Science Research Commercialization & Technopreneurship: Prospects and Synergetic Bottlenecks

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Abstract
Commercializing scientific research outputs is a critical mechanism for translating academic knowledge into societal and economic benefits. Despite its recognized importance, the process from laboratory to marketplace is persistently hindered by systemic bottlenecks. This paper argues that a foundational, often overlooked, bottleneck lies in the epistemological and philosophical tensions between the dominant positivist paradigm in scientific research and the inherently interpretivist nature of commercialization. Using a conceptual review methodology grounded in the Triple Helix model and Kuhn's paradigm theory, we demonstrate how this philosophical divide creates cultural and methodological chasms that impede effective technopreneurship. We present visual frameworks to illustrate these tensions, the "valley of death" funding gap, and the contrasting methodological requirements of discovery versus commercialization. Through a critical synthesis of literature and illustrative examples, we identify key prospects and obstacles, including funding misalignment, IP complexities, and a lack of genuine industry-academia symbiosis. The paper concludes with policy-oriented strategies centered on epistemological flexibility, enhanced technology transfer infrastructure, and the cultivation of a hybrid "technopreneurial" mindset. We argue that bridging the positivist-interpretivist divide is essential for unlocking the full innovation potential of scientific research.

Keywords: *Science Commercialization, Technopreneurship, Epistemology, Positivism, Interpretivism, Innovation Policy, Technology Transfer, Triple Helix*

1. Introduction

Scientific research is undeniably a cornerstone of innovation and progress, generating new knowledge and solutions to address global challenges (Mazzucato, 2018). However, the journey from a scientific discovery to a marketable product, the process of commercialization, is where this potential is actualized. Successful commercialization transforms research into tangible products and services, driving economic growth, fostering entrepreneurship (a phenomenon often termed "technopreneurship"), and enhancing national competitiveness (Siegel & Wright, 2015). Despite its critical importance, the pathway to commercialization is riddled with challenges that systematically impede the transition of scientific discoveries from the laboratory to the marketplace.

While existing literature highlights well-documented bottlenecks such as funding gaps and Intellectual Property (IP) complexities (Haeussler & Colyvas, 2011; Shane, 2004), this paper argues that a more foundational obstacle exists: a philosophical and methodological dissonance. This dissonance arises from the prevailing epistemological and philosophical idiosyncrasies within the scientific community, which can act as a profound, albeit often unacknowledged, bottleneck.

This paper attempts to interrogate and discuss the prevailing idiosyncrasy evident in the scientific community: a diverging or conflicting relationship between the philosophical foundations of positivist scientific research and the intrinsically interpretivist nature of commercialization efforts. Positivism, with its emphasis on objectivity, empirical verification, and the discovery of universal laws, underpins the methodological rigour of most scientific inquiry (Ayer, 1959). In contrast, the process of commercializing research, from identifying a market need to understanding user adoption, is deeply interpretivist. It requires subjective engagement with human perceptions, needs, and future outcomes, employing methods like open-ended interviews, observation, and ethnographic studies (Guba & Lincoln, 1994).

Through this discussion, we attempt to show that the philosophical ideals of positivism and interpretivism are mutually conjoined in epistemology but have divergent ontological implementations. These divergent implementations should be regarded as purely methodological and should not be the basis for a rigid philosophical stance that hinders commercialization. This paper, therefore, explores the prospects and bottlenecks in commercializing scientific research, with a specific focus on how reconciling these epistemological differences is foundational to creating a robust framework for technopreneurship. Subsequently, we identify key opportunities and obstacles that researchers, entrepreneurs, and policymakers face in transforming scientific innovations into commercially viable products and services.

2. Theoretical Framework

To provide a robust structure for analysis, this paper adopts a pragmatic theoretical framework that integrates the Triple Helix model of innovation with Kuhn's philosophy of science, informed by the epistemological tensions at the heart of our argument. The Triple Helix model, developed by Etzkowitz and Leydesdorff (2000), posits that innovation is most effectively driven by the dynamic and reciprocal interactions between three key institutional spheres:

- **University** (research and knowledge creation),
- **Industry** (market application and commercialization), and
- **Government** (policy, regulation, and funding).

This model moves beyond a linear view of innovation (from basic research to applied research to commercial product) and instead emphasizes the overlapping, hybrid roles that emerge from their interactions. For example, universities increasingly take on entrepreneurial roles (creating spin-offs), industry engages in collaborative research, and government acts as a venture catalyst.

