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The Structural Genomics Consortium: successful organisational technology experiment or new institutional infrastructure for health research?

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ABSTRACT

In a sector characterised by patenting, direct appropriations and returns from investment, the Structural Genomics Consortium (SGC) constitutes a radically different public-private and entirely open access approach to pre-competitive research. This paper discusses the significance of findings from the first independent review of the SGC. We argue that the SGC offers a shared knowledge resource for drug discovery which is distinctive from other types of knowledge production and, as such, provides a knowledge infrastructure for the wider scientific community. We distinguish three ways in which this infrastructure functions as a model for investing in, extracting value from, and generating knowledge for the field. Our analysis suggests there is a future for open science models such as the SGC in health research and innovation, but that such models raise a set of challenges over the role of different public and private institutional actors and the way in which value is extracted.

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1. Introduction and context

The life sciences industry has traditionally relied on a closed innovation model and models of research which require heavy use of intellectual property rights (IPR). The standard mode of practice has been to patent widely and early; securing intellectual property has become an entrenched practice at all stages of the value chain. However, many view the traditional model of drug discovery to be broken. It is expensive, time consuming and inefficient. A prevailing theme in the literature is the recognition that, in order to succeed in ever-challenging environments, more collaboration is needed and an increasing use of knowledge produced outside the firm (Powell 1996; Lane and Lubatkin 1998; Mathews 2003; Nicholls Nixon and Woo 2003; Athreye and Godley 2009).

This has led some to consider whether a model of 'open science' and 'open innovation' might be appropriate. 'Open science' broadly refers to a set of attitudes, beliefs, and practices that are characterised by open access to scientific research publications, open research data, and other forms of multi-directional exchange between academic researchers themselves and with the public (Smith et al. 2017). Open innovation describes a range of collaborations and mechanisms for sharing

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knowledge, research activity and results (Chesborough, Vanhaverbeke, and West 2006). Open science and open innovation are highly related concepts, but in some respects they are in direct tension and conflict with each other. Whilst both are underpinned by a belief in the benefits of collaboration and knowledge exchange, open innovation advocates often argue that intellectual property should be used to enable knowledge exchange; whereas an open science approach is more committed to radically altering the role of intellectual property in research and even in innovation (Bogers 2011).

This paper examines how the Structural Genomics Consortium (SGC), a unique, public-private partnership focussing on precompetitive structural biology and adopting an open science approach, has facilitated changes in the standard model of early stage drug discovery efforts. By adopting an open science model of knowledge production at the precompetitive stage of drug discovery, the success of the SGC was thought to be derived, in part, from its competence as a 'boundary organisation', capable of overcoming the challenges science-intensive firms face when working in open data environments (Perkmann and Schildt 2015).

There was initially a strong rationale for the SGC's pre-competitive public-private partnership and open science approach, particularly in the early stages (Lee et al. 2009; SGC 2018). However, as more private sector partners began to join the SGC, some began to ask whether there was still a role for the public sector. There was also a desire to understand the strengths and weaknesses of the SGC's model. It was against this backdrop, and ten years after its initial founding, that the SGC commissioned an independent evaluation.

This paper reports on the results of this independent evaluation of the SGC (Morgan Jones et al. 2014). The SGC itself provided funding for the study, but the research was carried out independently and objectively in 2013. With the exception of Perkmann and Schildt (2015), little systematic and rigorous analysis had been done to understand the impact of the SGC, or the nature and diversity of the benefits it affords, both for the partnering organisations and for the wider research community. Though several years have passed since the evaluation was conducted, the broader themes in this paper remain valid, perhaps all the more so in light of the COVID-19 global pandemic. The rate of knowledge development and learning, eventually leading to development and approval of a Covid vaccine was faster than anything we have known. This was due to many factors, but the rapid, real-time and open sharing of pre-prints and data was clearly important. The lessons of the SGC's model, become all the more relevant in this light.

