What Are the Benefits and Pitfalls of Innovation Ecosystems?

Lessons Learned From Tungsram's Ecosystem

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Abstract

Whereas innovation ecosystems became widely popular lately, our knowledge is quite limited on the practical implementation of the relevant ecosystem models, specifically in Hungary. Hence, the aim of this paper is to analyse an innovation ecosystem as a case study related to one of the biggest Hungarian multinational company, called Tungsram. The research is considered to be a qualitative research, as the methodology incorporates document analysis and 26 semi-structured interviews with the ecosystem's participants. The results show that the main benefits of participating in ecosystems are: new value creation by resource and knowledge sharing, networking and minimizing the cost of innovation. Meanwhile, the pitfalls of cooperation are closely related to the credibility of the ecosystem leader, to the formulation of the ecosystem's strategy and to the quality of the absorptive capacity of the partners.

Keywords: innovation, cooperation, innovation ecosystem, Triple Helix, open innovation

JEL Codes: O10, O32, O36, P13

Introduction

The complex phenomenon of innovation, closely linked to knowledge-based economy, plays an increasingly important role in sustainable economic development. Although the concept of innovation has been originally associated with Schumpeter [1934], the term is very diverse and its meaning is constantly evolving. The international definition of innovation is currently set out in the 2018 edition of the Oslo Manual, which defines it as *"a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that*

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has been made available to potential users (product) or brought into use by the unit (process)" [OECD, 2018: 20]. However, it is important to note that innovation is both an expensive (especially for product innovation) and an uncertain process, since it may take years to develop a new product or service, and market success cannot be guaranteed in advance.

In order to some extent reduce the aforementioned costs and risks of innovation, formal and informal cooperations between market players have become increasingly common since the 1980s [Nalebuff–Brandenburger, 1994]. This approach has been described by Chesbrough [2003] as a shift from a closed to an open innovation model. The essence of open innovation is that innovation can take place not only within a company, but also outside of it, with the involvement of several actors, since many tangible and intangible resources that are vital for the innovation process are not created within the company. Given that the exact conceptual framework of business and innovation cooperations is difficult to define, there are several types of cooperation models in the literature (e.g. networks, clusters, ecosystems) [Faria–Lima–Santos, 2010].

Innovation partnerships have become of paramount importance lately, as the Covid-19 pandemic and the current war situation highlighted the relevance of supply safety and the interconnectedness of market players. In its latest report, World Economic Forum (WEF) [2020] also identified fostering of innovation ecosystems as one of the main drives of the economic recovery and of promoting socially inclusive entrepreneurial culture after the pandemic. IBM's [2022] recent survey among business managers also indicated as a conclusion that fifteen years ago, companies relied primarily on in-house R&D Today, on the other hand, 80 percent of company executives implement new innovation ideas through some form of collaboration.

The use of *"ecosystem"* – referring to a type of cooperation – within business settings has grown exponentially over the last 15 years. Being embedded in business and innovation ecosystems facilitates the access to a greater pool of resources, diverse knowledge and financial background, which are key features of value creation and successful innovation [Kapoor, 2018]. However, as the definition of *"ecosystem"* from a business perspective is quite ambiguous, the term is used as a *"buzzword"* nowadays for various concepts. Hence, case studies of operating ecosystems are indispensable to shed light on the practical implementation of the scientific concept of business and innovation ecosystems [Gomes et al. 2018]. In this context, the specific aim of this paper is to analyse a Hungarian innovation ecosystem, and to share the practical application of ecosystemic cooperation within a moderately innovation driven economic environment such as that of Hungary.

The paper is structured as follows: firstly, a literature review segment is applied in connection with innovation ecosystems and the so-called Triple Helix model of innovation cooperations; secondly, the methodology of the qualitative research is described; thirdly, the results of the research are shared within the framework of a SWOT analysis; which is followed by a short discussion; while the paper ends with conclusions and practical recommendations for current and soon-to-be ecosystem leaders and participants.