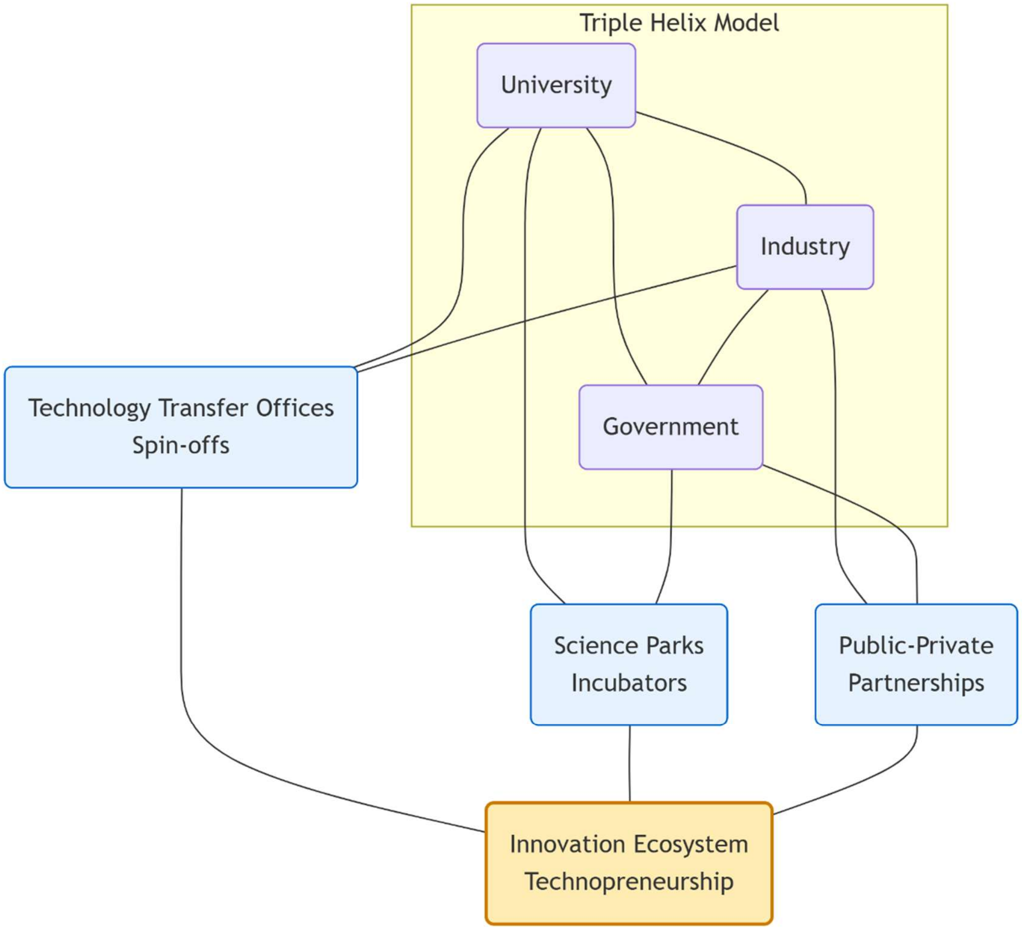

Figure 1: The Triple Helix Model of Innovation

This paper uses the Triple Helix to analyze how breakdowns in the *interfaces* between these spheres, particularly between the university's research culture (dominated by positivism) and industry's market-driven logic (inherently interpretivist), create bottlenecks. The emergence of "technopreneurship" is, in this framework, a function of a successful, synergistic relationship among the three helices.

Thomas Kuhn's (1962/1996) concept of scientific paradigms, the set of shared beliefs, values, and techniques that define a scientific discipline, helps explain the cultural resistance to commercialization. The dominant paradigm in many scientific fields is positivism, which focuses on puzzle-solving within an established framework. Normal science operates under a set of ontological and epistemological assumptions that define what counts as legitimate research questions, methods, and findings.