Two questions frame the analysis reported in this paper: (i) what are the defining characteristics of the SGC's model of pharmaceutical research and innovation?; (ii) what is the wider role of open science and PPPs in drug discovery and health innovation? We argue that the SGC, as an open science model in health innovation, serves as a platform for knowledge generation which provides a shared knowledge infrastructure for drug discovery. By knowledge infrastructure, we mean it is a soft infrastructure that others can readily draw on for further knowledge development, much like 'hard' infrastructure investments like synchrotrons or linear accelerators. Such a 'soft', knowledge infrastructure could allow for advances in drug discovery no matter the physical location of the researchers by providing an open, shared, and common knowledge resource for drug discovery. We argue that the institutional actors involved in the SGC each play distinct roles which are crucial to its success. This suggests that there are opportunities and challenges for open science initiatives like the SGC in the health innovation system. We conclude by exploring whether this model is still relevant, and its wider applicability to open science in drug discovery and health innovation.

2. A short profile of the SGC

Since its establishment as a not-for-profit, multinational public-private partnership in 2004, the Structural Genomics Consortium (SGC) has been supporting drug discovery efforts through a unique, open access model of public-private collaboration. Its primary focus has been and continues to

be on pre-competitive structural biology research, namely cost-effectively determining the 3D protein structures of biomedical importance on a large scale.

One of the primary rationales behind establishing the SGC was 'a motivation to accelerate the flow of human protein structures into the public database. It was hoped this would benefit biological research in general and 'particularly within the pharmaceutical area' (Williamson 2000). In particular it was recognised that at the current rate of development of 3D protein structures it could take over 1,000 years to generate structures for all human proteins (ibid). This desire to develop an 'industrial-scale drive to develop the high throughput determination of thousands of protein structures' (Butler 2000), rather than rely on the efforts of individual researchers studying one molecule at a time also drew on the (then recent) success of The Structural Nucleotide Polymorphism (SNP) Consortium. The SGC was also seen by some at the time as the natural successor to the Human Genome Project (Interviewee).

Since this time, the rationale for the SGC has further developed to address the need to better coordinate genomic efforts taking place across the globe at pre-competitive research stages, and to avoid duplication of efforts. The SGC is currently funded by a mix of public and private funders who contribute a fixed annual sum over the phase of research activity in return for membership of the SGC Board and a voice in determining the focus of research efforts.[1] At the time of our evaluation in 2014, the SGC had public funders situated in the UK and Canada, and there were two primary research sites: at the University of Oxford (Oxford, UK) and the University of Toronto (Tortonto, Canada). At the time of its inception in 2004, the SGC also received public funding from a number of Swedish sources. However, SGC Stockholm ceased operation in 2011 because the charitable funder had a strict rule to only provide one round of funding. Today, the SGC has expanded and in addition to the two initial sites in Toronto and Oxford, there are now SGC research sites at Universidade Estadual de Campinas (Campinas, Brazil), the Karolinska Institutet (Solna, Sweden), The University of Chapel Hill (North Carolina, USA) and Goethe University (Frankfurt, Germany).[2]

The original evaluation (Morgan Jones et al. 2014) provided detail on similar organisations to the SGC, but found there were no direct comparators. At the time, three main other groups provided structural genomic data: Japan's RIKEN research institution, the USA's Protein Structures Initiative (PSI), and Europe's Structural Proteomics in Europe (SPINE) initiative. All three relied either solely or largely on public funding. There are also a range of health innovation Public Private Partnerships across the global landscape, and a detailed analysis of these can be found in the original report. A conclusion of that analysis was that there were no detailed evaluations of any other major initiative which could be used as a comparator. This raises questions about the lack of sector-wide thinking and evaluation about how public and private sectors can best work together in pre-competitive and open innovation spaces (Chataway et al. 2011).

