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STI 2022 Conference Proceedings

Proceedings of the 26th International Conference on Science and Technology Indicators

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Citation: Ramos-Vielba, I., & Norn, M.-T. (2022). Open Science Partnerships' contribution to knowledge dissemination and value creation. In N. Robinson-Garcia, D. Torres-Salinas, & W. Arroyo-Machado (Eds.), *26th International Conference on Science and Technology Indicators*, STI 2022 (sti2283). https://doi.org/10.5281/zenodo.6974938

Collection: https://zenodo.org/communities/sti2022grx/

Open Science Partnerships' contribution to knowledge dissemination and value creation[1]

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Background and purpose

In response to increasingly varied strategic goals and changing environments, universities are widening the approaches to create value from research. In such context, the implementation of open and collaborative research practices denotes a relevant transformation in the way universities promote the production, dissemination and translation of scientific knowledge to industry and other sectors of society. The pivotal feature of openness appears, in this sense, as a means to achieve greater development opportunities and enhance the potential impact of science, according to the Open Innovation in Science (OIS) framework (Beck et al., 2020; Beck et al., 2021). OIS emphasizes the complementarities between the open science encouragement of transparent and accessible knowledge (Vicente-Saez & Martinez-Fuentes, 2018) on the one hand, and open innovation strategies for knowledge transfer and commercialization (OECD, 2013), on the other. On this dual basis, OIS exchanges with both industry and the public contribute to fuelling the entrepreneurial ecosystem of universities through innovation and the creation of new valorisation opportunities (Audretsch & Belitski, 2021).

Aligned with these principles, Open Science Partnerships (OSPs) emerge as a model that aims to accelerate science and innovation by actively engaging stakeholders and supporting experimentation (Ali-Khan, Jean & Gold, 2018; Ali-Khan et al., 2018; Gold et al., 2019; Gold, 2021). OSPs for university-industry collaboration also respond to growing challenges over conventional approaches to boost commercialization of research through Intellectual Property (IP)-based mechanisms associated with university patenting. OSPs are defined as 'private-public collaborations that have certain common elements: open access publications, open sharing of data, tools and materials and the absence of intellectual property rights that restrict improvement or use of jointly created inventions' (Gold, 2021, p. 2).

OSPs are, therefore, a form of public-private research partnerships (PPPs) that supports collaboration on precompetitive research. Such focus has been widely used in the last decades by combining multiple partners' resources –e.g. knowledge and materials– to pursue joint,

[1] This work was supported by the Novo Nordisk Foundation. The authors would like to thank Louise Isgaard Saugstrup and Daniel Conradsen for collaboration on the collection and analysis of data.

basic research and develop new technology platforms, tools, databases and/or predictive models (Stevens et al., 2016). Like other precompetitive PPPs, OSPs seek broad dissemination of research outputs. There are, however, some distinct characteristics of OSPs, since participants adhere to open principles –i.e. providing free research outputs to the public, with neither IP rights nor restrictions on their further use (Stevens et al., 2016). Additionally, OSPs promote open sharing with a wider community, including industry and other societal actors.

A small but growing number of OSPs have been set up across the world; most famously the Structural Genomics Consortium (SGC), but also more recent initiatives such as the Early Drug Discovery Unit (EDDU) at McGill University, the Innovative Medicines Initiative (IMI)-funded EUbOpen Consortium, the Open Discovery Innovation Network (ODIN) at Aarhus University, the Open Plastic research program at Queen's University, and OpenPlant, a collaborative research initiative between the University of Cambridge, The John Innes Centre and the Earlham Institute.

There is no single standard for OSPs; they differ in their organization and practices (Gold et al., 2019), e.g. in how they are governed and funded, although they usually rely on a mix of public, private and/or philanthropic funding. The aims of OSPs generally revolve around furthering basic scientific insight by combining scientific data and methods with external knowledge of needs and challenges in industry and society.

In this paper, we argue that OSPs may represent a new avenue for bolstering the valorisation of research by funding university-industry collaboration on precompetitive research and by creating favourable environments for developing and de-risking research outputs with a broad range of potential –both commercial and non-commercial– applications. OSPs can then lead to further research utilization and stimulate subsequent investment through the promotion of better alignment between research objectives and industry and the participation of potential users in validation and proof of concept studies.

We propose three important mechanisms by which OSPs facilitate a new pathway to value creation. First, early and ongoing involvement of industry stakeholders in *knowledge co-creation* processes strengthen partnerships and generate a foundation for accelerated discoveries. Second, an OSP realm results in *knowledge spillovers*, which support academics in identifying and exploiting new development opportunities. Third, OSPs reduce organizational and transactional obstacles to knowledge exchange with partners, which generate *mitigated barriers* to production, dissemination, use and commercialization of scientific knowledge.