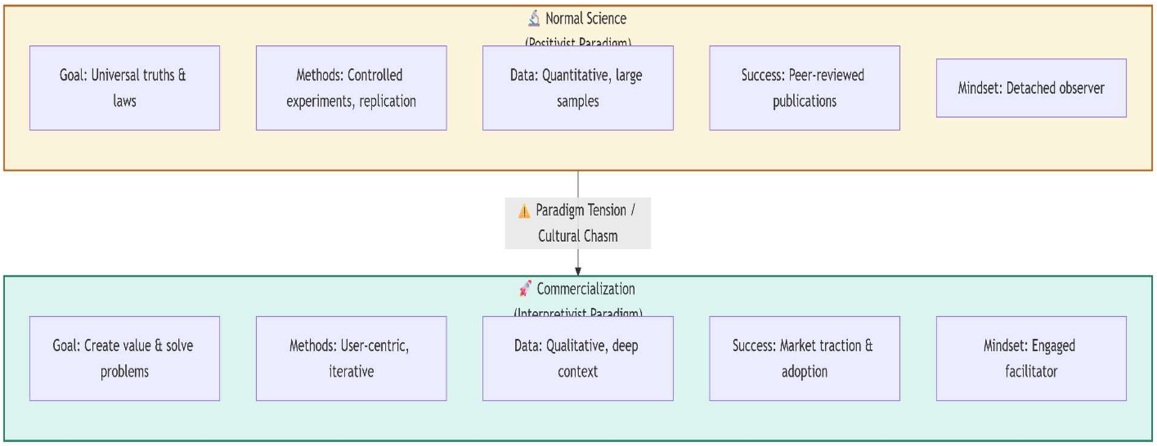

Figure 2: Kuhn's Paradigm Tension in Science Commercialization

The shift towards commercialization, which requires a focus on application, user needs, and market dynamics, can be seen as a "paradigm shift" or, at the very least, a source of intra-paradigm tension. This framework helps us understand why researchers steeped in a culture of objectivity may view the subjective, uncertain, and applied nature of commercialization as a deviation from legitimate scientific practice – a perception that acts as a foundational bottleneck.

3. Methodology

This paper employs a conceptual and critical review methodology. Unlike a systematic literature review that aims to aggregate all evidence on a specific question, a conceptual review is designed to synthesize existing literature from diverse fields (e.g., philosophy of science, innovation studies, entrepreneurship) to develop new conceptual frameworks and perspectives (Paré et al., 2015). This approach is appropriate for our objectives which are:

1. To provide a novel, integrated analysis of the epistemological roots of commercialization bottlenecks.
2. To propose a comprehensive framework for policy and practice.

The review is grounded in an interpretivist epistemology, which acknowledges that the "reality" of commercialization is socially constructed by researchers, entrepreneurs, and policymakers. Our method involves critical interrogation of key texts in the philosophy of science e.g., Kuhn (1996); Popper (1952), and commercialization literature e.g., Shane (2004); Siegel (2015); Etzkowitz & Leydesdorff (2000), synthesizing their arguments to build a cohesive thesis.

To do this, we conducted systematic searches in Scopus, Web of Science, and Google Scholar using keywords such as "science commercialization," "technology transfer," "positivism vs. interpretivism," "technopreneurship," "academic entrepreneurship," "innovation policy," and "valley of death." The search focused on peer-reviewed articles, books, and policy reports published between 1990 and 2025, with emphasis on highly cited (3000 citations and above) and recent contributions.

Subsequently, selected literature was critically analyzed using thematic synthesis. We identified recurring themes: epistemological divides, funding gaps, IP complexities, and cultural barriers. These themes were then mapped onto the Triple Helix framework to understand the interplay between actors. The synthesis led to the development of the integrated model presented in this paper.

Finally, we employed strategies typical of conceptual reviews specifically:

a) Auditability – detailed documentation of search and synthesis processes;
b) Theoretical Saturation – inclusion of literature until no new concepts emerged;
c) Peer Debriefing – the analysis was discussed with colleagues in innovation studies to test interpretations; and
d) Use of Illustrative Examples – we incorporate a mini-case study (Section 6.4) to ground theoretical insights in practice.