At the time of the evaluation, the SGC had operated for nearly ten years, and in that time had been through multiple funding rounds. The role of the private sector in the SGC (beyond funding and involving active collaboration) was novel, especially given the focus on pre-competitive research and open access Intellectual Property (IP). It experienced three phases of funding worth a combined $425,024,876 (based on the budgets submitted to the evaluation team by the SGC). This funding was relatively evenly spread across the three phases of the SGC, although Phase I included more infrastructure funding than Phases II and III.

3. A mixed-methodological approach to understanding the SGC

The evaluation that the research team carried out was multi-method and drew on quantitative and qualitative data (Morgan Jones et al. 2014). These included a literature review, a review of internal SGC documents, key informant interviews (44 interviewees), a researcher survey (17 respondents, 74% response rate) and analysis of quantitative data related to the SGC's relative productivity. Whilst this quantitative analysis was useful and gave insight into aspects of SGCs relative productivity, it highlighted the need for further quantitative assessment, particularly in relation to a

return on investment analysis and efficiency savings. The full evaluation report provides more detail on the methodology and also discusses methodological difficulties. It is worth highlighting two of those here.

First, the lack of traditional patent outputs and spillover effects, such as spin outs that are often underpinned by patented technology in the life sciences, raises a series of challenges in measuring and assessing the SGC's broader impact. Whilst some outputs are easy to measure (such as publications and protein structures), patent counts, which are often used as a proxy for productivity both in output and impact terms, are not relevant here.

Second, the fact that companies continue to invest in the SGC speaks to some sort of value which is being derived. However, understanding the detail of how the SGC contributes to their R&D effort poses challenges. Most companies are hesitant to reveal too much about the contribution of specific SGC outputs to research and product development. Moreover, trying to attribute outcomes to the SGC is a difficult task methodologically. It would require tracking the specific ways in which the SGC's outputs and interactions with companies and researchers the world over has led to advances and/or new drug discovery. Due to the cumulative nature of scientific discovery, it is not clear that monitoring attribution (as a proportional measure of fractional effort) versus contribution (as a simple indicator of effort) in this way would be either useful or possible.

4. The SGC provides a knowledge infrastructure

This section of the paper summarises our findings by discussing three ways in which we found the SGC to be providing a shared knowledge infrastructure for the wider biomedical research community and what the core characteristics of this infrastructure are.

4.1. An infrastructure which allows for investing in knowledge

As a public-private partnership model of investment, there were characteristics which we found influenced decisions about whether to invest in or become a part of the SGC. There were multiple incentives for investment in the SGC across both public and private funders, including:

- a strict open access policy which had desirable knock-on effects for science,
- the ability to 'de-risk' new areas of science, and
- a clear 'industrial' focus which results in rapid and efficient research.

The SGC's open access policy dictates that all research findings are made publicly available before publication and that none of the work is patented so that other researchers in the field can have free and open access to all protein and probe structures. This means that science, as a part of the global commons (Hess and Ostrom 2005) can be more rapidly advanced. As one external collaborator commented,

> Without SGC support it would have taken years to achieve the results and get the enzyme. SGC's open access policy meant knowledge and outputs could be shared to further the science in my laboratory (E3).[3]

The contribution of the SGC to these sorts of research efficiency claims are difficult to validate, nevertheless quantify due to the cumulative nature of scientific research. However, it is the case that several examples of efficiency in the research process, including improved research outputs and the identification of new areas for drug discovery, were highlighted by the collaborators, funders and researchers we spoke with.

Related, a pre-competitive consortium like the SGC enables shared risks when exploring new and complex areas. For many this meant that expertise in new and emerging areas of science and drug discovery could be quickly gained and new areas of science could be rapidly 'de-risked'. Joining a

consortium could offer gains in identifying new compounds and the ability to train their researchers (through sending them to work in SGC laboratories) at relatively little cost.

