

## News and opinions

## The rise of private–public collaboration in nanotechnology

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## ARTICLE INFO

## Article history:

Received 4 December 2017

Received in revised form 3 December 2018

Accepted 10 January 2019

Available online 22 February 2019

## Keywords:

Innovation

Patents

University

Collaboration

Technology transfer

## ABSTRACT

Against the backdrop of increasing private–public partnerships over the last decades, we are able to see the first promising signs in terms of research output, proxied by patents. Although the dominant innovation model seems to remain independent research and development, the partnering motion has the potential to remedy the criticized lack of technology transfer in the nanotechnology field. Nations entering the nano-space can strengthen their potential for growth by capitalizing on collaborative environments.

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## Introduction

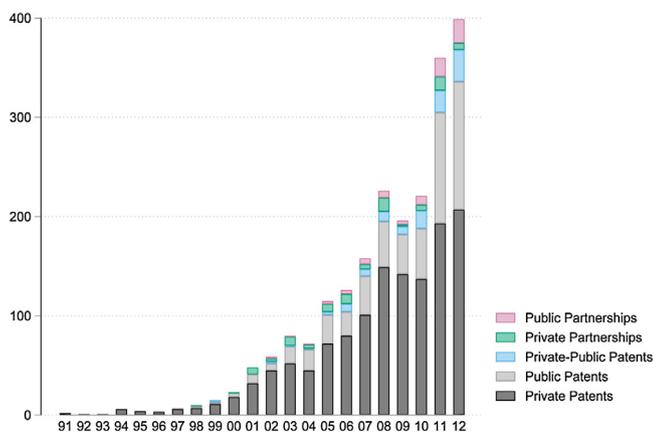
Over the last decades, the ties between universities and industry have grown increasingly stronger. It is a widely accepted notion that bridging the gap between basic and applied research is crucial for the advancement of any scientific field [1]. Among a range of disciplines such as chemistry, mechanical engineering, and biotechnology, nanotechnology figures among the main beneficiaries of this influx of private capital. In the science-based field of nanotechnology, corporations partner with universities and public sector agencies, frequently on multiple projects [2]. To name but a few examples, IBM announced a \$90 million strategic partnership with the ETH Zurich for a new nanotechnology laboratory ten years ago [3]. Another prominent case has been a \$25 million research alliance between Philips and the Massachusetts Institute of Technology (MIT) in the area of lighting solutions technology. Both partners jointly own a highly cited quantum dot patent portfolio, originally co-developed by MIT and Hewlett Packard [4]. In Japan, Hitachi is a sponsor of several research programs at the University of Tokyo, which has led to the joint development of several patented methods for carbon nanotube synthesis [5].

That academic institutions and technology companies should partner up is the ‘biggest lesson’ from Thomas Insel, former National Institutes of Health director who entered the private sector in Silicon Valley [6]. Establishing partnerships amongst different types of actors has been a primary objective of European and worldwide nanotechnology innovation policies [7]. Such joint research and development enhances efficiency and innovation through the pooling of resources [8,9]. The need for cooperation is exacerbated in the context of nanotechnology, a field that seems to have been stuck at the stage of an emerging science for decades, failing to make its way from invention to innovation. The absence of truly revolutionary nanotech-enabled products is presumably rooted in a variety of factors [10]. The lack of efficient technology transfer – that centers on getting nanotechnology from the hands of universities and public research institutions into those of commercial actors – is thought to be a key explanation [11].

Basic research developed by universities is often diffused by licensing patent rights to private companies. The dominance of public institutions in nanotechnology led to the patenting of upstream building blocks by universities; any restrictive academic licensing practice has the potential to hinder downstream implementation [12]. Another method of technology transfer is collaboration. Partnerships between private and public entities directly assign a commercial partner to an invention, therefore reducing transaction costs [13]. With this paper, we observe how collaboration manifests itself in terms of innovative output – proxied by patents, which are arguably considered the most objective measure for innovation [14]. In particular, we focus on those col-

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**Fig. 1.** Private and public patent applications over time. The Figure depicts the yearly number of patent applications filed (i) independently by private sector entities, (ii) independently by public sector entities, (iii) jointly by private–public collaborations, (iv) jointly by private sector collaborations and (v) jointly by public sector collaborations.

laborations leading to patents filed jointly by private and public institutions, which implicitly sheds light on the issue of technology transfer in nanotechnology. In other words, we examine how effective private–public partnerships have become in terms of patent output.

We aggregated data on nanotechnology patents by identifying all European patent applications relating to nanostructures (see the Supplementary Data for the data construction). Patent applicants were divided into private sector entities – companies and individual inventors – and public sector organizations – government non-profits, hospitals, and universities.

### Partnerships as pathways to commercialization

The number of patent applications in nanotechnology is ever-increasing (Fig. 1). A distinct feature of nanotechnology innovation is that patents are largely held by public entities. While the public sector generally holds about one percent of all patents [12], this share surpassed an average 30% in nanotechnology as demonstrated in the dataset spanning 1991–2014 (Fig. S1 in the Supplementary Data). The importance of university patenting calls for reliable technology transfer mechanisms, so that the patented subject matter may be turned into commercialized products by private actors.

