doi: 10.36689/uhk/hed/2023-01-031 HED Hradec Economic Days

Partnerships between Chemical Companies and Universities

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Abstract: Our current society is globalized, interconnected, and dependent on the collaboration of various entities and institutions. This collaboration and its influence on innovations in the knowledge society is a subject of research, and it reflects in the theory in the basic model depicting partnership in the form of the so-called triple helix model, where the partnership entities are represented by universities, public institutions, and companies. This paper focuses on partnerships between universities and companies from the point of view of the way how this partnership helps all the participants and benefits society. The paper describes the forms of partnerships and the advantages and disadvantages they have for the participants. It includes the outcomes of the research, which was conducted through the analysis of websites, annual reports, and structured interviews with representatives of three university faculties focussing on the area of chemistry and three chemical companies in the Czech Republic. Although the research implies that the partnership brings a number of benefits to both parties, it also identifies diverse views of an optimal form of cooperation on the side of universities and companies.

Keywords: partnership; triple helix; chemical industry; Czech Republic

JEL Classification: I23; O31; L65

1. Introduction

In the current society, there are various partnerships, and they can be described through different models based on their types and number of partners. The basic model defining forms of partnerships was created by Etzkowitz and Leydesdorff in 1995 (Etzkowitz, 2008), and they called it the triple helix model. The triple helix model concept was developed as a response to the emerging knowledge economy in the ’90s of the 20th century (Cai & Lattu, 2022). The authors mainly wanted to explain dynamic interactions among the academic communities, industry, and government. This model was created to support entrepreneurship, economic growth, and innovations in the knowledge-based economy (Etzkowitz & Leydesdorff, 2000). The triple helix model is, according to Cai and Etzkowitz (2020), based on five main aspects – the existence of complex relationships between different players in regional innovations, the mechanism of subject interaction within the triple helix model (the ability to take over the role of the other), evolution in time (the evolution process of the model and its structuring and coordination), convenient interaction within the model (where not only the potential top-down

coordination, but also bottom-up initiative are required), and effects of both tangible and intangible conditions on the model (the most important aspect).

Entities that are willing to work in groups can create bilateral, trilateral, and multilateral cooperative bonds. Such bonds can be created by economic entities in all sectors of the national economy (Tetrevova et al., 2017). However, the term partnership is often misunderstood by the lay public, and that is why it is necessary to define it correctly. Cepelka and Potluka (2011) point out the definition issued by the government of the Czech Republic (CZE) in 2009, which says that partnership refers to a common target and interest, close cooperation, and common responsibility for common projects, mutual support and confidence, mutual consideration of needs, the equal position of partners, higher performance while implementing various projects and their greater transparency. Mutual awareness and exchange of experience are also important.

Cooperation between universities and industry has a long history. Either of these entities is aware of their position in society, and they know that their operations would be limited without the support of the other partner (Tetrevova & Vlckova, 2018). Three basic areas of cooperation include collaboration in the area of research and development (R&D), cooperation within education, and commercialization of R&D results (Skopkova, 2007). Charles and Conway (2021) tried to put forms of cooperation into four categories as follows:

Services based on R&D – the creation of knowledge through sponsoring of scientific projects using research and other technical facilities.

Utilization of the latest existing knowledge – drawing on inspiration and professional expertise from patents, copyrights, or other forms of codified knowledge to be applied in practice.

Human resources exchange connected with exchange programs – exchange of academic workers or university students with the business sector based on the transfer of knowledge from theory to practice and vice versa.

Spin-off companies and other new companies – the creation of programs encouraging graduates to establish new companies with the support of infrastructure in entrepreneurship (incubators, scientific parks).

The form of cooperation based on contract research, founding spin-off companies, and participation in clusters to create a suitable business infrastructure is substantial for both sectors (Hrušová, 2012).

