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## Collaborative R&D the Key Cooperation Domain for University-Industry Partnerships Sustainability – Position Paper

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### Abstract

In society, there is widespread and growing acceptance of the value of cooperation between industry and universities being collaborative Research and Development (R&D) domain and industrial policy the fuel of knowledge-based economies. In this paper, different domains of cooperation between the University and Industry as well as their generated benefits for each partner are identified. These benefits have been assigned to each domain of cooperation, showing a large number of benefits associated to collaborative R&D. Leading us to make a statement - collaborative R&D is the key cooperation domain for sustainable long-term university-industry partnerships. Suggestions are given about how to continue this research study.

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## 1. Introduction

In the context of an economy and a society in which knowledge has been assuming a driving force status (hence the more and more common use of the expressions “knowledge economy” and “knowledge society”), the universities have gained an even more prominent role as institutions that promote knowledge production and its transfer [1]. Even if there are several other institutions that play a relevant role in any national innovation landscape, universities are the only ones whose core activities are indeed knowledge production, its reproduction and diffusion, which translates, among other things, into educating the next generation [2].

Nowadays, the higher education and research and innovation systems are closer to economic and social development and are seen, by most governments, as a necessary condition for attaining a knowledge economy / society. Hence, frequently driven by policy initiatives, many universities have recently taken steps to foster links with knowledge users and to streamline technology transfer, assuming a serious commitment to developing a ‘third mission’ [3].

The extraordinary growth of R&D investment since World War II has brought about the need for coordination between publicly funded research and the interests of relevant industries. Therefore, in order to enhance the return on public investment in terms of economic growth, policymakers entrusted with the responsibility of structuring national innovation systems should improve their understanding of the purpose of each actor in the innovation system plays and its ability to connect with other players. Armed with this knowledge, policymakers can better design policies that more effectively target innovation and social development [4].

Different authors mention Universities and High Education Institutions (HEIs), meaning all types of institutions which provide higher education, that are accredited by relevant national or regional authorities: this includes tertiary schools, universities, universities of applied sciences, polytechnics/technical universities and colleges. In the context of this paper, the term university is used for all research-based HEIs. Similarly, some authors mention business and industry as privately and publicly owned organizations, non-government organizations and not-for-profit organizations. In the context of this research, the term industry is used for all of these organizations.

The relationship between knowledge and universities for promoting sustainable development is framed by contextual and regional factors that need to be taken into account. Nevertheless, one can find out a couple of universal regularities in this relationship, one of them being that the sustainable and long-term beneficial contribution of knowledge to social development is indirect, not direct [4]. Building a sustainable development demands having the capacity for generating long-term knowledge. However, this idea is often ignored by policymakers and other relevant actors, who picture the relationship between knowledge and development as direct, since this makes it easier to demonstrate relevance, usefulness and applicability and fits better with a typically short-term oriented mindset. Another universal regularity one can highlight is that the university remains the best and only producer of this capacity for self-renewing knowledge. The best indicator that attests to this is the production of re-search-based doctorates. The remaining complementary organizations within the knowledge economy need a thriving university sector that provides them with that capacity for generating self-renewing knowledge (new doctors), on which they feed and depend to fulfill their goals.

Even if there are different institutional contexts, research universities play a fundamental role in nurturing a region or country’s capacity for both research and advanced education, thus being at the heart of every academic system. There are indeed countries that have a public R&D ecosystem that includes national laboratories, re-search institutes, universities, community colleges, polytechnics, think tanks and non-governmental organizations. There are others that have a more homogeneous system [4]. And while every country presents a specific division of labor between institutions, most research is conducted at research universities.

Today, relatively little is published about how research ecosystems and how their knowledge systems really work. Diverse socioeconomic conditions make further re-search more difficult and does not allow the design of a one-size-fits-all model. However, for research universities, it is of the utmost importance to define their proper place within the broader industry landscape and to reconcile their priorities with broader national development agendas.

Therefore, an important research question arises: What is (are) the cooperation domain(s) that enable(s) sustainable and long-term partnerships?

