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研究課題名（和文）Exploring the flow of publicly-funded research into commercialised inventions

研究課題名（英文）Exploring the flow of publicly-funded research into commercialised inventions

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研究成果の概要（和文）：本プロジェクトでは、ケースコントロール法、バーチャルパテントマーク、特許引用データを用いて科学研究から商業化への経路を明らかにしました。科学的起源から遠い特許ほど商業化可能性が高いこと、そして過去の科学研究と直接的なつながりがあると、古い研究は商業化と正関連、特許引用数とは負関連であることが明らかになりました。これらの結果は公的科学研究、特許創出、商業的成功の間の関係性を再定義し、商業的革新者が公的科学研究をどう利用するかの理解に貢献します。

研究成果の学術的意義や社会的意義
We traced how public science becomes real-world products. Surprisingly, inventions farther from original research often become successful products. Older science often aids commercialisation, suggesting that science's societal impact can be a slow burn, but no less significant.

研究成果の概要（英文）：In this project, we employ a case-control methodology to explore the pathway from scientific research to commercialisation. We used Virtual Patent Marks (VPMs) and patent citation data to trace the path from scientific research to marketplace.
Findings reveal that patents further removed from their originating scientific citation were more likely to be commercialized. However, once we condition on a direct link to past scientific research, older scientific work was found to be positively associated with commercialisation but negatively associated with a patent's citation-based impact. These findings are in disagreement with traditional analyses of the link between an invention's impact and its scientific antecedents, and stand up to several robustness checks.
These results shed new light on the complex relationship between public science, patent creation, and commercial success, significantly impacting how we understand utilisation of public scientific research by innovators.

研究分野：Innovation

キーワード：Innovation　Patents　Commercialisation　Science　Citations

1. Background at the beginning of the research

The critical role of public funding in driving scientific research and industrial development cannot be overstated. This funding, allocated to various entities like universities, private firms, or government research organisations, is justified by the projected benefits that society will reap from the research results. Indeed, many of today's widely used technologies, ranging from the internet to CRISPR, lithium-ion batteries, and LEDs, were birthed out of publicly funded research. However, it is challenging to empirically study and measure the relationship between publicly funded research and societal welfare. This project aimed to explore this relationship in depth, focusing specifically on new knowledge generated through research and its direct societal impact, primarily via commercialization.

2. Purpose of the research

The research sought to offer a quantitative analysis of the prevalence of public funding for scientific research in commercialised products. It aimed to dissect the complex ties between public science funding and commercialised products, using a network of linked patents, publications, and funding grants. This project proposed the first large-scale study of how public funding flows through scientific and industrial outputs, resulting in commercial products for public consumption. The methodology leveraged new developments: the collection of digital information about grant details and their output, the use of Virtual Patent Marks (VPMs), and the analysis of citation data. The overarching goal was to trace the innovation chain from public funding to commercial products, providing a more transparent view of the societal impact of funded research.

3. Research Methodology

In our finalised research methodology, we modify the initially proposed research plan due to challenges encountered in obtaining sufficient coverage of funding data that could be easily connected to the science cited by patents. Rather than investigating the proposed funding-science linkage, we delve deeper into the science-patent-commercialisation pipeline. Although this adjustment precludes us from tying the commercialisation outcomes to the specifics of funding behind the public science, it enables us to probe more expansively into the overarching impact of public science on patent success and commercialisation.

Our research methodology is structured around two sets of exploratory analyses designed to illuminate different facets of this complex process. The first set takes a broad, macro-level perspective, assessing a patent's overall relationship to science by determining its distance from the scientific frontier. This distance is then related to the probability of patent success, specifically a binary indicator of citation-based impact (top 5%) and likelihood of commercialisation. The former is

included in both analyses as a link to previous literature on this topic, and allows us to contrast commercialisation outcomes with an established quality indicator, in terms of their relationships to science.