Contract research represents the implementation of activities that have the character of research, development, and innovations as a service for reward provided to a third party. It is R&D to the order of a company which the university fulfills for a fee. These projects are original, and they mostly serve the needs of the organization financing the research, and they use the know-how and potentially top research equipment on the side of universities. A spin-off company is a company that uses tangible or intangible assets of another legal entity to start its own business activities (Komarek, 2006). A spin-off company is established to develop new knowledge, which is its intellectual property, and it has a lot of forms (Tormo-Carbo et al., 2014; Miranda et al., 2018). Dostalova and Drabkova (2020) state that the establishment of such a company is a much more complex process than the form of technology licensing or

sale. According to the type of involvement of the research organization in the spin-off company, there are three types of companies in the Czech Republic – a company with 100% equity participation of the research organization, a spin-off company with a share of a research institution, and a spin-off company without a research organization (Smolka & Bold, 2020). A cluster represents a beneficial partnership of companies, universities, and regional institutions, which has a lot of benefits for all its members (Paytas et al., 2004). Thanks to its structure, it can respond to new ideas and innovations and thus support research bases. Clusters can be horizontal (comprising manufacturers or suppliers of the same orientation with a minor deviation; the reasons are better prices of materials, raw materials, or services, better sales opportunities, or international cooperation), vertical (arising by the interconnection of subcontracting companies and institutions doing business in the same area, but with a different professional orientation, into a strategic chain; companies can operate as a whole, which can reflect in the prices of the provided services or the volume of orders), and lateral or side (a manufacturer creates a strategic interconnection with potential processors) (Panchártková, 2017).

Triple helix model entities formally cover partnerships through a partnership agreement. It specifies the reason for which the partnership has been established, if it is time limited, and it can also define the target of this partnership. A company can establish contact with a university directly or through mediators. In the Czech Republic, such mediators for building partnerships in the chemical industry include the Association of Chemical Industry, the European Association of Chemical Industry, the Czech Chemical Society, and CzechInvest. There are three levels of partnerships – a partner (a company cooperates with a university in the normal range), the main partner (such a partnership brings more significant opportunities for influencing a scientific institution and more demanding forms of cooperation and more intensive interaction), and a general partner (there is usually one only, it has the greatest authority, and it is usually integrated into the university R&D and other activities on a long-term basis, it contributes to the development of the university through its finances and practical know-how).

In the last 15 years, there has been a demonstrable interest in cooperation between universities and industrial companies regardless of its chosen form. Obviously, companies and universities have different opinions concerning the functioning and future development of their partnership. The attitudes of the collaborating parties were the subject of research conducted by Bekkers and Bodas Freitas (2008). The research showed that both companies and universities consider direct cooperation mainly as an effective tool for creating results. Academicians attach more importance to the transfer of information from the academic sphere to business. Most companies admit that without basic R&D it is no longer possible to innovate and that it can be used as a basis for applied research targeted directly at their business plan. The motivation and interests of the collaborating parties were assessed by Pitner and Tovarnak (2011). Their assessment implies that what companies see as of great importance is the licensed use of patented R&D results. On the contrary, they do not see big potential for legally unprotected R&D results, or in doctorands' R&DCompanies show great disinterest in sharing knowledge of their own experts within pedagogical or scientific work

at scientific institutions or the academic sphere due to their high workload. Universities, on the other hand, value it very much.

Companies put a lot of pressure on R&D activities in the area of applied research. It is necessary to combine the usability of R&D outcomes on the global level with usability in the industry (Lacko et al., 2008). It is also essential to improve communication between universities and their long-term strategic partners and between universities and their ex-students or ex-academicians (Lacko et al., 2008). If universities apply for international grants from European programs or national financial means, they are forced to prove the usability of R&D to be financed, and this is where the role of their partners from practice who will participate in R&D and eventually apply the outcomes is indisputable (Lacko et al., 2008).

Partnership support is financed not only by the state through national sources, but university-company partnerships are also supported by the European Union (EU) for the reason of knowledge and research development. Drawing European funds, which finance cooperation between companies and academic or scientific institutions, helped the state, as one of the triple helix model entities, reduce a significant part of the financial burden. Subsidy programs operate in yearly and multi-year periods. As for the EU, they are seven-year programming periods.

Together with the member state authorities, the EU supports various types of financing partnership projects. The main types of financing include grants, financial tools (loans, securities, and equity), subsidies, trust funds, or pricing. For example, the subsidy program of Horizont Evropa now takes place in the form of a grant. This program is mainly focused on the development of innovations and investments, education, science, and research. In connection with it, the subsidy fund of the educational program of Erasmus+ has also been doubled for the reason of the development of talented people (Gafrikova, 2021). The main subsidy program pillars include investments in scientific R&D, innovations, cooperation with the industry, transfer of the research outcomes into practice, and commercialization.