1. Literature review

1.1. Theoretical framework of innovation ecosystems

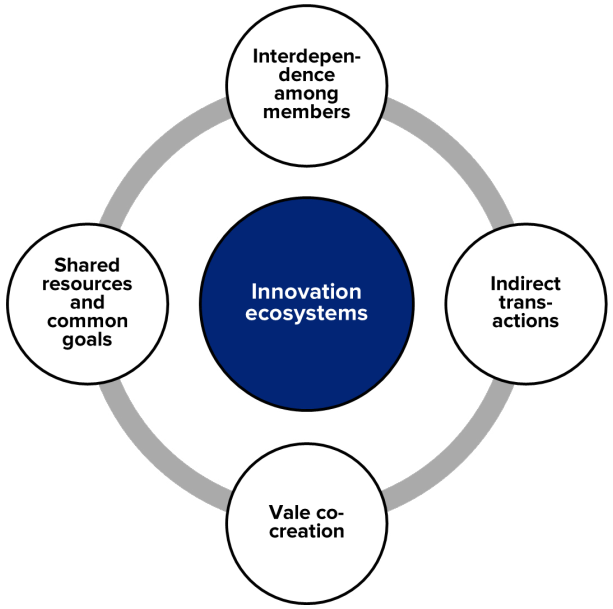
In economics and management sciences, innovation ecosystems are considered to be a type of innovation cooperation. The definition of innovation, as we have mentioned in the Introduction, has evolved after Schumpeter. However, the concept of ecosystem as a system of organisms first appeared in the field of ecology. In Tansley's [1935: 306] interpretation, *„the fundamental concept appropriate to the biome considered together with all the effective inorganic factors of its environment is the ecosystem".* In essence, a biological ecosystem is a complex set of interactions between actors and their environment, which are related on a spatial, structural or thematic basis, and whose primary purpose is to maintain a state of sustainable equilibrium [Willis, 1997].

The term was later successfully introduced into the field of business and management sciences by Moore [1993] with the concept of business ecosystem. In Moore's [1993; 1996] interpretation, a business ecosystem is *„an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. This economic community produces goods and services of value to consumers, who are themselves members of the ecosystem."* The ecosystem theory was further broadened by Gawer–Cusumano's [2002] business platform theory (which specifically interpreted the concept for big tech companies like Cisco and Microsoft), and by Chesbrough's [2003] open innovation model.

The first appearance of innovation ecosystem as a concept can be attributed to Ron Adner. Adner [2006] did not yet make a clear distinction between business and innovation ecosystems, but later on, several authors started to indicate them as separate concepts, such as Adner–Kapoor [2010], Yaghmaie–Vanhaverbeke [2020], Zahra–Nambisan [2012], Autio–Thomas [2014], Visscher–Hahnh–Konrad [2021] and Adner [2012].

In the literature, there are four well-defined characteristics that outline the specific nature of innovation ecosystems. The four attributes are shown in Figure 1.

Figure 1: The distinctive characteristics of innovation ecosystems
(Source: own editing)



The first characteristic of innovation ecosystems is the interdependence among members, which normally exceeds the boundaries of a related industry. Consequently, innovation ecosystems are often formulated within untapped or yet undiscovered industry segments and niche markets, like, for example, space industry and AI. [Walrave et al. 2017].

The second attribute that usually distinguish innovation ecosystems from business ecosystems, networks, supply chains, and so on, is that members are not necessarily linked through direct buyer-supplier relationships. Which practically means that the relationships may be formal or informal between the participants, but partners are usually depend on each other even if they do not do direct transactions. Therefore, the growth and success of an ecosystem depends on various actors that do not directly interact with the focal members (usually the product or service/platform providers) of the ecosystem [Dedeyahir–Mäkinen–Roland Ortt, 2016].

The third specific characteristic of innovation ecosystems is the value co-creation process. While business ecosystems focus on value capture and optimization of the benefits from the cooperation, innovation ecosystems focus primarily on new value co-creation [Valkokari, 2015]. More specifically, the value created by an ecosystem is not the outcome and sum of individual efforts of the participants. Therefore, value creation is not a linear process, in which every player has its own function like in the case of a supply-chain. In an innovation ecosystem, members work as an interrelat-

ed system, in which every participant has its own goals, while being similarly interested in maintaining the success of the ecosystem [Pushpanatham–Elmquist, 2022, Ranjan–Read, 2016].

Finally, the fourth specific feature of an innovation ecosystem is the shared, complementary resources and vision between members. Members pursue mutual objectives, even if those objectives do not entirely align with the individual companies' specific strategic goals, since the overall success of the ecosystem is vital for the participants' long-term survival and growth [Heaton–Siegel–Teece, 2019]. The complementary resources are also essential, as the main reason for being a part of an ecosystem from a business perspective is the need for resources and/or knowledge that the related members do not have, or acquiring them would not be profitable [Smith, K. R., 2006].

Based on a comprehensive literature analysis, Granstrand–Holgersson [2020: 105] defined innovation ecosystem as *„the evolving set of actors, activities, and artifacts*[1]*, and the institutions and relations, including complementary and substitute relations that are important for the innovative performance and value co-creation capabilities of an actor or a population of actors."* Although the referred definition is fairly extensive, it is contemporary and formally in line with the notion of different innovation ecosystem concepts. Therefore, this interpretation is applied in the paper.

As the theoretical framework of innovation ecosystems is quite indefinite, various models may be distinguished in the literature, from which one of the most common structure is the so-called Triple Helix model.