The second analysis set provides a more detailed, micro-level view by evaluating the patent's science base at the citation level. This granular approach enhances our understanding of the nuanced ways a patent relates to science and how this relationship might influence its impact and commercialisation potential, provided an established relationship to science exists.

To investigate these relationships, both analysis sets utilise logistic regression models. Specifically, we employ conditional logistic regression to appropriately handle pairs of patents that have been matched along several criteria (semantic similarity, priority date, and assignee) to form a case-control sample wherein one patent in the pair is commercialised while the other is not. The conditional logistic approach mitigates the issues of over-parametrisation often encountered with traditional pair-fixed-effect logistic regression models, allowing us to focus on structural parameters and their relationship with the outcomes without being distracted by fixed-effect coefficients.

In addition to these analyses, the study incorporates a broad spectrum of independent variables and controls. These include attributes related to patent-to-patent and patent-to-science citation networks, citation lag, citation source, and the diversity of scientific fields a patent cites. Other crucial factors include the total count of a patent's scientific article citations, inventor count, and geographical family size, which act as proxies for various ex-ante patent quality dimensions.

Having established this revised analytical approach, the next section of the report will discuss the empirical findings derived from these methodologies.

4. Research Results

There are two main areas of significant achievement in this research. Firstly, our results demonstrated the nuanced impact of a patent's "distance" from its originating science on its probability of commercialization, which we defined as the number of citation steps it takes to trace a patent back to a scientific publication that is cited in a patent. Specifically, we found a positive correlation between the number of citation steps a patent was from an in-text science citation and the likelihood of that patent being commercialised, suggesting that patents that are less directly tied to their scientific roots may be more likely to result in commercialised products.

Secondly, our study highlighted a counterintuitive relationship concerning the age of the science cited by a patent. Older scientific research appeared to be beneficial to commercialization efforts, but negatively correlated with citation-based impact. This indicates that while use of older, established science may be advantageous for commercialization, it may limit the citation-based impact when patents are not directly tied to the latest scientific discoveries.

These findings offer significant contributions to both the domestic Japanese context and the international scholarly community. For Japan, a nation that consistently ranks among the world's top nations for patents filed and scientific publications produced, understanding the path from scientific research to commercial success is crucial. This insight can inform and shape future research policies and industry direction.

On the international stage, our findings contribute novel insights into the understanding of the science-technology nexus. We reveal the complexity of the relationship between scientific antecedents and patent outcomes, demonstrating that traditional (and most accessible) measures of patent success might be insufficient to encapsulate the direct societal impact of scientific discoveries.

Despite our significant findings, we also identified several limitations that signal avenues for future research. A notable shortcoming is our inability to measure the success of products post-commercialization. In addition, the use of VPMs as a measure of commercialization is inherently restrictive, as it requires firms to make use of these legal tools. Future research could expand on our findings by extending information about scientific antecedents, such as data on public funding, or by examining other outcomes that have direct relevance to society, such as the progress through clinical trials for novel medical treatments.

In summary, our research has demonstrated that the journey from scientific discovery to societal benefit is a complex and multifaceted process. Our findings offer valuable insights for science policy and future scientific endeavours, paving the way for more comprehensive investigations into the science-technology knowledge pipeline. These results promise to make a considerable impact on the understanding and advancement of science commercialization both in Japan and internationally.

５．主な発表論文等

〔雑誌論文〕　計0件

〔学会発表〕　計4件（うち招待講演　0件／うち国際学会　0件）

１．発表者名 Kyle Higham, Gaetan de Rassenfosse
２．発表標題 Product Commercialisation and Prior Scientific Advance: Evidence from virtual patent marks
３．学会等名 Kyoto University
４．発表年 2022年

１．発表者名 Kyle Higham, Gaetan de Rassenfosse
２．発表標題 Product Commercialisation and Prior Scientific Advance: Evidence from virtual patent marks
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３．学会等名 Victoria University of Wellington
４．発表年 2023年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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７．科研費を使用して開催した国際研究集会

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８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関