These activities are also supported on the national level. For instance, the Czech Republic is willing to support the development of innovations, knowledge, and skills. The country supports the business and academic spheres through its own institutions, such as the Czech Science Foundation (Grantova agentura CR) for basic research and the Technology Agency of the Czech Republic (Technologicka agentura CR) focusing on the support of research applicable in practice.

2. Methodology

The research was based on the primary analysis of secondary sources dealing with triple helix, quadruple helix, and quintuple helix. By narrowing the research to the partnership of universities and companies and by choosing the industry – the chemical industry in the Czech Republic, it was possible to determine the research target. The research aimed to specify what forms the partnerships between universities and companies in this particular area take, on what principles and how intensively the cooperation runs, how it is implemented, and what the partnership brings to both parties.

To fulfill this target, comparative analysis and structured interviews were chosen as the qualitative research methods, and partnerships of three universities focusing on education in the area of chemistry and three selected chemical companies in the Czech Republic that cooperate with universities on a long-term basis were analyzed. The data were collected by authors´team using a content analysis of websites (from June 2022) and annual reports (year 2021) of the universities and companies. At the same time, structured interviews were conducted with representatives of the assessed institutions (at the universities vicedean, specialist officers of the faculty resp. the university and personal managers of chemical companies has been interviewed). The structured interviews have been focused on areas of questions: identification of university/company, forms of the partnership and its usage in practise, assessment of the partnership and financial support of the partnership.

3. Results

The research respondents included three public universities in the Czech Republic focusing on the area of chemistry (University of Chemical Technology Prague, the University of Pardubice – Faculty of Chemical Technology, and Brno University of Technology – Faculty of Chemistry – hereinafter referred to as VSCHT, FCHT UPCE, and FCH VUT) and three chemical companies (ORLEN Unipetrol, a.s., Synthesia, a.s., and ASIOgroup).

For a summary of the basic characteristics and forms of partnership at universities and faculties focusing on education in the area of chemistry, see Table 1 below. All the universities and faculties are involved in various forms of partnership with companies, and each of them has defined a strategy they apply in this area.

VSCHT now has four faculties focusing on chemistry, and so it is the largest assessed university, not just a faculty, which gives it a specific position. As for the forms of partnership, this university mostly uses contract research. Within such research, they solve projects focused on solving analytical and technological issues from the practice of entrepreneurial entities, and sometimes it is also service work (custom analysis). In 2014, VSCHT established the Technology Transfer Department, which provides the university with counseling in the area of protection of intellectual property, and it also helps with founding spin-off companies. These firms mostly operate on the principle of granting a license and establishing a new company with the legal form of a limited liability company (s.r.o.). VSCHT is also involved in the cluster CZECHIMPLANT z.s. It is a cluster with a horizontal arrangement. VSCHT shows great interest in cooperation with the industrial sector. It usually prefers direct cooperation, but it is not opposed to cooperation through intermediaries. The university also uses the possibility of sharing experts from practice, which operates based on personal ties and contacts of the academic staff and industry experts.

The university enters into partnership contracts in a lot of areas (research, pedagogical), it has a clearly defined structure of general, major, and other partners. VSCHT Prague has, as for building partnerships, a clearly defined strategy, and it determines the form and the rules for establishing a partnership with the fact that it divides the partners into three categories – a general partner, major partners, and partners. By this division of partnership, the university is, compared to the other ones included in the research, exceptional. In 2015, its partnership

Table 1. Assessment of partnerships at universities

		VSCHT	FCHT UPCE	FCH VUT
Provided types of courses				
	Full-time	yes	yes	yes
	Distance	yes	no	no
	Combined	no	yes	yes
Cooperation within the quintuple helix model		yes	yes	yes
Number of students		3,836	1,322	1,031
Number of employees (calculated number)		1,263.4	324.9	175.53
Forms of partnership				
	Contract research	yes	yes	yes
	Spin-off firms	yes	yes	no
	Official clusters	yes	yes	no
	Unofficial clusters	yes	yes	yes
Cooperation with industry		yes	yes	yes
Sharing experts		yes	yes	yes
Making partnership contracts		yes	yes	yes
Areas of partnership				
	Scientific and research	most often	most often	often
	Pedagogical	often	often	most often
	Other activities	less often	less often	less often
No. of partners from the industry for 2021		N/A	128	131
Use of support from				
	European sources	yes-just as often	yes-often	yes-often
	National sources	yes-just as often	yes- most often	yes- most often
Use of EU fund sources				
	Grants	yes	yes	yes
	Financial tools	no	no	no
	Trust funds	no	no	no
	Subsidies	yes	yes	no
	Pricing	no	no	no
Involvement in the Horizont Evropa program		yes	yes	yes
Support of the Erasmus+ educational program		yes	yes	yes
No. of Erasmus+ students in 2021		91	14	24
Use of European and national sources to support partnerships		yes	yes	yes