1.2. Triple Helix model

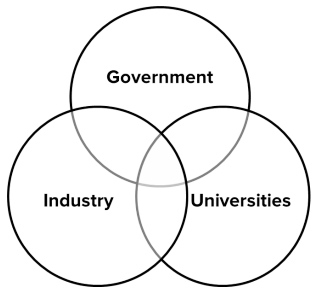
There is an increasing awareness that a knowledge-based society operates according to a different set of dynamics than an industrial society focused on manufacturing. Knowledge-based economies are more tightly linked to new knowledge. Furthermore, they are also subject to continuous transformation rather than being rooted in stable settings [Etzkowitz–Zhou, 2018]. Consequently, instead of the traditional technology-push and demand-pull innovation process, innovation began to be perceived as a linked and systemic activity from the 1960s, which entailed the creation of Innovation Systems Theory (specifically National Innovation System (NIS), Regional Innovation System (RIS), Sectoral Innovation System (SIS), etc.) [Edquist, 2004].

An innovation (eco)system is the result of a complex set of relationships among actors in the system. This includes enterprises, universities and gov-

1 Artifacts include products, services, resources, system inputs and outputs [Granstrand–Holgersson, 2020].

ernment institutions, which are the three spheres that formulate the Triple Helix model [Trautmann–Vida, 2021]. The model is illustrated in Figure 2.

Figure 2: Triple Helix model
(Source: Etzkowitz–Leydesdorff [2000])



According to Etzkowitz [1998], government and enterprises, the classic elements of public-private partnerships, have been recognized as primary institutional spheres since the 18th century. –Therefore, the essence of the Triple Helix model is that universities are moving from a traditional educational (albeit secondary) function to a leading role on a par with industry and government as a generator of new knowledge, which is fundamental for the development of a knowledge-based society, hence for innovation as well.

The Triple Helix became a widely popular and cited concept from the 2000s, since the model is well applicable for R&D and regional development policy as well. Policy makers have always been particularly interested in implementing the model in Europe, as the concept is proved to be one of the main reasons for the success of Silicon Valley [Pique–Berbegal-Mirabent–Etkozwitz, 2018].

As the main driver of the Triple Helix is the consideration that the relations between industry, government and universities enable the creation of new knowledge and facilitate innovation process, the model is currently one of the most common structures of innovation ecosystems. The Triple Helix is considered to be an ecosystemic model, as the dynamics for growth is rooted in the interactions between the three institutional spheres. Moreover, the Triple Helix is expected to evolve by self-organization., This slightly differentiates ecosystemic innovation models from the traditional Innovation Systems Theory perspective, which mainly focuses on the institutionalization processes.

In view of the fact that the application of the Triple Helix is widely common, but Hungarian empirical results of Triple Helix ecosystems are scarce in the literature, the aim of this paper is to identify which strengths and weaknesses the participants of the analysed ecosystem have identified

regarding the application of Triple Helix model. SWOT analysis is used as the conceptual framework of this analysis.

2. Tungsram's innovation ecosystem

The research is a case study analysis, which focuses on an agricultural innovation ecosystem, managed by a Hungarian multinational lighting company called Tungsram. The cooperation was chosen for our empirical analysis for two reasons. First, a well-defined cooperation was needed, which is perceived as an ecosystem by its participants. Secondly, as empirical results of Hungarian ecosystems are scarce in the literature, a Hungarian-centred ecosystem was chosen for the case study. In the following, the operation and the business context of the analysed cooperation is described briefly to facilitate further understanding of the results.

Tungsram was originally established as the United Incandescent Lamp and Electrical Company (*Egyesült Izzólámpa és Villamossági Rt.*) in 1896. General Electric (GE) acquired the company in 1989 during the Central-European privatisation; however, as a result of a management buyout (MBO) in April 2018, Tungsram re-entered the market as a Hungarian-headquartered European lighting brand, becoming independent from GE again [Bauer, 2019].

Following the divestment from GE, Tungsram's management has been consciously looking for new markets and business opportunities that may exploit the company's century-long experience in lighting technology, and also may utilize the remaining manufacturing capacity of the company. Tungsram has set a strategic goal that 50 percent of the company's revenues should come from new, open innovation-based products by 2023, but the difficult economic situation caused by the Covid-19 epidemic and the current war situation has forced the company to restructure radically, as the traditional light bulb industry will disappear in the foreseeable future. The accumulation of economic challenges plunged the company into a serious financial crisis by the Spring of 2022.

