Max-Planck-Institut
für Innovation und Wettbewerb

Science Quality and the Value of Inventions

Dietmar Harhoff

Focus Session "The value of fundamental research“
NWO Physics Conference
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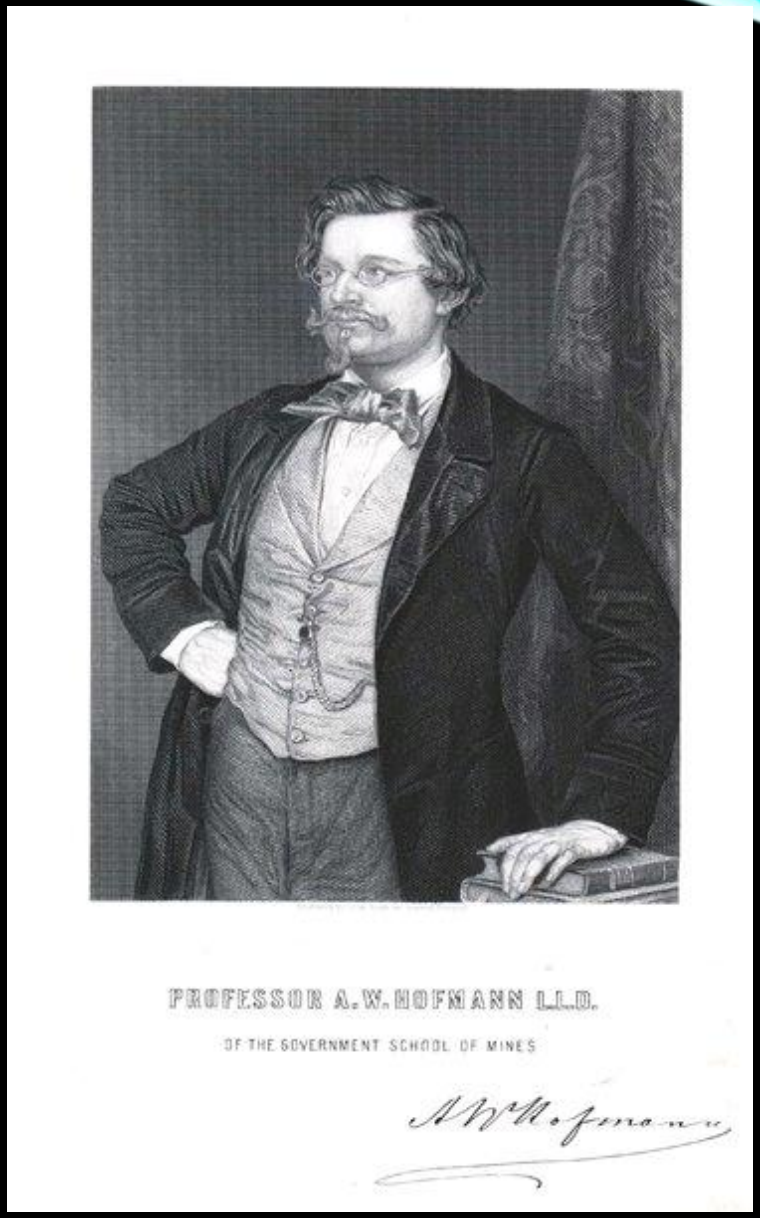
Agenda

- The Potential of Science
- Governance of Science
- The Economic Returns to R&D
- A Tale of Two Worlds
- Alignment of Science and Innovation
- Innovation Policy

The Potential of Science

- Early 18th century: German chemists flock to England‘s booming academic system.
- So does *August Wilhelm Hofmann* who becomes a Professor at the Royal College of Chemistry.
- In the 1860s: England dominates chemicals production and has all industrial advantages: inputs, customers, financial means.
- “Killer application” of the day: artificial dyes.
- 1865: *August von Hofmann* returns to Germany (first Bonn, then Berlin) and establishes a large institute.
- 1869: *Baeyer* sets up a large lab in Munich.
- 1875: first R&D laboratories in the emerging chemical industry.
- 1865-1892: *Hofmann* trains in Berlin 150 doctoral students - 1875-1915: *Baeyer* trains in Munich 395 doctoral students.
- The graduates become the founders and C-level leaders of the new chemical enterprises who commercialize academic and own research.
- 1913: Germany produces 140.000t dyestuffs, CH 10.000t and England about 4.000t.