with ORLEN Unipetrol, a.s., which is its general partner, resulted in the establishment of the University Centre at the manufacturing plant Litvinov, thanks to which training takes place directly in production.

The university tries to establish spin-off companies. Although it has already established 3 spin-off companies, it runs into ambiguities in what forms of joint ventures they should include in spin-off companies and which not, as some of the companies the university has established do not correspond to theoretical definitions. According to a university representative, it would be suitable to refine, or extend, the definition of the forms of partnerships for establishing spin-off companies. The VSCHT representative also

emphasized that for a seamless partnership it is essential that the utilization of R&D outcomes is sufficiently legally treated for the protection of both parties.

FCHT UPCE cooperates with all the quintuple helix model entities, but mostly with companies. As for the basic partnership areas, it mainly uses contract research. In 2022, it established the first spin-off company for the next commercialization of the important discovery of the pancreatic cancer diagnosis method using lipid analysis made by the team of prof. Ing. Holcapek, Ph.D. FCHT is fully open to the establishment of the next spin-off companies, but it primarily patents its own important R&D outcomes, or it offers their utilization in the form of licenses. In this area, FCHT also uses the support of the university Technology and Knowledge Transfer Centre, and it is involved in the cluster of Nanomedic. It is a vertical cluster. FCHT is interested in extending cooperation with the industrial sector. The association of the Chemical Industry of the Czech Republic is its important intermediary, with whom FCHT has made a partnership contract, and together they, for example, share the organization of the event of the Young Chemist (Mlady Chemik). FCHT shows a great interest in sharing experts from practice. Lectures led by experts from practice are common here, and they are integrated into training as a tool for transferring current information from various areas. Companies can suggest topics for final theses to be solved at the faculty. FCHT uses experts from practice not only for teaching, but also for the assessment of final theses.

As for cooperation with companies, FCHT tries to maintain regular contact with company representatives. Although it supports all forms of partnership, it has not structured its partners into groups. In its contract research, FCHT relies on the interest in the specialized workplaces of the faculty and the continuation of cooperation based on previous experience when establishing this cooperation. What is also positive is its involvement in clusters and the establishment of the first spin-off company. Also here, we can see an effort to support cooperation in the form of utilization of licenses or patents, and protection of these outcomes stabilizes step by step, and we can see an effort to promote more towards potential partners.

FCH VUT is involved in all the basic partnership forms. It mostly uses the form of contract research, where it achieves good results. Although the faculty is inclined to the possibility of establishing a spin-off company, it has not implemented this form of partnership yet. However, it has been involved in one of the cluster projects, i.e. in the pharmaceutical cluster Nanomedic. The faculty is interested in cooperation with industrial partners and communicates with them directly, rather than through intermediaries. The faculty also uses sharing experts from practice, it enters into partnership contracts, which usually relate to the pedagogical area. To a lesser extent, they relate to the scientific-research area.

An important part of the strategy of FCH VUT Brno is maintaining personal ties and contacts with its graduates. This faculty, mainly thanks to these ties, has established cooperation with the largest number of industrial companies from all the assessed universities. As the only one of the universities, it uses the possibility of supervising university theses by external supervisors from practice based on a contract, by which it tries to ensure greater commitment on the part of the company and involvement of students in solving particular practical problems. On the other hand, as for the involvement in clusters

and establishment of spin-off companies, the faculty still has no experience with this form of cooperation or a partner structuring system.

As well as the universities, the researched companies also use various forms of partnership with the academic sphere. Table 2 summarizes the results of the survey conducted at the selected companies.