Indoor farming and agricultural technology as an industry segment came into the company's sight primarily because of LED lighting sources. Tungsram already had several competitors (for example Philips Signify, Hortilux, Current and OSRAM Fluence) in the market of agricultural lighting technology. Therefore, the company has consistently sought to serve specific customer needs and 'niche markets'. Tungsram has discovered early, that the customization and testing of lighting products are of particular importance for potential customers with strong capital access (e.g. foreign greenhouse-owners). However, most industry players do not have the necessary testing infrastructure. Consequently, in order to increase Tungs-

ram's market credibility, the company has started to develop the design of its own indoor farm as an R&D centre. Recognising that Tungsram has no relevant market experience in either the agricultural or food processing industry, the company sought partners with the necessary biotechnological and food industry knowledge related to indoor farming. As a result, the cooperation currently consists of Tungsram as the leader of the cooperation, a public authority, two Hungarian SMEs and two universities – one foreign and one Hungarian. Thus, Tungsram, within this ecosystem, is currently operating an R&D indoor farm as an R&D centre, which provides infrastructural support for the customization process of the company's indoor lighting products.

As the cooperation is formulated by companies, universities and a public authority, the collaboration is considered to be an implementation of the Triple Helix innovation model. The relations within the ecosystem are illustrated in Figure 3.

Figure 3: The relations between participants of Tungsram's ecosystem
(Source: own editing)

3. Methodology

The research is considered to be an exploratory and explanatory one, as the empirical analysis of operating Hungarian innovation ecosystems have not been in the forefront of scientific interest so far. Although the inevitable

limitation of the case study methodology (especially in the case of single case studies) is that it does not allow general conclusions to be drawn on the basis of the results obtained, it is nevertheless a frequently used methodology in management science, because it is well suited for gaining a practical, comprehensive and deep understanding of various organizational, managerial and structural problems [Yin, 2018; Saunders–Lewis–Thornhill 2019].

The analysis aims to answer the following two research questions:

- Q1: What strengths and weaknesses have the participants identified with the application of the Triple Helix?
- Q2: What threats and opportunities have the ecosystem participants perceived due to the fact that the focal firm is in a serious financial crisis?

The research questions were analysed applying a qualitative method; on the basis of document analysis and 26 semi-structured interviews with ecosystem participants. The main criteria for the selection of the respondents were, on the one hand, that (1) the senior managers of all the organisations involved in the cooperation should express their views on the strategic importance of participating in the cooperation and, on the other hand, the research was aimed to interview (2) all the colleagues who actively work in the cooperation at the operational level. The resulting two levels of interviewee selection provided a comprehensive picture of both the strategic importance and the daily challenges of cooperation.

Separate questionnaires were used to analyse the cooperation leader, the corporate partners, the universities and the public participants. Four versions of the questionnaire were necessary, since each of the participants involved in the cooperation considers the partnership from a different perspective. However, in order to compare and synthesise the responses, the main question groups were the same throughout the interviews. A detailed breakdown of the interviews by partners is presented in Table 1.

The interviews were conducted between October 2021 and February 2022. The interviews were audio-recorded for later analysis, resulting in 39 hours of audio material recorded during the sessions. The information provided during the interviews was later refined by the interviewees during several informal conversations. The results are presented within the framework of SWOT analysis. The quotations in the paper are used with the consent of the respondents in all cases.

Table 1: Breakdown of interviews conducted
(Source: own editing)

Analysis code[2]	Partner type	Participant in the cooperation	Number of interviews conducted	Tirple Helix structure
PP1	Public partners	Public authority	3	GOVERNMENT
PP2				
PP3				
FC1	Ecosystem leader (Tungsram)	Focal company	8	INDUSTRY
FC2				
FC3				
FC4				
FC5				
FC6				
FC7				
FC8				
CP1	Corporate partners	Hungarian food producer SME	5	
CP2				
CP3				
CP4				
CP5				
CP6		Hungarian biotech SME	3	
CP7				
CP8				
UP1	Hungarian university partner	Institutes of higher education	5	UNIVERSITY
UP2				
UP3				
UP4				
UP5				
UP6	Foreign university partner		2	
UP7				
Total number of interviews included in the analysis			**26**	

4. Results

4.1. The strengths and weaknesses of the triple helix model in practice

The fundamental strength of the cooperation identified by the participants is the ability to combine resources, which is a typical advantage of ecosystemic cooperations [Rinkinen–Harmaakorpi, 2017]. Resource combination is a major advantage of ecosystems, since one player usually does

2 In the remainder of the paper, quotes and findings are referred to the interviews regarding this analysis code.

not have all the resources needed for new value creation. Furthermore, one participant (specifically SMEs) generally only covers a fragment of knowledge, which has more value when combined with other segments. In essence, ecosystem collaboration helps to combine resources and knowledge of various actors, enabling each participant to create more value than one would be able to create on their own. In this context, corporate partners consider it a benefit that competitors do not participate in the cooperation, since competitors would be seen as a deterrent in relation to knowledge and information sharing (referring to the FC2, CP4, CP5, CP8 interviews).