Material and methods

To explore the potential of OSPs to support further development of early-stage research results, we examine two cases of OSPs within the biomedical field, where the majority of OSPs have been established (Gold et al., 2019). This field is dominated by research-intensive firms which have strong science base and a long-standing tradition of collaboration with academia, and are involved in a shift to more open, collaborative innovation models (Mueller & Weigelt, 2010; Dolgin, 2014; Stevens et al., 2016).

The first of the two OSPs examined is the Structural Genomics Consortium (SGC) established in 2004, a pioneering OSP. The SGC case study draws on information and insights presented in an interim evaluation of the SGC (Morgan Jones et al., 2014), the results of which were

expanded upon by Morgan Jones & Chataway (2021), as well as a study by Perkmann & Schildt (2015). In addition, two interviews were conducted with a leading profile at SGC: an informal background interview in January 2021 and a semi-structured interview in November 2021.

The second OSP examined is of newer date and smaller scale: the Open Discovery Innovation Network (ODIN), a philanthropically funded, three-year OSP anchored at Aarhus University, Denmark, which has provided funding for 11 collaborative research projects. The ODIN case study draws on data collected from a document study of projects materials, from semi-structured interviews with the principal investigators and industry participants of all 11 projects, and background interviews with ODIN managers: secretariat, steering group, project review committee, and the technology transfer office.

Major themes in the interviews with key personnel at the SGC and ODIN were the aims and activities of the OSP, its organization and governance, degrees of openness and the instruments used to ensure openness, the roles of funders and participants, and intended and realized outcomes of the OSP. Interviews were recorded and transcribed.

The cases were selected using a purposeful sampling approach aimed at identifying information-rich cases through an intensity sampling (Patton 1990). The aim was to capture substantial variation in OSPs by selecting the SGC as a partnership that is large in scale, has been in operation for almost two decades, and is a multinational partnership involving multiple universities, while ODIN is a small-scale, newly established and nationally focused OSP anchored at a single university. Table 2 provides an overview of the two cases, including the data sources on which the case studies draw.

Table 2. Two studied OSPs cases

OSP	Involved universities	Duration	Funding	Data sources
SGC	University of Toronto (Canada) Karolinska Institutet (Sweden) University of North Carolina at Chapel Hill (USA) Goethe University Frankfurt (Germany) University College London (UK)	2004-	Mixed (public, philanthropic, private)	Morgan Jones et al. (2014) Morgan Jones & Chataway (2021) Perkmann & Schildt (2015) Interviews with a SGC leading figure
ODIN	Aarhus University (Denmark)	2020-2023	Philanthropic (7.3 mill. €)	Document study Interviews with managers, principal investigators and industry participants

Findings

The Structural Genomics Consortium (SGC) is a multinational, not-for-profit PPP, a registered charity, whose mission is to accelerate the discovery of new medicines using open science through strengthened university-industry collaboration. More specifically, SGC aims to map and create three-dimensional pictures of human proteins to be used for new

treatments, by improving fundamental insight into how the physical shape of proteins affects their interaction with other molecules. The SGC does not employ academic researchers directly. Instead, they disburse funds to the universities that employ the researchers.

All information and research results from SGC are placed in the public domain without restrictions. Members of the SGC do not have any advanced access to the data to ensure free use by both academics and commercial efforts avoiding delays. SGC has a strict no-IP policy: findings cannot be patented but must be shared and made public by a Protein Data Bank (IP is seen as a barrier to upstream drug discovery research). The SGC also shares any discovered reagents (as tangible, physical entities) without any limitations for using them.

Continued operation and expansion of the SGC has been further supported over time. Moreover, companies like Tensha Therapeutics have built on SGC research, and the SGC has spun out several companies, including Harbinger Biotech and 1DegreeBio (Morgan Jones et al., 2014), as well as more recently the public interest, open science company YCharOS.

The main insights from the case study of SGC are summarized in Table 3.

Table 3. How SGC may stimulate research valorisation

Mechanism	Key insights
Knowledge co-creation	• Large-scale university-industry collaborations enables more productive results • Efficiency of drug discovery processes is boosted by (i) ability to generate rapid high-quality reproducible science, based on a cost-effective approach to protein structures and 'industrial model' for large-scale; (ii) flexibility to adapt research to explore emerging scientific themes; (iii) contributing to decrease duplication of efforts among participating companies through transparency in ongoing in-house research activities
Knowledge spillovers	• Alignment of academic and industry aims by letting scientists pursue follow-on research and publish while providing firms with key insights • Open principles and training of participating companies promote multidirectional exchanges • Openly shared outputs can be drawn freely upon to identify new opportunities for drug discovery, while company inputs contribute to ensuring the practical and commercial relevance of research foci and outputs
Mitigated barriers	• Barriers to collaboration and knowledge exchanged mitigated by legal instrument and no-IP policy • Industry participants' suggestions for research while world-class research delivers high-quality outputs • De-risks new areas of science by providing ground-breaking, yet reliable and reproducible, new knowledge and allows for academic-industry risk sharing

The Open Discovery Innovation Network (ODIN) is a three-year initiative for industry-university collaboration. Its stated aims are to speed up drug discovery through the development of open knowledge and data for a faster translation of research into new and improved treatments of disease.