Source: Murmann, J. P. (2003). *Knowledge and competitive advantage*. Cambridge University Press.

The Governance of Science

- *Science, the Endless Frontier*. A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development and former President of MIT
- … proposed the establishment of the National Science Foundation (NSF)
- … developed the conceptual foundations of post-war division of labor in R&D
  - fundamental (basic) research financed by the state and executed by universities and PROs
  - most applied research financed and performed by private organizations

The Economic Returns to R&D

A Thought Experiment (*Jones and Summers 2020)

- Consider an economy with growth rate g of GDP per capita, R&D intensity s, and interest rate r
- USA 1953-2019: $g = 0.018$, $s = 0.025$, $r = 0.05$
- switch R&D to zero for one year – assume: growth equal to zero for one year
- What is the benefit-cost ratio BCR of R&D?
- benefit = g/r – cost of R&D = s
- In this case: BCR = $g/rs = 14.4$
- With other (more realistic) assmptions: BCR > 3.5.

Broad consensus among economists: the long-term benefit-cost ratio is about 3 to 4.

***Jones, Benjamin F. and Summers, Larry, A Calculation of the Social Returns to Innovation (September 2020). NBER Working Paper No. w27863, Available at SSRN: https://ssrn.com/abstract=3700691**

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Azoulay, Pierre and Danielle Li. "Scientific Grant Funding," in Innovation and Public Policy, A. Goolsbee and B. F. Jones (eds.), University of Chicago Press, forthcoming.

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A Tale of Two Worlds

	industrial innovation	scientific discovery
currency	$, €, SFr	reputation, scientific awards, citations
output	patents, prototypes	publications
behavior	secrecy, establishing property rights	free revealing, establishing priority claims
enforcement	courts	norms reciprocal behavior

Alignment of Science and Innovation

We have very different outputs and incentives.

Is a breakthrough in science related to downstream breakthroughs in technology?

Yes - and the link is quite strong!

Alignment of Science and Innovation

A simple test looking at publications and patents …

SCIENCE ADVANCES | RESEARCH ARTICLE

SOCIAL SCIENCES

Science quality and the value of inventions

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Despite decades of research, the relationship between the quality of science and the value of inventions has remained unclear. We present the result of a large-scale matching exercise between 4.8 million patent families and 43 million publication records. We find a strong positive relationship between the quality of the scientific contributions referenced in patents and the value of the respective inventions. We rank patents by the quality of the science to which they are linked. Strikingly, high-ranking patents are twice as valuable as low-ranking patents, which, in turn, are about as valuable as patents without a direct science link. We show this core result for various science quality and patent value measures. The effect of science quality on patent value remains relevant even when science is linked indirectly through other patents. Our findings imply that what is considered excellent within the science sector also leads to outstanding outcomes in the technological and commercial realms.

Alignment of Science and Innovation

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Excerpt from the Examiner's Search Report

[X]US2005069539 (COHEN BRUCE D [US], et al) [X] 1,2,12-15 * claims paragraphs [0008], [0044], [0125] - [0148] *;
[XP]WO2009155725 (ESBATECH AN ALCON BIOMEDICAL R [CH], et al) [XP] 12-14 * pages 2-5, 16-20 *;
[XP]WO2009155726 (ESBATECH AN ALCON BIOMEDICAL R [CH], et al) [XP] 12-15 * pages 14 - 16, 50 claims *

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Alignment of Science and Innovation