The second strength of the ecosystem is the trust-based relationships between participants, the existence of weak ties (interpersonal ties) referred to after Granovetter [1973]. Based on the interviews conducted, the functioning of Tungsram's ecosystem is largely determined by the fact that the partners knew each other, often through previous business and personal connections (referring to the FC1, FC5, CP1, CP2, CP4, CP5, CP7, CP8 interviews). One corporate respondent (CP7 interview) described the importance of trust in the ecosystem as follows: *"In a project as complex and risky as this indoor farming R&D centre, if you don't have a good relationship, cooperation is impossible, because this innovation is quite resource-intensive and the outcome is obviously very uncertain. Who would take a risk with a partner/partners they don't trust?"*

The third strength of the ecosystem is considered to be the market credibility of the ecosystem leader. Tungsram has returned to the global market with its well-known, historical lighting brand in 2018. Therefore, specifically in Hungary, other market players contemplate Tungsram as a reliable partner (referring to the CP3, CP4, CP5, CP6, CP7, UP3, UP4 interviews). Another advantage of Tungsram as a focal actor of the ecosystem is its manufacturing infrastructure, which none of the ecosystem's participants have. As Tungsram is currently under a serious reorganization (due to the collapse of the market of traditional lighting products, which was briefly described in the previous chapter), it is questionable to what extent the company will be considered reliable, hence an attractive partner in the future. This aspect of the ecosystem is further analysed in the next section.

The results of the case study also highlight that in small and/or moderate innovator countries (such as Hungary), national champion companies (sometimes considered to be *"hidden champions"* [Simon, 2009]) may be used to promote ecosystem cooperation culture, because these companies usually have the necessary manufacturing/service provider experience, and more direct ties to markets and consumers.

Based on the interviews, one of the weaknesses of the ecosystem that Tungsram and the participating actors identified was that the cooperation

did not facilitate the acquisition of external resources, specifically venture capital (referring to the FC3, FC5, FC7, FC8, CP1, CP2, CP3, CP8, UP1, UP6 interviews). Consequently, the lack of financial resources increasingly characterizes the cooperation. The public partner provided fund primarily for the construction of the R&D centre; but those funds had run out by the time the project reached the market entry level capital (referring to the PP1, PP3, FC1, FC3, CP6 interviews). At the micro level, this confirms the phenomenon of the so-called European paradox, namely that EU Member States generally have difficulties in bringing innovations and basic research results to the market, partly due to poor innovation fund structures [Héder, 2017; Argyropoulou–Soderquist–Ioannou, 2019].

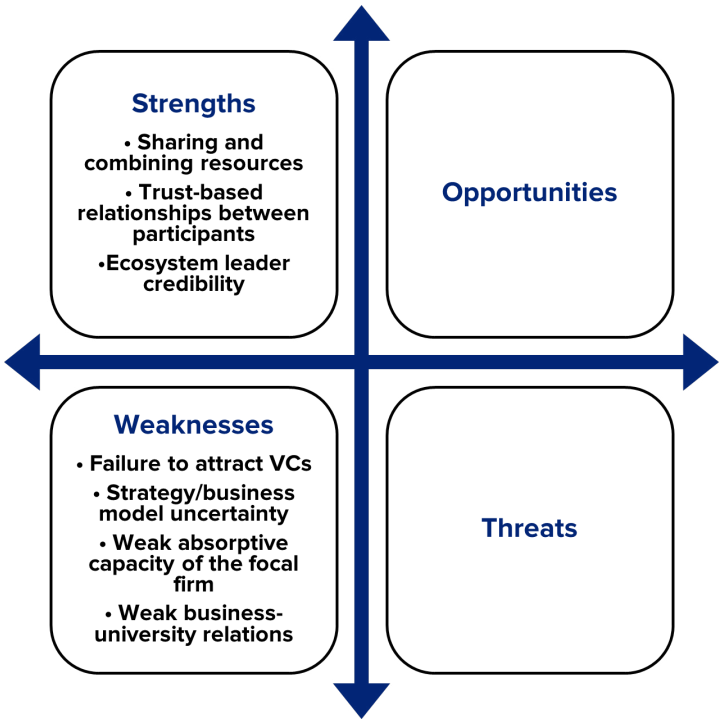
The second weakness that partners pointed out is the fact that the manager of the ecosystem was extremely late in outlining the actual strategic directions of the ecosystem, hence viable business models were not created before market entry (referring to the FC3, FC5, CP1, CP2, CP4, CP5, CP8, UP7 interviews). As a result, various research activities and product developments of the same time dissipated the ecosystem's resources. As one partner (CP6 interview) described the problem: *"...the day-to-day workflow is always smooth, but the strategically important decisions are made much slower, since we do not know where we are really going with this cooperation"*. Management deficiencies became more and more apparent as the participants approached the market entry phase. Hence, the low level of absorptive capacity of Tungsram proved to be one of the main reason of the misalignment in strategic goals, which later resulted in inertia (referring to the FC1, FC6, FC7, CP2, CP4, CP5, CP6, CP8, UP1, UP4 interviews). As one manager (FC7 interview) of Tungsram pointed out: *"...we are a big company, with all of its benefits and discommodities. The legacy of bureaucracy from GE is still in our everyday work-cycle, while being a part of an innovation driven ecosystem requires a lean approach. We currently do not have the capability to adapt to our partners"*.