ODIN projects include academic researchers from at least two faculties at Aarhus University and at least one industry partner. Funding is provided solely for academic participants, while industry and other partners (e.g. regional hospitals) make in-kind contributions. Most projects involve large pharmaceutical companies, but some also include small or medium sized enterprises (SMEs) offering specialized expertise and services.

All research within ODIN occurs at the precompetitive stages of drug discovery (TRL 0-3), and contributors openly share their research data and results with the public without any further restrictions. Participants, as well as any other interested parties, are free to access, use or re-purpose outputs from ODIN funded research, including the development of products that can be commercially protected. The main insights from the case study of ODIN are summarized in Table 4.

Table 4. How ODIN may stimulate research valorisation

Mechanism	Key insights
Knowledge co-creation	• Emphasis on active involvement of industry partners in design and execution of projects promotes collaboration, drawing on complementary skills and resources • Research addresses complex challenges in industry, and increases alignment of scientific and industry aims • Commercial relevance of joint research is expected to strengthen, as company inputs allow for industry expertise and practices to be taken into account
Knowledge spillovers	• Industry participants (both big pharma and SMEs) access tacit knowledge in academia and build in-house capacity for further R&D • Support for industry participants in more efficient search for new commercial opportunities and for the scientific building blocks and tools with which to pursue them
Mitigated barriers	• Legal instrument (project agreement) reduces experienced barriers to entering into collaboration and to ongoing knowledge exchanges within projects • Openness principles reduce barriers to further development/application of outputs within or beyond funded projects • Industry participants are able to pursue more exploratory, high-risk but potentially high-gain projects than they would normally pursue • Ongoing exchange of expertise, materials and tools within projects de-risks early-stage outputs with a view to future private investment

Discussion and conclusions

The translation of scientific discoveries into beneficial applications and wealth for society endures as a major policy objective of governments and academic institutions. Universities' institutional adaptation is taking place primarily through a broader spectrum of measures to boost innovation and societal impact of research, which includes the promotion of open collaborative practices for the production, dissemination and valorisation of scientific knowledge. OSPs seem to offer a promising supplement for the generation of relevant outcomes as they enable the engagement of non-academic stakeholders in the processes of value creation and knowledge dissemination, which become fundamental tools to find further applications for inventions (Beck et al., 2019; Audretsch & Belitski, 2021).

Openness appears in this context as an emerging transversal dynamic that is re-shaping science and innovation through a diverse array of processes, infrastructures and practices. The SGC and ODIN case studies show that –irrespective of their different features and scales– open collaborative processes result in cross-fertilization of knowledge and technologies that may enhance the competitive position of partners, e.g. either in terms of high-quality reproducible science for academic researchers or in-house building capacity for further R&D of firms. Likewise, diverse open exchanges between the academia and industry, –including know-how, data, training or testing– are helping to foster cross-boundary knowledge flows based on the complementary expertise of participants. The two observed OSP reflect partners' strategic needs for high-risk projects in drug discovery to be grounded on novel combinations of the stakeholders' knowledge base. Besides, interviews confirmed that the OSP experience seems to push the participants towards both more flexible managing practices within the partnership and mutual adaptation techniques as part of the learning process.

Unlike traditional linear models, an OSP collaborative platform is not necessarily university-led; instead, multiple actors mobilise resources and capabilities in a fluid and interactive manner to generate value from research. More distributed leadership in knowledge production and dissemination may, therefore, enable academic institutions to account for additional nuances and complexities involved in technology transfer and commercialization processes (Bradley, Hayter & Link, 2013). Within the emerging diversification strategies of universities, OSPs illustrate a type of intervention that seems better aligned with the stage heterogeneity of technology development cycles (Wright et al., 2006), which potentially strengthen the basis for identifying wide-ranging opportunities, like the SGC case indicates.

In addition to industry uptake of research outputs and the creation of private-held companies, SGC also inspired the launching of a public interest open science company owned by a registered charity. This company coordinates drug discovery projects in specific therapeutic areas, with the participation of a university lab, to provide services to the scientific community, the healthcare systems and other agents. The combination of open science principles with commercial incentives based on regulatory IP assets seem to suggest arising mixed forms of valorisation of science.

From a policy perspective, our results show how, in response to a changing landscape, academic institutions expand their boundary spanning strategies with their participation in interdependent knowledge networks to fuel innovation, while also furthering understanding of imperative societal challenges. Fostered personal relations between scientists and industry have proved to be of critical importance for this function as bridging organizations. Nevertheless, open collaboration practices may also represent some managerial challenges, notably in terms of coordinated contributions and a shared innovation agenda.

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