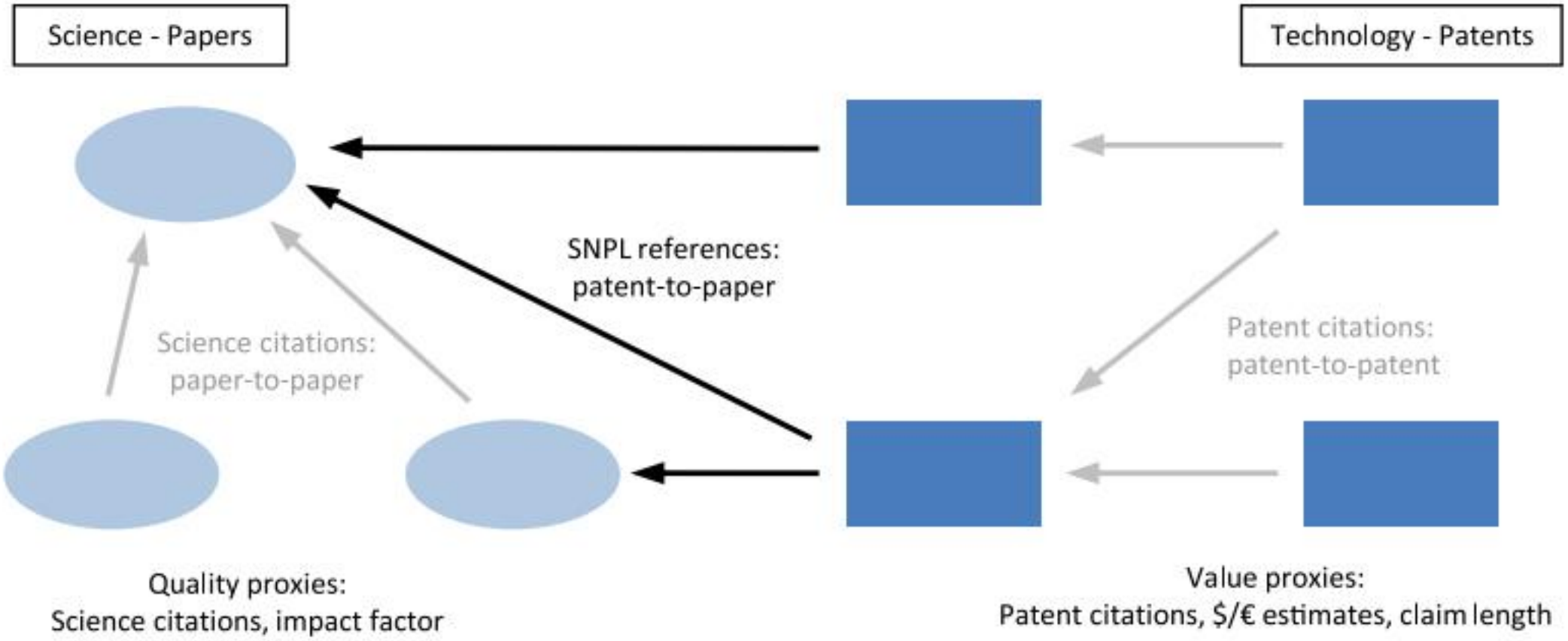
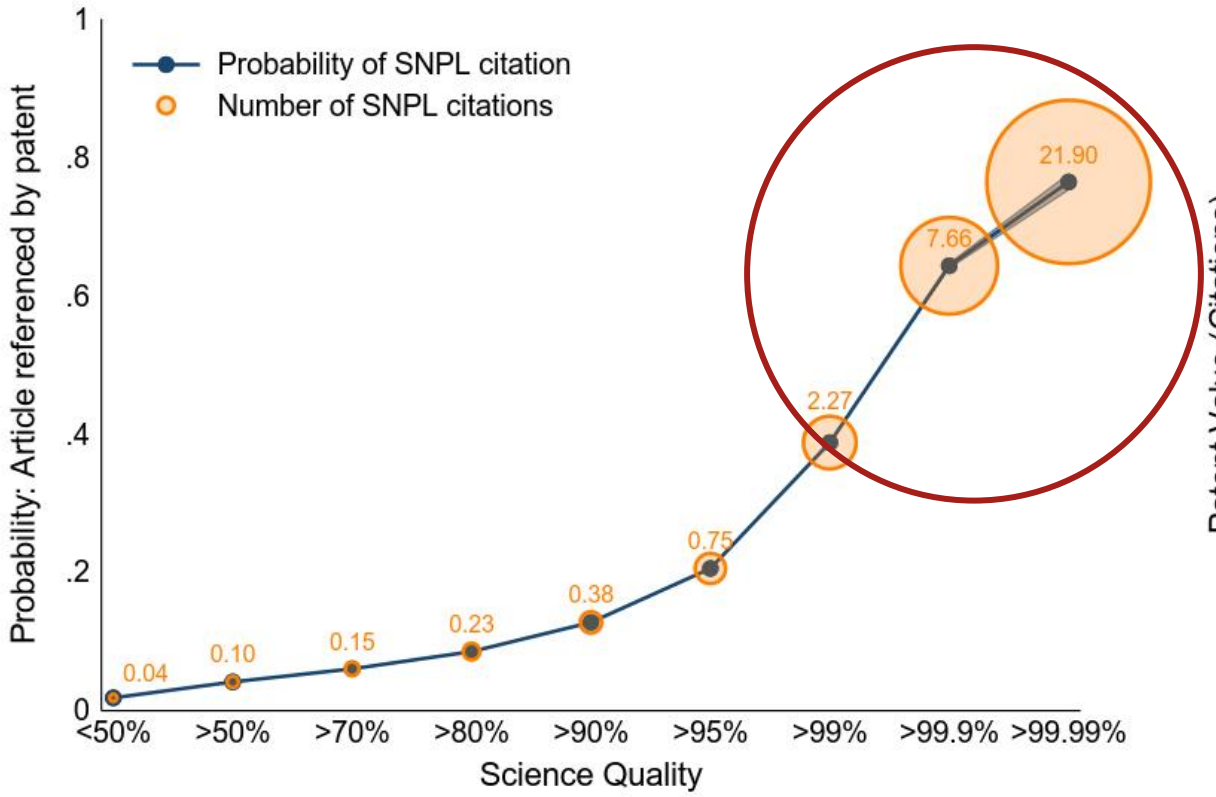