The third weakness of the cooperation is identified in the weak industry-university relations of the Triple Helix. The flexibility of the ecosystem is difficult for university bureaucracies to manage (referring to the PP3, FC1, CP4, CP5, CP6, CP8, UP1, UP2, UP5, UP7 interviews). In general, the corporate partners do not have a positive opinion of institutes of higher education in Hungary; as one corporate partner (CP1 interview) puts it: *"...we have tried to cooperate with universities in the past, but the decision-making structure is so complex that by the time the question is referred to the person responsible, the subject of the request has already become out of date. Universities need to respond to market needs much more quickly"*. In addition to bureaucracy, several interviewees (referring to the FC2, CP1, CP3, CP8, UP1 interviews) underlined that although some segments of the

R&D process would be cheaper if carried by universities, due to the fact that market players have little confidence in the competences of Hungarian higher education institutions, the development is often entrusted to other companies, which fulfil the request more expensively.

The weak industry-university relations are also confirmed by the university partners (referring to the UP1, UP3, UP4, UP7 interviews), but at their discretion, the main reason for the weak relations is that the university partner is not able to position itself in the cooperation. Therefore, the added value of higher education institutions in the ecosystem is not outlined. At the same time, the relations between universities and companies have been well exploited by the parties in the recruitment of professionals working in the R&D centre, as almost all of those working at the indoor farm have studied at the Hungarian university partner – in this respect, the role of the university as a knowledge centre is emphasised in the cooperation. Given that the foreign university partner is involved in only a few priority research tasks, and that the Hungarian university would like to strengthen its position in the ecosystem, it is a question of the future whether the role of the Hungarian university partner may be enhanced in the ecosystem after the reorganization of Tungsram. The results of the SWOT analysis is presented in Figure 4.

Figure 4: SWOT analysis of Tungsram's agricultural innovation ecosystem
(Source: own editing)



4.2. The perceived threats and opportunities of the ecosystem

When analysing the ecosystem, two main threats were identified, both closely related to the current uncertain macroeconomic conditions and environment.

Firstly, the Covid-19 pandemic and the war situation highlighted, in many ways, that even in developed countries, ensuring a stable food supply can be a problem that could escalate into a global crisis. Hence, the importance of the agricultural sector and the demand for agricultural innovations, such as indoor farming, are expected to gain a momentum in the future. On the other hand, the interviewees' suggest that the current economic situation did not have a significant positive impact on the demand for innovative agricultural solutions. The reason for this was seen by interviewees (referring to the FC1, FC4, FC8, CP7, UP1, UP6, UP7 interviews) as follows:*"...because the economic recovery following the Covid-19 epidemic was accompanied by a large increase in energy prices (mainly as a result of the war on Ukraine): even though the pandemic highlighted food security issues and the importance of indoor farming, the cost of energy actually made it more expensive to apply these technologies, which in turn neutralised any increase in demand that might have been generated by the pandemic."* Meanwhile, another respondent (UP7 interview) said *"Due to the European Union's strong agricultural subsidies and related regulations (in the EU, crops grown without soil cannot be certified organic), the European market's growth potential is artificially limited. Even if the European Green Deal declared that a complete transformation of the European agricultural sector is necessary to achieve climate neutrality"*. Essentially, the economic crisis and the skyrocketing energy prices are expected to slow the agritechnological industry's growth rate, as indoor farms are too energy-intensive with their current technology. Consequently, the further operation of the ecosystem is largely determined by the future trends of the whole industry segment. Participants perceive this market crisis as a threat to the ecosystem, since the cooperation cannot provide achievable goals for its participants, hence the added value of the ecosystem is eroded for each participant.

The second threat to the ecosystem was revealed in the existential crisis of the leader company, Tungsram, this Spring. The currently unsettled macroeconomic environment is putting the crisis-hit Tungsram, and therefore the whole ecosystem at a crossroad. Following the reorganisation of the company, key issues for the ecosystem are: (1) how much production capacity Tungsram will retain (especially as the partners' motivations for cooperation are strongly influenced by the company's manufacturing infrastructure); (2) what strategy and business model the company may choose to commercialize the products developed within the ecosystem, and to what extent these will be compatible with the partners' own business ex-

pectations and, last but not least; (3) to what extent the market players' trust in the Tungsram brand and company will be shaken?