In order to answer this research question three research phases are conducted. Firstly, the different University-Industry Cooperation (UIC) domains are identified. Secondly, the benefits of UIC are identified. Thirdly, the benefits of each UIC domain are established.

Firstly, based on literature review, we identify the different UIC domains and its generated benefits. Then, based on the researchers' expert judgement the benefits to each UIC domain are identified. These results allow us to endorse the position that collaborative R&D is the key cooperation domain for university-industry partnerships sustainability.

This paper is structured as follows: after the introduction, Section 2 identifies the cooperation domains of university-industry partnerships. Then Section 3 identifies the university-industry R&D collaboration benefits and, in Section 4, we present the link between the different university-industry cooperation domains and the benefits result-ant discuss and present the research results. In the conclusions section, a synthesis of the key results and suggestions for future research work are presented.

## 2. Cooperation Domains of University-Industry Partnerships

Today, there is an increasing recognition of the value of UIC in such a way that R&D and industrial policies assume UIC domains are the energy of knowledge-based economies [5]. However, cross-published literature in university-industry collaboration is fragmented and dispersed [5] [6]. Universities are supposed to serve a 'third mission' by contributing to economic development [5] [3]. In recent years, there have been community efforts to establish a common framework in order to understand those relationships. Similarly, policymakers and those who manage or oversee the process are challenged to maximize the results accomplished from the public investment, which requires a strategic vision and understanding of how the whole phenomenon happen. Those relationships are highly sophisticated and a complex phenomenon, far from being an uncomplicated and easy to do or understandable and a linear knowledge transfer process.

Commissioned by the European Commission - DG Education and Culture - the Science-to-Business Marketing Research Centre in Münster, Germany (S2BMRC) deliver the outcomes of the first major study on UIC in Europe [5]. That study de-fined UIC as 'all types of direct and indirect collaborative interactions between universities and any public or private organization for mutual benefit' and that there are eight different paths in which universities and industry cooperate: (1) Collaboration in Research and Development (R&D); (2) Mobility of academics; (3) Mobility of students; (4) Commercialization of R&D results; (5) Curriculum development and delivery; (6) Lifelong Learning; (7) Entrepreneurship, and (8) Governance. Fulfilling the different university missions: research, education, valorization and societal.

Meanwhile, Galan-Muros and Davey [7] proposed a UIC framework in which they define partnerships as 'collaborative interactions and cooperative efforts to transfer or exchange knowledge, technology or other properties between a university or academic manager and a member of any public or private external organization'.

Based on a review of the published literature, in particularly on the studies of Galan-Muros and Davey [7] and Davey, Baaken [5], the available cooperation do-mains to establish UIC sustainable partnerships were identified (Table 1). In this re-search study, a cooperation domain is seen as a field of action, thought and influence.

Casual relations, such as meetings at conferences and fairs, while important, are not considered UIC activities, but precursors of cooperation. Shorter and easier cooperation activities are related with early phases in the relationship; e.g. collaborative R&D entail more commitment and take place when the bond is more mature and consolidated [8].

## 3. University-Industry R&D Collaboration Benefits

University and industry engage in cooperation efforts with several expectations of benefits from both sides. Benefit is understood as a measurable improvement that derives from the results obtained [9], i.e., it is a result of a perceived change that is seen as an improvement through the eyes of a stakeholder [10].

A systematic literature review was conducted analysing papers published between 2000 and 2020. The papers were selected by means of the search engines Science Direct, Emerald, Wiley, Taylor and Francis, using the keywords: "benefits"; "benefits management"; "university-industry partnership benefits"; and "managing university-industry cooperation". 68 papers were selected after an initial screening, reduced to 40 papers after the final screening.

Table 1. University-Industry cooperation domains.

