proportion of all startups by the source of funding in a given year

Funding sources	2019	2020	2021
Founders' own assets	78.9	77.2	76.8
Family, friends	12.6	12.7	12.5

Funding sources	2019	2020	2021
Support of the state	7.9	10.3	12.8
Business/angel investor	3.2	2.6	4.3
Venture capital investment	14.4	12.7	17.6
Incubator/accelerator	5.8	6.1	7.1
Bank loan	3.5	3.8	4.5
Crowdfunding	0.4	1.0	0.6
Other supports, sources	3.6	4.5	3.7

Source: Hungarian Central Statistical Office 2022b.

Regarding the net sales for 2021, available data is just a current expectation, but it shows a rise in every life cycle of the companies. The more mature the companies are, the more summarised net income they reach, as Table 3 presents.

Table 3: Hungarian Central Statistical Office: Average net sales of startups by startup life cycle stage

Startup life cycle phases	2019	2020	*2021**
Average net sales (thousands HUF)			
Idea, pre-seed	4,988	4,657	*7,367*
Early stage	22,154	19,091	*29,491*
Growth stage or later	33,325	43,574	*45,212*
All startups	20,496	20,812	*22,543*

** Expected data for 2021.*

Source: Hungarian Central Statistical Office 2022c.

Within the Dealroom.co, the "Hungarian Ecosystem at a Glance" have 493 registered startups,[29] where one can search within attributes, like which next generation digital technologies they use. As they usually use more technologies, usage numbers are higher than the summary of the relevant 165 startups. It means a third of the added startups in the database use some new technology. Deep tech (94) is the most common one, followed by mobile apps (47), big data (34) and AI (31). Startup Hungary found similar trends:[30] web/mobile application was the most common product or service. The verticals described the most companies answered the questionnaire for 2021 were: AI/machine learning, big data, fintech, hardware, education, medtech.[31]

Terminology inconsistencies appear in supporting organisations as well. There is no proper division in business incubators, which are dedicated to specific startup needs, but 21 listed accelerators in the Dealroom.co database should indicate the least amount of proper actors. European Union and government grants were available to some of them.

[29] Added startups are less than a third of their summed 1,470, but still, this is the most accurate search option.

[30] The categorisation of the Dealroom.co and Hungarian Startup Report are not identical; therefore, direct comparison is not possible, but both leads present similar trends in technology use.

[31] Startup Hungary 2022: 27, 29.

Similar tenders were available for venture capital building, next to the full state-owned capital Hiventures Ltd.; therefore, financing is not appearing to be a huge problem in the country.

From an educational perspective, the Hungarian Startup University Program is running for two years around the country as an elective course to teach students how the ecosystem works and how to set up their own businesses. Regarding the specific technological knowledge, Hungary is said to have historical roots in science, technology, engineering and mathematics (STEM) field, but that does not necessarily mean that any level of education adequately prepares students for developing in an emerging area – one has to investigate further in that topic.

Artificial Intelligence Coalition

Based on the webpage of the Hungarian AI Coalition, its goal is to "be at the forefront of artificial intelligence developments and applications in Europe and to become an important member of the international AI community". It aims to create a forum where relevant actors "jointly define the directions and frameworks for the domestic development of artificial intelligence".[32]

The mission of the AI Coalition is to:

- "propel Hungary to the European forefront in the area of AI developments
- facilitate the participation of Hungarian start-ups and SMEs in AI development activities in partnerships with large enterprises, universities or international partners
- strengthen the competitiveness of domestic enterprises through extensive dissemination and utilization AI-based use-cases
- make sure that the government, as a user of AI-powered solutions, should be actively engaged in developing the local AI ecosystem by systematically utilizing the national data asset pool"[33]

The AI Coalition together with the relevant ministry created Hungary's Artificial Intelligence Strategy (2020–2030), adopted by Government Resolution 1573/2020 (IX.9.). The AI Coalition's assignment is to review the Strategy with its milestones.

The 392 member organisations include more than 900 experts in 6 working groups. Working groups are the following:

- Technology and security
- Use cases and market development
- Data industry and data asset pool
- Education and awareness raising
- Regulation and ethical framework
- International relations

[32] Artificial Intelligence Coalition webpage.
[33] Artificial Intelligence Coalition webpage.

The board's composition is a good illustration of a mapping of the logic of innovation ecosystems. Board members represent the science community, public administration, Hungarian SMEs, mid-sized enterprises, chambers, professional organisations and startups. Both the user and the developer sides are presented. Joining the Coalition is possible for companies and organisations with a registered seat/branch in Hungary.

Next to its forum providing work, it also offers educational opportunities for all (AI Academy, AI Podcast), creates an AI Marketplace and disseminates success stories, involving a wider audience and raising social awareness.

Discussion and conclusions

Although there are many lessons to learn from the Hungarian startup scene, and actors from the ecosystem are still searching for their exact role in the system, it can be already predicted that digital startups could have the potential to thrive, and with them, economic growth of the country could be expected. Usage of Next Generation Digital Technologies around startups is common; their digitalisation is present from the ground. Detailed information about digital business connections is less available than those dealing with AI-connected technologies. Therefore, the organised form of the AI Coalition and its members are tested in the chosen innovation model.

The expanded Triple Helix Model has three main dimensions, where workplaces are further itemised to see the role of startups. R&D units incorporate universities and research institutes. In the Coalition, 18 universities took part from various fields of studies, including STEM, social sciences and art. State and privately funded research organisations are both present.

From the policymaker dimension, many ministries, agencies, and state-owned companies (both from the regulatory and user side) are involved. This model also assigns industry-related organisations, such as trade unions and chambers of commerce, to the policymaker side. Both Hungarian and international (American, French, Swiss) chambers of commerce are taking part, together with many associations and organisations bringing together representatives of a profession or a scientific field. The former Ministry of Innovation and Technology and now its successor, the Ministry of Technology and Industry, is not just taking part in the Coalition but also plays the role of a facilitator.

Companies cover the spectrum of startups, corporations, non-innovative SMEs and other businesses. Their cooperation within the Coalition or as business/research partners bring them even closer to the down model.

Next to the state, academia and market, AI cooperations also include social stakeholders.

In the Minister's Greeting of the Hungarian AI Strategy, László Palkovics states that the Strategy is a "joint, action-oriented product of the Coalition's professional community" and it "initiated exemplary bottom-up cooperation and market creation among the stakeholders, as part of which an action plan was developed as early as in the autumn

of 2019 to perform tasks not requiring government decisions. The implementation of the Strategy is also based on this cooperation".[34]

This paper can conclude that cooperation within the AI Coalition looks alike with the Extended Triple Helix Model as described and based on the documents issued. One can see that all searched "workplace" actor is present; startups have a role in the network. Its practical effect will be visible with time, but the first milestone – publishing a strategy – is already achieved. The state appears both in regulatory and facilitator roles.

Good practice of this concrete technology-driven segment can be taken to other digital ecosystems or even to further cooperations. At the same time, one has to keep in mind that many practical issues might have occurred that a research cannot see; therefore, further quantitative research is required to avoid information asymmetry-led bias.

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