Table 2. Assessment of partnerships at selected chemical companies

		ORLEN Unipetrol a.s.	Synthesia a.s.	ASIOgroup
Type of company		large	large	medium
Legal form of business		joint-stock co.	joint-stock co.	Ltd.
Type of company by character of activity		manufacturing	manufacturing	manufacturing
Cooperation within the quintuple helix model		yes	yes	yes
Number of employees		4,875	1,500	215
Forms of partnership				
	Contract research	yes	no	yes
	Spin-off firms	no	no	no
	Official clusters	no	no	yes
	Unofficial clusters	yes	yes	yes
Cooperation with universities		yes	yes	yes
No. of cooperating universities with a contract		3	1	1
Sharing experts		yes	yes	yes
Making partnership contracts		yes	yes	yes
Preferred field of education		chemistry	chemistry	chemistry
Preferred level university degree		master's degree	master's degree	master's degree
Areas of partnership				
	Scientific and research	most often	less often	often
	Pedagogical	less often	most often	most often
	Other activities	often	often	less often
Use of support from				
	European sources	yes- less often	no	yes- less often
	National sources	yes- most often	no	yes- most often
Use of EU fund sources				
	Grants	yes	no	no
	Financial tools	no	no	no
	Trust funds	no	no	no
	Subsidies	no	no	yes
	Pricing	no	no	no
Involvement in the Horizont Evropa program		yes	no	yes
Use of European and national sources to support partnerships		yes	no	yes

ORLEN Unipetrol, a.s. is a group of chemical companies manufacturing petrochemical and refinery products. The assessment of its partnership with universities showed that the company only implements one of its forms, i.e. contract research. In the future, new forms are not opposed if it benefits the company. The company has not established a spin-off company, but it nowadays supports the establishment of start-ups both financially and administratively. It is not involved in any of the official clusters either. The company usually cooperates with universities directly, i.e. without intermediaries, focusing on processing final

theses, it employs graduates, helps universities with tuition, and takes part in various events taking place at universities. ORLEN Unipetrol, a.s. is satisfied with the existing form of cooperation with universities, and it wants to continue and develop it. It is the general partner of VSCHT, and this form of cooperation has resulted in the establishment of a training center and the Technology Park at the company premises. The company also cooperates with other universities. A number of students solve actual company problems in their final theses, and subsequently, they become company employees.

Synthesia, a.s. produces qualified chemistry. In the past, the company used contract research, but currently it does not use any of this type of partnership. It has not established any spin-off companies. Synthesia, a.s. and holding Agrofert, a.s., in which is Synthesia, a.s. the member, they have great interest in cooperation with universities. This cooperation takes place directly, i.e. without intermediaries. The company most often cooperates with FCHT UPCE. In 2022, negotiations are underway to conclude cooperation in the areas of student support after the pandemic and the acquisition of new employees for the company. Experts from practice are shared less often. The company has only entered into one partnership contract, which is with FCHT UPCE, and it concerns above all writing final theses. The company also cooperates with Czech Technical University in Prague and VSCHT, but not based on partnership contracts.

Two companies belonging to ASIOgroup deal with the development of new technologies in the area of wastewater cleaning, water treatment, and air purification. The company uses two forms of partnership. The first one is contract research, where it cooperates on the level of examinations and R&D, which serve for verification and development of the company's business plan. It has not established a spin-off company, but it is involved in a cluster called the Association for Water of the Czech Republic. It includes more companies doing business in water management, but there are no universities. ASIOgroup companies are involved in a lot of "unofficial clusters", where companies help each other break into foreign markets and where they share their information. The company has long-term experience with partnerships with universities, and such cooperation takes place directly and is based on personal contacts. Company experts lecture at a lot of universities in the Czech Republic. Students implement their final theses at the company, and they also often find jobs there. The company is open to partnerships with universities. For the time being, it has officially entered into a partnership contract with VUT.

4. Discussion

Due to the long history of the investigated entities, the basic presumption was that each of the companies uses a form of partnership. The above research outcomes can inspire both universities and companies in, for example, VUT FCH and their intensive cooperation with graduates in practice, use of external trainers in final theses, and integration of experts to the boards of study fields. What is inspirational in VSCHT is its active role in the establishment of various forms of spin-off companies, its approach to a partnership as an appraised value it offers to its partners, structuring partners according to the scope of cooperation, and not underestimating the legal security of cooperation. What is inspirational in FCHT UPCE is its

support of the promotion of specialized workplaces, striving for an individual approach, or organizing round tables to assess cooperation and to get more stimuli. In the same way, the approach of businesses can inspire many others, e.g. by combining partnerships with more universities with the most suitable orientation according to the industry orientation of the company, by actively trying to work at the school as part of teaching, or by getting involved in the promotion together with a university as early as within the introduction of the university to secondary schools.