U Mission	UIC domains	Definition
Education	Joint curriculum design and delivery	Joint development and supply of courses, modules, programs, majors or minors, planned experiences as well as course delivery by delegates from external organizations within undergraduate, graduate or PhD programs. Includes cooperative project work and work-based learning, planned experiences in business for students, definition and organization of new study programs, guest lectures by business representatives, curriculum evaluation and joint supervision of PhDs.
	Lifelong learning	Provision of adult education, permanent education and/or continuing education by HEIs to people employed in external organizations. Ex: the provision of adult education, distance and open learning and continuing education for business people, as well as training courses targeting a particular skill and training needs of industry.
	Student mobility	Temporary movement of students from universities to business as placements or internships. Includes doctoral studies hosted inside industrial labs or students hired through academic contacts.
Research	Professional mobility	Temporary movement of employees between universities and businesses for work-related purposes. Includes sabbatical periods for professors and professionals, secondments, adjunct professorships for professionals from industry within the universities, non-academic 'in-residence' professionals from local communities and professors of practice.
	Collaborative R&D	Arrangements under which universities and business cooperate to pursue research objectives together, regardless of where the funding comes from. Includes all joint R&D activities like cooperative research projects funded by industry, contract research, R&D consulting, business testing and certification, joint publications with firm scientists/researchers and co-funding PhD students and industrial PhDs.
Valorization	Commercialization of R&D results	Process of bringing scientific research and technologies to the market through the trading of intellectual property assets: disclosures of inventions, patenting, licenses and sales.
	Entrepreneurship	Actions towards the creation of new ventures by students and academics based or not on their research, and by academics and industry together.
Societal	Governance	Cooperation at a management level of the university or firm. This includes having business leaders involved in university decision-making or sitting on their boards, as well as being involved at a faculty management level. Equally, governance also includes academics involved in firm decision-making or sitting on the boards of firms.
	Philanthropic	Gifts, in kind or money, Philanthropic grants and contracts Philanthropic funds can support buildings and land, staff appointments, equipment and other assets, scholarships and other academic activities, core funding of academic activities, and in some circumstances funding of research programmes. A gift is defined as any item of value given by a donor who expects nothing significant of value in return, other than recognition and disposition of the gift in accordance with the donor's wishes.

Based on this analysis and the researchers' professional experience on university-industry collaborations resulted in the gathering of a long list of benefits generated by UIC presented in Table 2.

One of the most relevant works analysed was the work recently published by Fernandes et al. [11], which based on a systematic literature review, identified the key benefits of the particular university-industry domain cooperation - R&D collaborations and identified the critical factors for the realization of each identified benefit.

Another relevant sources were the studies from Ankrah and Al-Tabbaa [12] and De Fuentes and Dutrénit [13]. Ankrah and Al-Tabbaa [12] made a systematic literature review of university-industry collaborations acknowledging that this kind of collaboration allows to enhance innovation through knowledge exchange and identifies namely the motivations for university and industry to collaborate. De Fuentes and Dutrénit [13], focus on the channels of UIC that allows long-term benefit, where the authors acknowledge the perceived benefits from collaboration as an important aspect. The types of benefits considered were benefits for firms (e.g., access to new knowledge and use of resources available at public research organizations) and benefits for researchers (e.g., ideas for further research, reorientation of the research/development agenda and financial resources).

Table 2. Benefits of University Industry Cooperation by beneficiary.

	B. N°	Benefit Description	References
Industry	B.01	Increase competitiveness	[11-14, 16]
	B.02	Portfolio diversification: new products/services/processes	[11-13, 17-19]
	B.03	Acceleration of the commercialization of new technologies/products	[11-13, 17]
	B.04	Access to state-of-the-art research as well as new knowledge/discoveries and insights (including receiving a "tidbit of knowledge" to assist development efforts), namely by a wide network of international experts	[11-13, 17, 18, 20-24]
	B.05	Consolidation of industry reputation among clients, partners and potential employees	[11, 12, 15, 17, 25]
	B.07	Access to training facilities	[24]
	B.08	Cost-effective research and reduced risk	[11-13, 26-28]
	B.09	Sustained increase of the company's turnover	[12]
	B.10	Improvement of the profit margins and cost reductions as a result of an increase in efficiency	[13, 18]