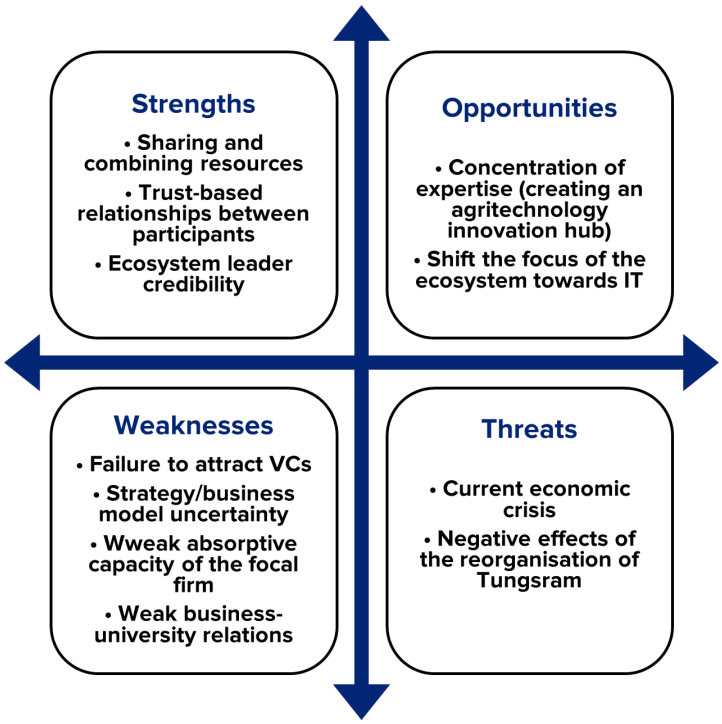
Regardless of whether the analysis of the cooperation had started before the financial crisis of Tungsram, the results implicate that the lack of business goals and strategy restrained the ecosystem, creating less output than one potentially would expect. Hence, the partners realized before the crisis hit Tungsram that – as a corporate partner (CP1 interview) puts it: *"the collaboration has started to cool down, as we had some great products and research results, but the market penetration was not planned beforehand"*. Therefore, Tungsram's existential crisis (which became a serious threat to the further operation of the cooperation) only amplified one of the original weakness of the cooperation: that, as a result of the lack of strategic thinking, the focal firm could not orchestrate the accumulated resources and knowledge effectively within the cooperation. Recent informal conversations with the ecosystem participants lead the research to the conclusion that the partners are still counting on Tungsram as a participant (not a leader!) of the ecosystem. However, they – specifically the SME partners – are open to cooperate with other market players to commercialize the results so far.

In addition to the above mentioned threats and challenges of the ecosystem, two further opportunities of the cooperation may also be identified, both of them underpin the continuation of the ecosystem. Firstly, as the ecosystem's development and research results are unique within the lighting industry, and the R&D centre is technologically developed, there may be an opportunity for the ecosystem to create a European competence and knowledge centre for indoor farming (referring to the FC2, FC5, FC6, CP7, UP1, UP3, UP6, UP7 interviews). The World Horti Centre in the Netherlands operates on a similar basis as a globally recognized knowledge centre and innovation hub for the modern greenhouse industry segment. The legitimacy of the creation of the competence centre is reinforced by the fact that sustainability, specifically in the area of food safety, remains a top priority in the currently booming economic crisis, exacerbated by the war conflict, throughout the world [Barbier–Burgess, 2020].

The other opportunity that was defined based on the interviews is to expand the ecosystem with new partners, specifically towards IT (referring to the FC4, FC5, CP1, CP3, CP5, CP6, CP7, UP7 interviews). The reason being that AI, various sensors and algorithms are essential for a more efficient operation of indoor farming, but the necessary technological solutions are yet scarce in the market. Thus, focusing the ecosystem on connecting agricultural lighting to big-data technologies would create new value, with expertise and knowledge that is unique on the global scene. In this context, the crisis of Tungsram may turn the whole ecosystem into a more produc-

tive cooperation, expanding its borders and shifting the focus towards a more promising niche market. The results of the complete SWOT analysis is presented in Figure 5.

Figure 5: Complete SWOT analysis of Tungsram's agricultural innovation ecosystem
(Source: own editing)



Discussion and conclusions

The aim of this paper was to shed light on the practical application of the theory of innovation ecosystems in Hungary through a case study related to one of the biggest Hungarian multinational companies called Tungsram. However, given that the analysis only serves as a single case study, the results do not allow general conclusions to be drawn about the Hungarian innovation cooperation culture. At the same time, as the analysed ecosystem is formulated on the basis of the so-called Triple Helix model, throughout the interviews of different actors, the research was striving to grasp the driving force and key hindering factors of the ecosystem. Since Tungsram, the focal firm of the analysed cooperation, has fallen into a serious financial crisis this Spring, the case study may also give practical insights on how to ensure the survival of an ecosystem after the impairment of its leader. In or-

der to systematize the results of the interviews conducted, SWOT analysis was applied as a methodological framework of the research.