> We […] recognised that we needed […] a lot more infrastructure in epigenetics which we didn't have here. In order for us to get up to speed with other pharma companies we needed to join the SGC. (F15)

Finally, we found that the ability of the SGC to take on an 'industrial' focus, with clear targets and milestones to accelerate the pace of the science conducted, was a clear incentive for the private sector to invest in the model. This was perceived to have a significant, positive effect on the speed and volume of the SGC's research.

4.2. An infrastructure for generating knowledge

As a model for generating knowledge for the field, our study revealed how the SGC provided a viable knowledge infrastructure. First, a major strength of the SGC is the fact that it enables extensive collaborations, not only between pharmaceutical companies, but also between the pharmaceutical industry and academia. Many attributed the breadth and depth of the networks to the open science model; specifically it allowed researchers to arrange collaborative working relationships quickly and easily without long delays (eg negotiations over IP).

Second, the SGC has an ability to produce high quality, *reproducible* science in a rapid and efficient manner. In 2012 Begley and Ellis exposed a problem of reproducibility of scientific experiments.[4] This problem has significant costs for private and public bodies attempting to take promising science forward to drug discovery. High levels of reproducibility are widely perceived to be associated with the SGC's full and open disclosure of detailed materials and methods and the reagents corresponding to those methods, as well as a strong private sector presence in undertaking the science. One of our interviewees claimed that the way in which the SGC produced knowledge served to decrease 'scientific pollution' in the field (F9).

The incentive structure in academia may also help to explain the disparity between the reproducibility of academic research and that produced by the SGC (Begley and Ellis 2012). For academics, publication is often the end point. The aims and objectives of the SGC go beyond publication and the presence of private sector funders makes it imperative that the SGC contribute to drug discovery. We found that practices and forms of work were influenced by the broader aims of the SGC and in turn operationalised through the SGC's institutional norms.

There were some weaknesses raised in relation to the roles the public and private sectors currently play, as well as their expectations of the initiative. The greatest challenge the SGC faces is the need for sustained funding. Public sector funding diminished significantly since the start of the initiative, though this was accompanied by an increase in the number of pharmaceutical investors. However, the majority of stakeholders felt that a balance of private and public funds was important to maintain the SGC in its current form (see Section 5.1).

4.3. An infrastructure for extracting value from knowledge

At the time of our evaluation, the SGC had three main streams of work: determining structures and sequences; developing chemical probes; and developing biological probes (or antibodies). The study we carried out allowed us to look in some detail at the SGC's outputs (see Morgan Jones et al. 2014). Context is important to understanding the significance and meaning of the data. The SGC set itself a specific task to deliver protein structures that go beyond those already developed in the scientific literature. This means that the SGC specifically targets proteins that are considered more difficult to work with. Therefore, any consideration of the outputs of the SGC research should take into account the relative difficulty of the task the consortium has set itself. We show in the full evaluation how the SGC had some success in moving science in the direction of unexplored areas of protein structure research.and had been responsible for the publication of sequence data for proteins it

works on. The data at the time also suggested that SGC outputs are roughly comparable to those of other structural genomics organisations in terms of structures delivered.

These quantitative outputs seem to indicate the relatively productive nature of the SGC. But it is not just that the SGC is productive, the knowledge generated has intrinsic value. Drug discovery is increasingly reliant on understanding the structure of proteins so new targets for drugs can be identified. The SGC fills a gap that is not, and cannot, be undertaken to the same extent by the private sector alone. Many we spoke with believed that pre-competitive collaborations were the future for drug discovery.

> SGC has played a valuable service in pushing the boundaries of pre-competitive research […] These kinds of public-private models will become more usual and the pre-clinical model will further move down the drug discovery pipeline […] the sheer complexity of biology research [makes this inevitable]. (F7)

However, what our evaluation could not uncover were the wider outcomes and impacts of the SGC further down the drug discovery pipeline, including quantifying or contextualising wider economic and societal spill overs. This was due to the difficulty of tracking how knowledge is taken up and translated into wider benefits. This is a common challenge in any set of impact studies (Greenhalgh et al. 2016). In particular, in the absence of concrete data, we found that the perceived lack of wider economic and societal spill-over effects was challenging for some public sector funders who aimed to stimulate economic growth and scientific innovation, specifically.