	B. N°	Benefit Description	References
University		provided by the developed solutions	
	B.11	Improvement of the key performance indicators	[13]
	B.12	Increase of exports resulting from new products development	[12]
	B.13	Resolution of several technical problems	[13, 18, 29]
	B.14	Improvement of product quality	[18]
	B.15	Reinforcement of companies' internal competences	[12, 17]
	B.16	Increase the industry's absorptive capacity for new knowledge	[13]
	B.17	Fulfilling 'third mission' responsibilities	[30]
	B.18	Improve recognition of University and its academics in the academic community	[5, 12, 13, 15]
	B.19	Source of income for universities (either public and/or private)	[12, 13, 17, 26, 31, 32]
	B.20	Affiliation with a safe environment to receive feedback on ideas/results/theories	[12]
	B.21	Reinforcement of the university's know-how due to the industry's intrinsic characteristics	[12, 13, 33]
	B.22	Reorientation of the university research/development agenda in order to be aligned with the industry needs and uncovering knowledge gaps	[12, 13, 18, 34, 35]
	B.23	Increase the capacity for scientific production and improvement of academic's capabilities	[12-14, 17, 29, 36, 37]
	B.24	Increase of the attractiveness for new and more skilled students (bachelor/master/PhD)	[12-14, 36, 38]
	B.25	Opportunity for practical application of research results	[39]
	B.26	Support to curriculum development and delivery	[40, 41]
B.27	Access and improvement of scientific and business networks	[29, 40]	
B.28	Real world experience for students in order to increase their practical and soft skills, knowledge and experience.	[12, 30, 39, 42]	
University/Industry	B.29	Acquisition of funds to hire researchers, purchase cutting-edge equipment, etc.	[13, 17, 18, 26, 43]
	B.30	Increase the number of patents	[17]
	B.31	Produce technological breakthrough	[34, 44]
	B.32	Improvement of the innovation ability; ongoing follow up of technological changes	[13, 45]
	B.33	Stimulate long-term innovation and technology pipeline	[24, 26]
	B.34	Retaining talented staff	[21]
	B.35	Improving the relevance of teaching and research	[29, 46]
	B.36	Increase in qualified employment through the direct recruitment of university qualified graduates, improving the quality of recruitment.	[12, 13, 18, 27, 28, 34]
	B.37	Learning/continuous professional development (more qualified company staff and researchers)	[12, 17, 29, 38]
	B.38	Creation of future research opportunities	[44]
	B.39	New business opportunities (start-ups/spin-offs)	[24, 47]
	B.40	Reinforcement of the knowledge transfer from University to the industry	[13]
Society	B.41	Increase the number of local suppliers, reducing dependence on suppliers associated with logistics costs	[12]
	B.42	Increased value in the labor market /employability of students	[29, 42, 48, 49]
	B.43	Student access to employment opportunities	[50, 51]
	B.44	Advancing of the body of knowledge	[44]
	B.45	Generation of income for scientific endeavors	[52]
	B.46	Attracting and retaining technology-intensive firms	[30]
	B.47	Providing the regional labor force with modern knowledge skill	[30]
	B.48	Regional/local economic development, namely through the direct and indirect increase of production of added value of goods and services and export orientation of regional/local companies	[12, 53]
	B.49	Promotion of environment sustainability, by developing eco-friendly solutions	[12]
	B.50	Spill-overs from universities to SMEs	[47]

#### 4. Results and Discussion

In order to support the statement - Collaborative R&D is the Key Cooperation Domain for University-Industry Partnerships Sustainability - Firstly, the different domains of UIC (**Error! Reference source not found.**) and its benefits (Table 2) were identified through a systematic literature review. Secondly, based on the researchers' expert judgment (more than 25 years of experience on university-industry partnerships), the benefits for each UIC domain were established, as shown in Table 3. The benefits (B.XX) identified in the right- and leftmost columns are the ones generated by all UIC domains.

Table 3. University and Industry benefits generated by UIC domains.