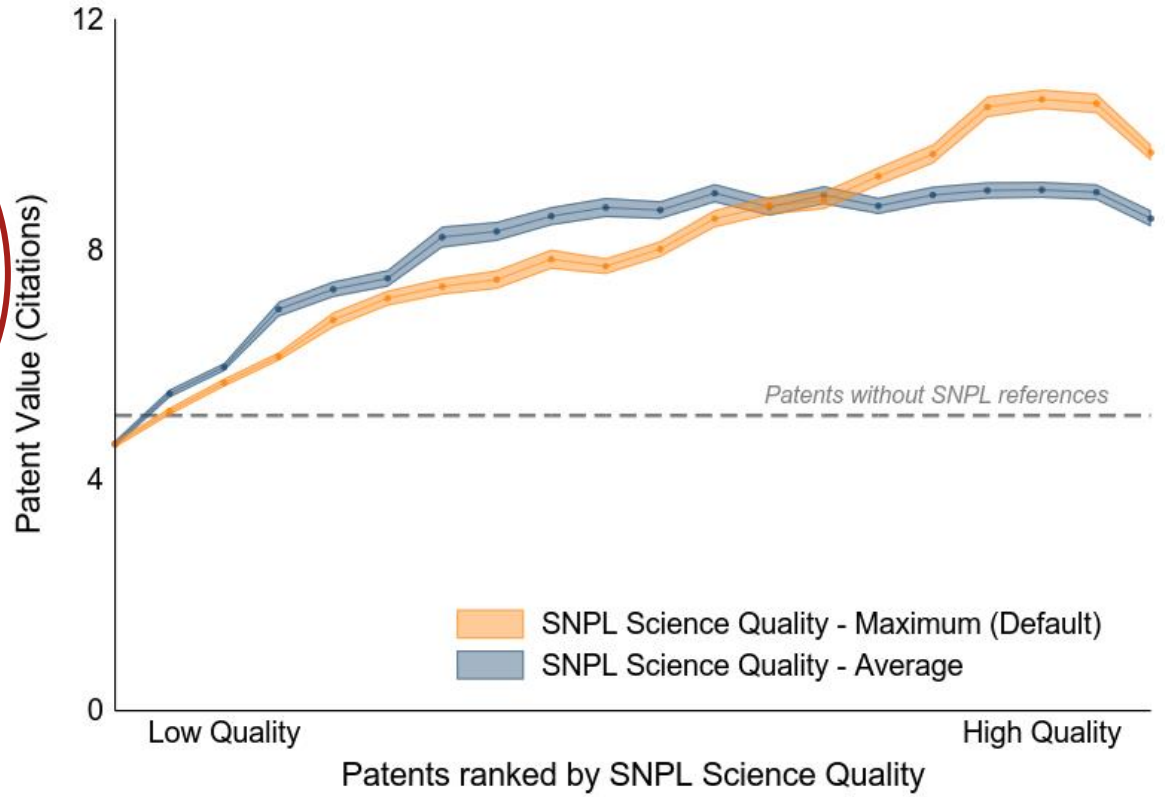