The results revealed that the major motive for collaboration is the possibility to create new value by sharing knowledge and resources between the participants – a finding that resonates with other case studies (E.g. Cheng et al. [2019], Jensen–Tragardh [2004], Klitkou–Godoe, 2013, Radziwon–Bogers–Bilberg [2018]). The stability of the ecosystem was ensured by trust-based relations between partners who already had previous business connections outside of Tungsram's ecosystem. Hence, interpersonal trust is defined as a *"glue"* between ecosystem actors that facilitates the operative cooperation between different spheres to a great extent. The interviewees confirmed that the credibility of the focal firm, Tungsram, was also considered to be a strength of the ecosystem, because the company disposes a manufacturing infrastructure that other participants do not have. The results of the case study also highlight that in small and/or moderate innovator countries (such as Hungary), *"national champion"* companies may be used to promote ecosystem cooperation culture, because these companies usually have the necessary manufacturing/service provider experience, and more direct ties to consumers.

Although the most relevant features of innovation ecosystems (see Figure 1) are recognized in the analysed cooperation, some deficiencies were also discovered during the interview sessions. Notably, the main hindering factor of the ecosystem was the lack of viable business strategy, hence the ecosystem could not commercialize its results efficiently. Without defining a common business goal, the participants dissipated the ecosystem's resources. This management insufficiency is closely related to the low level of absorptive capacity of the focal firm. As the respondents expressed, lean management is the key to successful ecosystem operation, which requires all participants to handle the ecosystem separately from their inner bureaucratic processes. On the other hand, the ecosystem has suffered from a lack of external financial support lately, because the public fund, which supported the ecosystem in the first place, only provided financial assistance for the creation of the R&D centre, but failed to support the developed products' real market entry. As the economic crisis hit, the cooperation could not attract venture capital, even though the technology developed by the cooperation would be new on the market.

Considering the structure of the ecosystem, weak university-industry relations characterize the collaboration. Several interviewees underlined that, although some segments of the R&D process would be cheaper if carried out by universities; due to the fact that market players have little confidence in the competences of Hungarian higher education institutions, the development is often entrusted to other companies, which fulfil the request

more expensively. This attitude leads us to the conclusion that the role of universities is not positioned properly within the ecosystem. To put it briefly, the added value of cooperating with universities is not attractive enough to corporate partners. Consequently, the weakest relations between participants were found between industry and academia in Tungsram's Triple Helix ecosystem.

As Tungsram has gone through a serious financial crisis this Spring, the ecosystem is at a crossroad. Two possible directions were identified, both of which could ensure the survival of the ecosystem (creating a competence centre to sell the research results or shift the focus of the ecosystem towards IT). In both scenarios, the leading position of Tungsram is eroded, hence participants see the key of continued operation of the ecosystem in expanding its borders and/or shifting the focus towards a more promising niche market.

Although the results of a single case study cannot lead us to precise conclusions, some general remarks for policy makers and current or soon-to-be ecosystem members and leaders may be summarized:

- Ecosystemic cooperations may actively support new value creation, even in small and/or moderate innovator countries (such as Hungary), hence supporting the formulation of these connections should be promoted by national institutions.
- One of the driving forces of cooperation should be the sharing of resources, knowledge, risks, and to reduce the cost of innovation. This dynamic ensures that participants are able to create more value in the ecosystem than they would be able to outside of the cooperation. It also indicates that ecosystems should be formulated on the (potential) partners own-perceived interest, hence the bottom-up approach is preferred to the top-down perspective.
- Previous relations between market players serve as a foundation of ecosystemic cooperations, since trust-based relationships (or weak ties) influence both the selection of partners and the cohesion of the cooperation.
- The weakest relations between participants in the Triple Helix model were found in industry and academia relations, which manifested in the fact that corporate partners do not perceive universities as valuable partners related to innovation. The value proposition of universities should be communicated more plainly – specifically after the recent model change of higher education in Hungary [Kováts, 2020].
- Defining common business goals and strategy is a key for the long-term operation of an ecosystem, which implicates a credible ecosystem leader or focal firm who orchestrates the management of the

ecosystem. The results show that it is recommended to formulate a business strategy, which comes across as beneficial for all participants, right from the formation of the ecosystem, in order to prevent the dissipation of the ecosystem's resources.

In addition to the evident limitations of the case study, future research should cover other Hungarian innovation ecosystems, thereby enriching our knowledge on the practical aspects of managing successful ecosystemic cooperations. Comparison of other case studies would enable uncovering patterns and analysing common practices that may have a decisive effect on the success of (Hungarian) ecosystems.

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