5. The role of the knowledge infrastructure in the innovation system

We have argued the SGC's open science model results in a platform for knowledge generation which is akin to a knowledge infrastructure and shared resource for the field. As such a resource, it enables other actors in the wider research and innovation system to further scientific investigations. We now turn our attention to analysing the characteristics and role of this knowledge infrastructure in the wider health innovation system and the relationships with open science.

5.1. The role of different institutional actors in building the knowledge infrastructure

While it is the case that the SGC is not unique in being a PPP in the biomedical space (Müeller and Weigelt 2010; Mittra 2015), it is the case that it has unique features which have been summarised above. While we do not have the space to summarise it here, we have reviewed other PPPs in the biomedical space as part of the SGC evaluation and have found that there are strengths common to many of them. These include features like the establishment of a network of collaborative research partners and experts, as well as the function of distributing risk and fulfilling a role where there has otherwise been a market failure (this being one of the primary functions of any PPP) (Morgan Jones et al. 2014).

However, what we do find in the case of the SGC is a set of benefits which are a direct result of its particular model. As discussed above, these include a strong and extensive network of collaborating researchers and institutions around the world, reproducibility, and a spreading of risk. These benefits are a direct result of the open science approach and public-private partnership model of funding.

Importantly, they point to a role for different institutional actors in the SGC which has not previously been articulated. The private sector plays a role in maintaining the targeted focus, high production output, and reproducibility of the SGC science. Both features keep it relevant for the drug discovery pipeline. This is a core and fundamental strength of the SGC and one which many interviewees in our research suggested was responsible for the speed, volume, and efficiency of the SGC's findings.

The public sector, meanwhile, plays a fundamental role in maintaining the trust in the openness of the SGC's research. It not only serves to help keep the science open and freely available, but the presence of the public sector as a funder and board member of the SGC means that others in the

research community have trust in that openness. The public sector presence helps others believe that all the research done with the SGC really is made available to the wider research community. Without this, it seems there is little to prevent distrust that the SGC is a group of pharmaceutical companies acting in their own interest.

Moreover, the role of the public sector also helps to keep the SGC innovative and sitting on the cutting edge of pre-competitive drug discovery. It was suggested to us by some interviewees that without the public sector, the SGC would become similar to a Contract Research Organisation, simply doing whatever the private sector members thought was in their interest. The fact that the SGC does not do this, and continues to pursue ground-breaking areas of science, for example, their work in membrane structural proteins[5], is evidence that there is some push against this.

5.2. The opportunities for an open knowledge infrastructure in an environment of patents

The SGC leadership views open science collaboration at an early stage of research without the act of patenting as providing the most productive and efficient results for pharmaceutical firms and drug discovery more generally. Patents are recognised to play a role in early stage discoveries in bringing public and private sectors together (Mowery and Sampat 2005b). Proponents of strong IPR regimes and the granting of patents on early research point to the increasing reliance of the pharmaceutical industry on the biotechnology sector, which is heavily dependent on venture capital and IPR for its survival. In addition to this, it is widely thought that biotechnology-based SMEs can and do play a vital role in moving the pharmaceutical industry in novel and much-needed directions (Nature 2011a). They can be 'disrupters' to technological and industrial trajectories that have become unproductive (Nature 2011b).

However, the SGC's model fundamentally challenges this point. The generation of knowledge crucial to this sector is not aided by patenting. Because protein structures are not patentable, there have been insufficient incentives for firms to make progress in this area. The gap in the knowledge base is being addressed by the SGC. Moreover, the SGC also generates antibodies and chemical probes which are patentable. This leads us to conclude, as have others, that health innovation in particular is not being served well by early patenting (Mazzoleni and Nelson 1998; Murray and Stern 2005).