University benefits		UIC domains		Industry benefits	
B.01 B.48 B.40	B.24; B.26; B.42; B.35; B.47	Education	Joint curriculum design and delivery	B.05; B.15; B.07; B.35; B.47	B.01 B.04 B.41 B.09 B.11 B.48 B.37 B.49 B.40
	B.18; B.19; B.20; B.34; B.47		Lifelong learning	B.22; B.15; B.16; B.34; B.47	
	B.28; B.36; B.27; B.42; B.43; B.46; B.47; B.50		Student mobility	B.31; B.15; B.16; B.47; B.50	
	B.17; B.20; B.21; B.32; B.37; B.27; B.46; B.47; B.50	Research	Professional mobility	B.13; B.15; B.16; B.32; B.46; B.47; B.50	
	B.03; B.04; B.41; B.30; B.08; B.17; B.19; B.20; B.21; B.22; B.23; B.24; B.28; B.29; B.31; B.32; B.36; B.37; B.49; B.18; B.25; B.38; B.27; B.42; B.43; B.33; B.34; B.45; B.44; B.35; B.46; B.47; B.50		Collaborative R&D	B.03; B.02; B.30; B.08; B.10; B.12; B.13; B.14; B.15; B.16; B.29; B.31; B.32; B.36; B.07; B.38; B.33; B.34; B.45; B.44; B.35; B.46; B.47; B.50	
	B.03; B.17; B.19; B.29; B.49; B.18; B.25; B.33; B.45; B.35		valorization	Commercialization of R&D results	
B.03; B.17; B.19; B.20; B.21; B.32; B.49; B.18; B.25; B.43; B.33; B.44; B.35; B.46; B.47; B.50; B.39	Entrepreneurship	B.03; B.13; B.33; B.44; B.35; B.50; B.39			
B.17	*	Governance and Philanthropic			

As shown in Table 3, the UIC domain collaborative R&D is the responsible for the highest number of benefits in all available UIC domains. Therefore, it seems that the UIC domain that promotes more sustainable and long-term partnerships is the ‘Collaborative R&D’. As argued by Davey et al. [5], UIC domains that offer more direct, measurable and promotable benefits are the most established ones. Their study also showed that academics that engage in one domain of cooperation are expected to be also involved in a similar way in other domains of cooperation. On the other hand, Table 3 shows that a lesser number of direct benefits is associated with ‘less measurable’ domains that provide a more indirect benefit and low potential to promote sustainable long-term partnerships, such as governance.

A university-industry R&D collaboration is perceived as a temporary organization with a collaborative work environment with heterogeneous partners, collective responsibilities and, in many cases, with public funding support [54]. University-industry R&D collaborations are based on interactive relationships, trust and commitment between partners aiming to create mutual value over time, which allows diffusion of creativity, ideas and skills, hence promoting a bilateral exchange of knowledge [55]. A university-industry R&D collaboration exists to produce new results under (a) pre-defined research objective(s), within several limitations (time, cost and resources), resulting in a set of benefits for partners.

## 5. Conclusions and Future Work

In this paper, based on literature review, we identified the different university-industry cooperation (UIC) domains, and the benefits of UIC. Then based on the researchers’ expert judgment the benefits associated with each UIC domain were established. These results allow us to answer the research question: What is (are) the cooperation do-main(s) that enable(s) sustainable and long-term partnerships? Endorsing the position that collaborative R&D is the key cooperation domain for University-Industry partnerships sustainability, since most of the benefits of UIC are related to university-industry R&D collaborations.

In future work we intend to study and validate this hypothesis that collaborative R&D domain is the key ingredient for university-industry sustainable and long-term partnerships. The research methodology strategy planned is to carry out 2-3 case studies of different university-industry partnerships, using research methods such as document analysis, observation, surveys and Delphi method. Additionally, we intend to perform bibliometric analysis based on scientific publications and patents, in order to achieve the following research objectives: (1) from the viewpoint of publication placement, verify whether R&D collaboration with the industry truly delivers improved qualitatively scientific results; (2) verify if academics, that collaborate with industry, perform better than colleagues who are not involved in such research and collaboration activities; (3) verify the level of multidisciplinary on the publications of university-industry

collaboration are superior/equal/inferior to the rest of the publications authored solely by academics; (4) explore the effect of: geographical proximity or innovation level (from fundamental research to product development – TRL – R&D intensity on the sustainability of university-industry partnerships.

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