Factors that make an impact

Number of citations in academic papers is not always a good measure for the influence of applied research papers.

In the vast majority of cases, scientists use public money to support their research.

In return, the public wants to see real benefits, else the faucet risks running dry. These benefits can come in the form of fundamental advances or, in the case of applied research, of new technologies that can solve real-life problems.

But assessing fundamental and applied research outputs are two separate trades. Fundamental research is mostly done by academics for other academics with the aim of making a contribution, however small, to our understanding of the laws of nature. Whether the taxpayer gets an intellectual benefit out of it is certainly desirable, but is not an immediate concern. Editors, science journalists and scientific institutions should be those helping the wider public to appreciate these kind of advances. The most impactful papers tend to get the highest number of citations, and this is one accepted way to measure their relevance.

In contrast, for applied research, taxpayers should be able to appreciate real-life benefits far sooner than for fundamental research. These benefits can be measured by the number of jobs created, the amount of money saved through using a more efficient technology, the number of lives saved (for example for biomedical research), the productivity increase, the enjoyment arising from using a new gadget, and so on. The number of citations by other academics is rather irrelevant to the taxpayer.

At *Nature Nanotechnology*, we publish a fair amount of papers reporting applied research, but we hardly ever look at how they have fared after publication. Yes, we might check the number of citations accrued, out of curiosity, but as mentioned this is not a relevant metric for real-life impact. We thought, therefore, that it would be interesting to look back at all the papers we have published since October 2006 (our first issue), and rank them in terms of the number of citations racked up in the patent literature. This is not quite real-life impact, but it is certainly a closer proxy than the number of citations in other scholarly publications. And it is also a relatively easy number to measure.

We were very pleased to see that a range of topics in nanotechnology have resulted in patented technologies, some of which have also hit the market. In the top ten most-cited papers there are graphene and two-dimensional materials for flexible electronics,

Fig. 1 | Number of granted patents citing *Nature Nanotechnology* articles versus year.

nanostructured materials for batteries, nanopores for DNA sequencing, nanowire-based transistors, nanocarriers for cancer therapy and memristive switching devices. It is important to note that the number of citations in patents does not correlate with the number of citations in scholarly literature, at least in our little sample. We were also reassured to see that the number of granted patents citing papers we are publishing is increasing from year to year (Fig. 1).

With the help of colleagues at *Nature Index*, we obtained these numbers from a dedicated website, Lens.org, a free search engine that can be used to data-mine the patent literature¹. The search we extracted our data from has been made freely available at the following link: <https://www.lens.org/lens/scholar/search/results?collectionId=29157>.

During our search, we found out that there is no standard formatting for citations in patents, though tools such as the Lens are now making it easier to extract relevant data. In addition, the patent ontology seems more like a patched up maze than an organic hierarchical structure. To name a famous nanomaterial, it's very hard to understand the difference in the following categories found in the Cooperative Patent Classification: "Graphene characterized by its properties" versus "Structure or properties of graphene"; or "Graphene oxide" versus "Graphene or derivatives, for example, graphene oxides" versus "Oxides Hydroxides graphene oxides". Not to mention the presence of misnomers such as "grapheme" in some descriptions.

Patents are a treasure trove of technical knowledge that academics can easily benefit

from, but not many are able to search or read a patent, let alone the wider public. Tools like the Lens and others are now opening up the patent corpus to exploration by academics. Authors have the possibility to see which companies are using and citing their papers, offering them a direct link to industry they might not have been aware of. Additionally, authors can use patent citations as a pertinent metric for the impact of their research. Funding agencies too can benefit from these search tools when assessing the outcome of grants in applied fields.

As a journal with a strong interest in technology, we are glad to see that some of the papers we have published contained the seed of new commercial products. In this issue, we present an [interview with Jong-Hyun Ahn from Yonsei University in Seoul, Yi Cui from Stanford University and Hagan Bayley from Oxford University](#), the corresponding authors of the top three most-cited papers in the patent literature. They share insights about doing impactful applied research in academia. Publishing a good 'applied' paper is only the beginning of the journey — the distance between an academic paper and a successful technology is vast. Paraphrasing Jong-Hyun Ahn, any proposed new technology risks fading away without patient optimization work and dedication. □

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References

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