What is also inspirational is the findings about the existence of the so-called "informal" cluster of faculties of chemical technology, which includes VSCHT Prague and all faculties of chemistry from the Czech Republic. This cluster has already existed for 20 years. It serves to discuss current issues of chemical faculties, and it solves the problems of financing and budgeting. It also pays attention to the assessment of research organizations and evaluation of targeted R&D and innovation support programs under the M17+ Methodology (the Office of the Government of the Czech Republic, 2022). Similarly, companies also create informal partnerships within their holding groups and according to the thematic focus.

The research also discovered certain problematic areas in partnerships between companies and universities. Particularly, it is a slow response of universities to the development of the demand for graduates on the market from the point of view of companies, and generally a lower ability to respond flexibly to the situation on the market or the partners' requirements. There is e.i. slow ability to include in studying programs uptodate ICT qualifications required by companies. This response concerns the accreditation of branches, which are however limited not only by the internal rules of universities, but also by the higher education law. This opinion is also reflected in the companies' assessment of the possibilities of educating their employees through universities. They only use them to a limited extent in the case of very specific knowledge. Otherwise, they are more likely to use a commercial offer due to greater flexibility. Companies and universities also differ slightly in their opinion on the qualifications of graduates with respect to the achieved degree, where companies mainly prefer master's degree graduates. On the other hand, universities prefer the equal application of all graduates. An example of more flexible form of preparing of students based on requirements of companies is concept of industry PhD studying program (Roolaht, 2015) used on technical universities in west Europe and USA, but also in some countries of east Europe like Estonia.

The answers from only three companies as selected partners of chemical oriented universities or faculties limit the results of the article, the evaluation of other companies, partners, comparison with partnership of chemical universities and companies from abroad could bring inspiration and it is the plan for future research in area of quintuple helix.

5. Conclusions

Although the research revealed that cooperation between universities and companies exists and that it is positively evaluated on both sides, the full potential of cooperation forms is not being used. Within the cooperation, companies mainly appreciate the possibility of establishing contact with students, i.e. future potential employees, and the benefits in the area

of applied research. An objective finding was the low rate of involvement of partner entities in cluster initiatives, which is connected with their low viability in the area of the Czech Republic. One of the barriers to greater development of other forms of cooperation the companies mentioned is less flexibility and administrative complexity of formal steps on the part of universities.

There is room for improvement, for example, in increasing the scope of contract research, support of patenting R&D outcomes, commercialization of the outcomes through spin-off companies in expanded form with various forms of involvement of partners, and simplification of formal processes for establishing cooperation. The research shows a low rate of establishment and support of spin-off companies, which mainly have the potential to commercialize the results. It is necessary to pay attention to the reasons why it is so, although it is very likely primarily a lack of risk capital. This limits the possibility of successfully commercializing R&D results as well as achieving mutual financial benefits. An impulse can also be greater activity in patenting, which can be the basis for the creation of spin-off companies (Odei & Novak, 2022).

Information sharing could help more frequent linking of universities and companies into clusters. This research focused on partnerships within one industry and only from selected chemical companies, which brings interesting and detailed information about partnerships in this field, but it is also limiting. Further research would be appropriate to extend to the comparison of multiple partners and their assessment of partnerships with universities, to assess the role of the public sector, the public or non-profit organizations in this partnership with the quintuple helix model, and possibly compare with other sectors of the economy or with the situation abroad. It would be beneficial to extend the research to a more detailed analysis of partnership financing options. It was found that national resources and the EU programs are very important sources of funding for the financing of some assets. This issue will become more important, especially with the reduction of support from the EU for developed countries and also in connection with the development of the economy. The resources to the extent they were before the COVID-19 pandemic and the energy crisis will certainly no longer be available (Vlcek & Kostalova, 2020; Bednarikova & Kostalova, 2022).

Acknowledgments: This paper is based upon collaborative work from COST Action CA18236 SHIINE “Multi-disciplinary Innovation for Social Change” supported by COST (European Cooperation in Science and Technology).

Conflict of interest: none.

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