Fig. 1. Setting: Domains of science (left), technology (right), and patent-paper references.

Alignment of Science and Innovation



(b) SNPL references by science quality



(c) Patent value by SNPL science quality

How to manage the handover of results from science to innovation…

Innovation Policy

- US: Bayh-Dole Act (1980) – universities receive ownership over and manage intellectual property generated in publicly funded R&D projects (e.g. NSF-funded work).
- DE: similar change in IP policies (2002)
- Other EU countries introduce similar policies between 1995 and 2005.

Die Universität Studium Forschung Wissenstransfer

Zukunftsweisendes Modell der Rechteübertragung

Neuer Service „IP for Shares“ vereinfacht den Erwerb von geistigem Eigentum

10.02.2022

Das am Gründungszentrum HIGHEST der TU Darmstadt neuartige entwickelte Modell „IP for Shares“ bietet einen einfachen und günstigen Weg für Start-ups, Rechte an universitärem geistigem Eigentum zu erwerben. Im Gegenzug für die Weitergabe von Wissen erhalten Universitäten Anteile am jeweiligen Unternehmen.

- Critical issue: conditions for IP transfer to start-ups at universities and PROs … startups need control over IP (transfer or license).
- Classical solution: access (license) in exchange for a share in the start-up.

Innovation Policy

Towards having more breakthrough innovation in Europe (and Germany) …

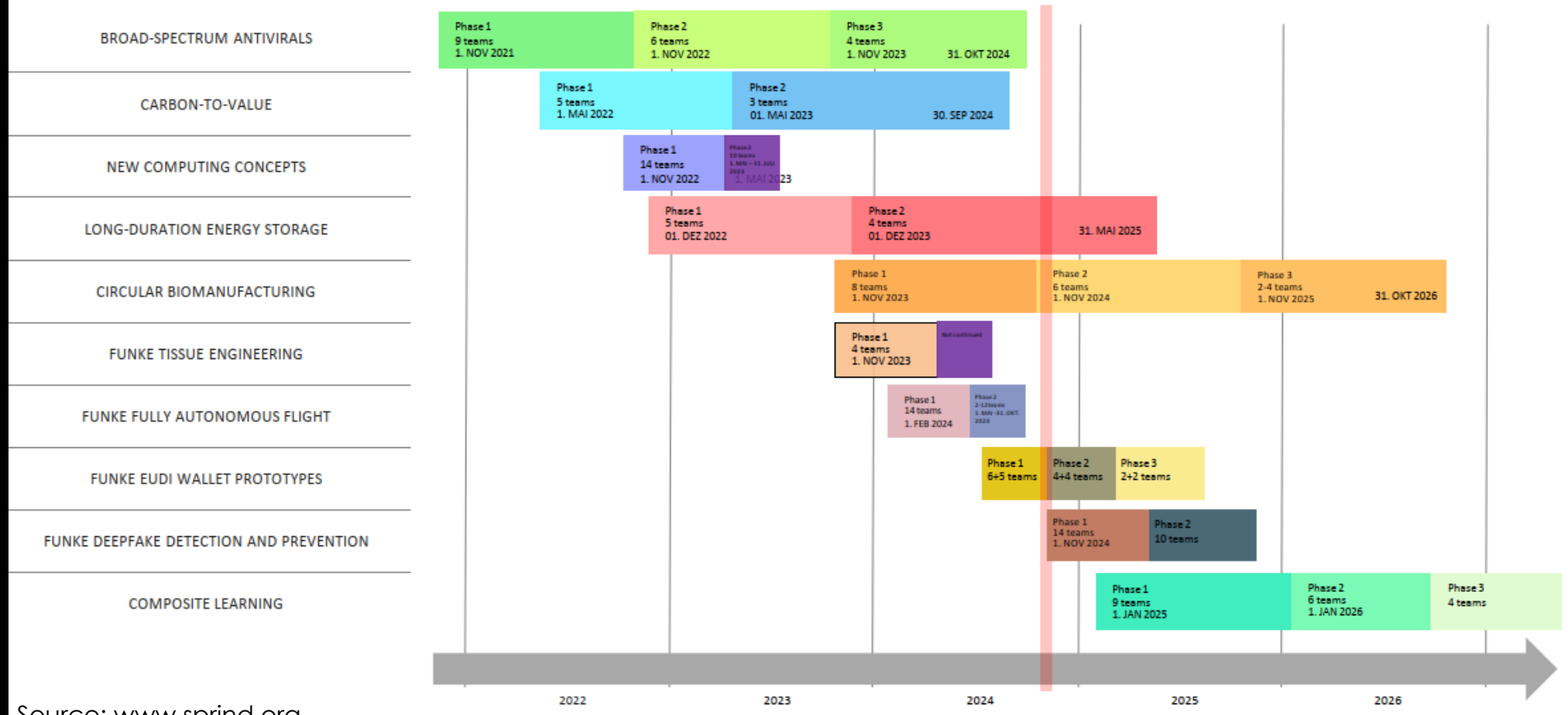
- facilitate transfer from science to innovation, esp. for start-ups
- reduce „control aspect“ of public funding institutions
- empower agencies dedicated to the support of breakthrough innovations, such as SPRIND and EIC (European Innovation Council)

Source: www.sprind.org

Innovation Policy

TIMELINE of SPRIND CHALLENGES

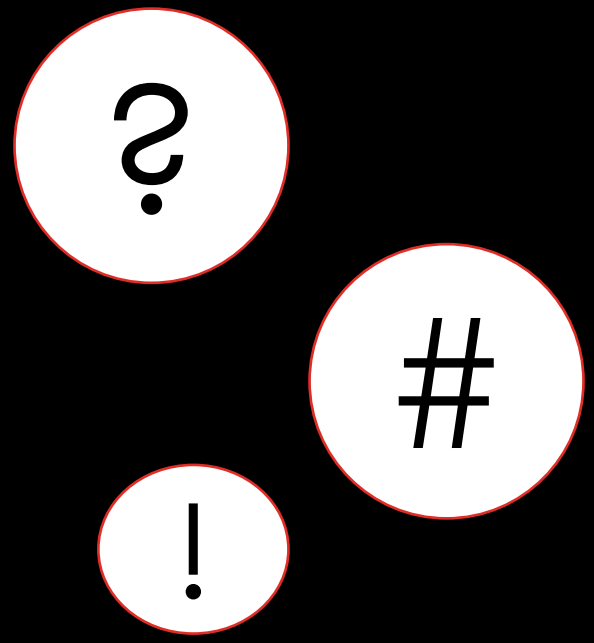
SPRIN–D



Source: www.sprind.org

Input for the Discussion

1. Science creates value (economic and societal) – it enables innovation.
2. The social returns to research and development (R&D) are much larger than the private returns.
3. The transition from science to technology (innovation) occurs at the intersection of two worlds with very different cultures and incentives. How to bridge the gap?
4. R&D and innovation policies in Europe may have become too incremental.
5. Policy-makers now embrace new approaches for encouraging break-through innovation (EIC, SPRIND).



Questions & Comments

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