In the same vein as Nelson (2004, 2008), Nelson and Sampat (2001) and Chataway et al. (2010), we believe the model of the SGC's open knowledge infrastructure reinforces the view that technological advance is an evolutionary process, that physical and social technologies must work together with institutions, and innovation benefits from the development of knowledge via multiple paths by a number of different actors. It is also cumulative, as bodies of knowledge build on previous understanding of practice. Outputs of scientific research are almost never themselves final products but are used in further research. Our findings about the SGC as a knowledge infrastructure fully support this.

Thus in a modest but important way, the SGC is demonstrating that open access health research and innovation is possible and in the eyes of investors, beneficial. This leads us to a set of final reflections on the future role of open science PPPs.

6. Observations about the future of open science PPPs

Existing analyses of the SGC describe the SGC as a boundary organisation which is able to overcome two main challenges (Perkmann and Schildt 2015). Firstly, it is able to reconcile the different goals of academia and industry. This is accomplished as the SGC allows time for its scientists to pursue publishable 'follow-on' research. Secondly the SGC finds a way to produce outputs despite the inverse relationship between the need for firms to shape the research agenda and the need to reveal as little as possible so as not to compromise its competitive advantage. The SGC has been described as a

boundary organisation by these authors because its interstitial position allows it to manage operations by maintaining social boundaries between participants (ibid).

Our findings complement this assessment and expand upon it to connect it to a different area of the innovation literature. As a new model, the knowledge infrastructure provided by the SGC responds to current challenges in health research and innovation. Could open science help to alleviate the productivity crisis in drug discovery through knowledge sharing, the facilitation of further research and the reduction of research inefficiencies (Hopkins et al. 2007; Ioannidis et al. 2014; Al-Shahi Salman et al. 2014)? The SGC is providing its partners with an alternative to common conventions which are perceived to be failing companies in their quest to improve productivity in early stages of research related to drug development.

An interesting question which arises, though, is whether the SGC will have a broader impact on the institutional norms that govern health research and innovation. Collective buy-in to open science, driven by the incentive of public sector funds, has enabled pharmaceutical funders to avoid high risk investment and early-stage protection of knowledge generated within the firm. Other open innovation initiatives in the private sector also benefit from the sharing of knowledge and resources, although they continue to rely on patenting – thus limiting the benefit of the research for the wider field. Unlike these initiatives, the SGC is more likely to succeed if open science is accepted collectively. Pharmaceutical partners are more likely to share their work if they are collaborating with a larger number of other pharmaceutical players (Saez, Marco, and Arribas 2002).

The outstanding question is whether SGC will disrupt more widely. In strands of socio-technical and sustainability transitions literature, this question is commonly theorised as the extent to which 'niche experiments' which are protected from dominant regimes evolve alongside other niche developments and in relation to performance and change in practices, routines and norms characterising dominant socio-technical regimes. Such 'landscape developments' at a macro level may slowly change and shift in such a way that underlying realities or high level ideologies and narratives favour some trends in socio-technical regimes over others (Schot 1998; Rip and Kemp 1998; Geels 2002).

Widespread collective buy-in to initiatives such as the SGC may serve to change the institutional environment in which pharmaceutical companies operate. If initiatives such as the SGC can change practice in relation to patentable outputs arising from pre-competitive research in the long-term, the institutional environment in which drug discovery takes place will be transformed. However, at present it is unclear how far this change is likely to take place. Further research is certainly needed on what the most useful time to patent within drug discovery should be.

7. Conclusions: the SGC as an interesting experiment or harbinger of more generalised change?

The original question of this paper is whether the SGC is simply a successful organisational technology experiment, or more akin to a new institutional infrastructure for biomedical health research and innovation. Based on the evidence presented here, the jury may still be out. The SGC, if supported by the appropriate mix of public and private sector actors, is certainly a viable alternative to more conventional modes of health research. However, if the recent pandemic has shown us anything, it is that rapid and open information to research has been critical. This suggests that when seen in the light of recent events, the model of a knowledge infrastructure for drug discovery which provides a shared knowledge resource for the field may be even more necessary.