Patents filed jointly by private and public organizations are still on a low level in absolute terms (see Fig. 1). Nevertheless, there has been a sharp increase in the share of these patents since the year 2000. In fact, in the most recent years, already approximately 8% of all patents have been filed jointly by private–public partners (see Fig. S2 in the Supplementary Data). This suggests either that such collaboration is growing more common or that these partnerships became more effective in reaching the patenting stage. Actors engaged in joint research appear to be convinced of the value of their patents; private–public patents were filed with more patent offices than independently developed public ones, obtaining wide geographic scope (see Table 1) [15]. However, the subsequent use and diffusion of the knowledge underlying these partnerships has been slow. Private–public patents exhibit one of the lowest forward citation rates of all types (see Table 2). The latter quantifies the number of citations a patent receives over a period of five years after its publication and is the most widely used proxy for the private and social value of inventions [16].

Financing and supporting collaborative environments may be key for nations to foster growth in nanotechnology. In countries

**Table 1**  
Family size (patent applications up to 2014).

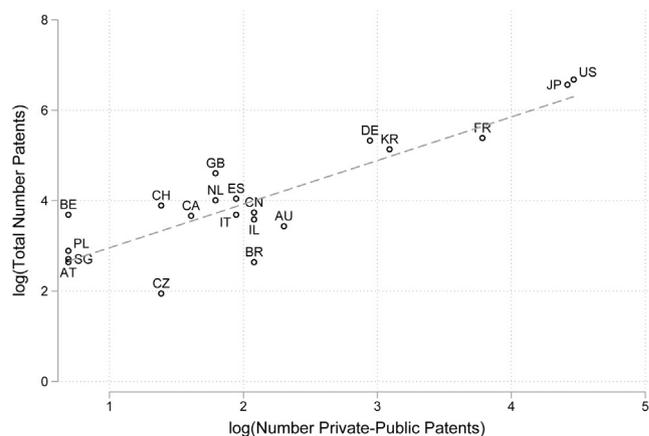
Type	Number	Mean	95%CI <sup>a</sup>
1. Private patents	1453	5.58	5.42–5.75
2. Private–public	147	5.28	4.79–5.76
3. Private–private	97	4.96	4.51–5.41
4. Public patents	609	4.31	4.14–4.79
5. Public–public	90	3.55	3.18–3.93

<sup>a</sup> CI denotes Confidence Interval.

**Table 2**  
Forward citations 5 years (patent applications up to 2012).

Type	Number	Mean	95%CI <sup>a</sup>
1. Private–private	91	1.54	0.95–2.13
2. Private patents	1314	1.26	1.10–1.42
3. Public patents	534	1.05	0.81–1.28
4. Private–public	114	0.81	0.53–1.08
5. Public–public	80	0.51	0.29–0.73

<sup>a</sup> CI denotes Confidence Interval.



**Fig. 2.** Correlation between private–public and total patenting. The Figure represents the positive linear correlation between the number of private–public patents and the total number of patents on logarithmic axes by country. The country codes are as follows: AT (Austria), AU (Australia), BE (Belgium), BR (Brazil), CA (Canada), CH (Switzerland), CN (China), CZ (Czech Republic), DE (Germany), ES (Spain), FR (France), GB (Great Britain), IL (Israel), IT (Italy), JP (Japan), KR (Republic of Korea), NL (Netherlands), PL (Poland), SG (Singapore) and US (United States of America).

where private–public patents are more frequent, the total number of nanotechnology patents is higher – a trend that seems driven by powerhouses like the US, Japan, South Korea, France, and Germany (see Fig. 2), which all have an established framework for public and private entities to work hand in hand (see also Table S1 for goodness-of-fit analyses). In fact, France may serve as a poster child for how investment in collaborative environments can accelerate growth. Seeking to curv its initial lack of patent filings, France launched its Nano-Innov plan, creating clusters associating scientific research and industrial development [17]. As a result, it appears to have built a solid network of collaborating partners, with the French National Center for Scientific Research and the French Alternative Energies and Atomic Energy Commission emerging as particularly prominent and prolific public partners (see Table S3). Similarly, Israel, the country with the third largest concentration of nanotech start-ups [18], and Singapore and Brazil, countries positioning themselves as regional drivers in nanotechnology, possess above-average rates of private–public patents (see Table S4 in the Supplementary Data) [19].

## Conclusions

All in all, this suggests that from a patent data viewpoint the research output of private–public collaborations in the field of nanotechnology is on the rise, albeit on a small level. While research institutions still develop the majority of their patents independently, our data fleshes out promising signs that private–public knowledge transfer is coming to fruition. Private–public partnerships provide a pathway to commercialization, and partners involved in such collaboration are willing to invest heavily in patenting strategies, implying a high internal valuation. Yet, the assessment of patent quality proxies suggests that the output does not, at the current stage, yield innovation with the highest technological impact.

Collaborative trends in nanotechnology are reflected in the rise of private–public partnerships. Research and development conducted jointly between public entities respectively private companies are increasing, as measured in the patents they produce. The pooling of assets, know-how, and technologies provides innovators with better ways to address the challenges of innovation in nanotechnology. Some countries seem to have developed reliable frameworks and close institutional networks between entities active in nanotechnology. Strengthening these may be key for countries entering the nano-space, or those seeking to develop or strengthen their presence worldwide.

## Competing financial interests

The authors declare no competing financial interests.

## Acknowledgements

We are grateful to Stefan Bechtold, Erasmus Elsner, Lisa Larimore Ouellette, and Hisashi Sugime for comments and suggestions. We thank Waseda University's support program for publication in high impact journals for covering the Open-Access fees.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.nantod.2019.01.002>.

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