The SGC provides clear incentives for investment in new ways of producing knowledge through its open access model. It allows for spillovers and co-production of knowledge, a shared approach to 'de-risking' new areas of science, an 'industrial' focus which is appealing to the private sector, and its efforts align the goals of different actors and allow research priorities to be jointly decided.

It also rationalises and centralises the production of knowledge on protein structures. In so doing, it avoids duplication of effort and allows for the development of specialisation. Economies of scale

result from this and economies of scope from its 'family-based' approach. It enables reproducibility of research findings, something that is not seen as achievable on the same scale by academia alone.

In relation to *generating value* from the knowledge produced, the SGC model reduces the cost of inputs by providing one of the most cost effective modes of determining protein structures in comparison to similar consortia. There is also anecdotal evidence to suggest its findings have served as the basis for further developments and drug discovery. However, this success itself raises important questions about health innovation not being served well by early patenting. Scholarship and thinking even by those who support some of the basic tenets, continues to argue that the patenting system needs review and reform (Saxell, Takalo, and Izhak 2020 and Arora and Athreye 2012).

Many questions remain about how significant the SGC will be, but there are indications that in important respects things are moving in the direction of open science. A number of research funders now insist on open access and the European Commission has made strong commitments to open science.[6] However, the challenges experienced by the SGC from conventional norms to judge success would indicate difficulties in sustaining the type of alternative that SGC constitutes. Thus, one important question is how open science and open innovation will resolve their inherent tensions. Other funders in the research and innovation system will necessarily have an effect on this. The study we have done suggests that the supporting structures for life sciences such as funding norms and conventions, the metrics by which scientists are judged, and conventional ways of measuring spillovers (breakthrough studies which highlight individual contributions and impact on local clusters for example) are not the most conducive to an initiative such as the SGC.

The original evaluation concluded that the SGC's model and achievements over the first ten years were, overall, a success. Though we have not conducted an evaluation of the period from 2014–20, the SGC has survived since then and, moreover, expanded. This all suggests the SGC does present a new model for drug discovery. And though its research efforts lie primarily at the very beginning of the drug discovery pipeline, it is in fact this position that puts its future in jeopardy. It sits in a space that borders basic and applied research and in many respects serves the needs of both communities. Its open science approach reinforces this, but as more private sector money has been invested, it has raised the question of whether the area has been sufficiently 'de-risked' so that the public sector can withdraw. This is an important and pressing question for public policy: the role of the public sector in the SGC goes far beyond a monetary one, and this raises important questions for innovation in the sector.

Notes

1. Governance arrangements are detailed on the SGC's website: https://www.thesgc.org/about/governance.
2. See SGC's website: www.thesgc.org.
3. All quotations given are paraphrased. All interviewees were given assurances of anonymity and that no directly attributable quotations would be used in any reporting. We are not able to provide any identifiable information other than designating whether a stakeholder was representative of external stakeholder views (E), was an SGC researcher (R), or was a funder, past or present (F) of the SGC. The numbers represent the unique code given to that individual and are taken from the original SGC evaluation study (Morgan Jones et al. 2014).
4. This problem is also discussed in The Lancet's series of articles on waste in biomedical research (Chalmers et al, 2014; Al-Shahi Salman et al., 2014; Chalmers et al. 2014) and in The Economist's feature on 'How science goes wrong' (http://www.economist.com/news/leaders/21588069-scientific-research-has-changed-world-now-it-needs-change-itself-how-science-goes-wrong).
5. See http://www.thesgc.org/science/imp for a description of their work in this area. They were the first group to solve the structure of a human ABC transporter, ABCB10, a mitochondrial membrane protein which helps to protect the mitochondria against oxidative stress and aids in heme production.
6. https://ec.europa.eu/research/openscience/index.cfm?pg=home&section=monitor.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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