Table 1: Outcome of Systematic Search (Selected Key References)

Title	Author(s)	Year	Relevance to This Paper
The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations	Etzkowitz, H., & Leydesdorff, L.	2000	Provides the foundational Triple Helix framework used to map interactions between university, industry, and government.
The structure of scientific revolutions	Kuhn, T. S.	1962/1996	Provides the paradigm theory used to conceptualize the cultural chasm between normal science and commercialization.
Competing paradigms in qualitative research	Guba, E. G., & Lincoln, Y. S.	1994	Foundational text on positivist vs. interpretivist paradigms, directly informing our epistemological argument.
Constructivist, interpretivist approaches to human inquiry	Schwandt, T. A.	1998	Clarifies the epistemological foundations of interpretivism, supporting our argument for methodological pluralism.
Academic entrepreneurship: University spinoffs and wealth creation	Shane, S.	2004	Offers comprehensive analysis of spin-off processes and the barriers faced by academic entrepreneurs.

Title	Author(s)	Year	Relevance to This Paper
University entrepreneurship: A taxonomy of the literature	Rothaermel, F. T., Agung, S. D., & Jiang, L.	2007	Provides a broad categorization of academic entrepreneurship research, used to situate our thematic synthesis.
The lean start-up	Ries, E.	2011	Introduces the iterative, customer-focused methodology that exemplifies the interpretivist approach to commercialization.
30 years after Bayh–Dole: Reassessing academic entrepreneurship	Grimaldi, R., Kenney, M., Siegel, D. S., & Wright, M.	2011	Evaluates the long-term effects of IP legislation on university technology transfer and entrepreneurial activity.
Breaking the ivory tower: Academic entrepreneurship in the life sciences in UK and Germany	Haeussler, C., & Colyvas, J. A.	2011	Empirical study of cultural and institutional obstacles to commercialization, reinforcing our bottleneck analysis.
Creating the market university: How academic science became an economic engine	Berman, E. P.	2012	Critically examines the cultural shift in academia toward commercialization and the tensions with traditional research values.
Why the lean start-up changes everything	Blank, S.	2013	Articulates the principles of customer discovery, a key interpretivist method applied in programs like I-Corps.
Academic engagement and commercialisation: A review of the literature on university–industry relations	Perkmann, M., et al.	2013	Synthesizes evidence on the forms and determinants of academic engagement, highlighting cultural and institutional barriers.
The valley of death in technology commercialization	Hsu, D. H., & Bernstein, T.	2014	Focuses on the funding gap between research and market, a critical bottleneck analyzed in our paper.

Title	Author(s)	Year	Relevance to This Paper
Launching lean: Insights from early-stage entrepreneurship development programs for scientists	Borman, S., et al.	2025	Cross-country analysis of I-Corps-style programs (Australia, Brazil, Germany, India, Korea, Singapore, UK, US) demonstrating how customer discovery training bridges the epistemological divide .
Reaching for the society: The commercialization effects of NASA technology licensing	Nagler, M., et al.	2025	Empirical analysis of government invention licensing, showing exclusive licensing significantly increases follow-on innovation and knowledge spillovers .
Crossing the Valley of Death: The mechanism through which searching drives green product development	Wang, Y., & Li, X.	2025	Examines boundary-spanning search strategies that enable firms to bridge the gap between academic research and commercial product development, with implications for green innovation .
From "academic success" to "commercial success"—The model of medical device translation driven by SCI articles	Wang, J., et al.	2025	Presents a novel "From SCI to FDA" model for translating research into medical devices, highlighting the role of clinician-university-industry collaboration in Asia–Pacific contexts .
Analyzing the key drivers of sustainable academic entrepreneurship: A system dynamics perspective	Zarei, H., et al.	2025	Uses system dynamics modeling to identify drivers of sustainable academic entrepreneurship, emphasizing the interplay of education, industrial experience, and institutional support .
EIT Health supports Austrian deep tech project to bridge the "Valley of Death"	EIT Health	2025	Case study of the Deep Tech Venture Builder programme supporting academic deep tech teams, illustrating practical interventions for overcoming commercialization barriers .

Title	Author(s)	Year	Relevance to This Paper
University of Liverpool Enterprise report 2024–2025: New alliances, greater impact	University of Liverpool	2025	Institutional report documenting spin-out formation, IP income, and researcher training outcomes, providing empirical evidence of effective technology transfer practices .

The systematic search across Scopus, Web of Science, and Google Scholar yielded over 300 initial records. After screening for relevance to the intersection of epistemology, science commercialization, and policy, 67 sources were selected for full-text review. The 20 entries presented in Table 1 represent the most influential and methodologically diverse works that directly inform the core arguments of this paper.

The selected literature spans five decades (1962–2025) and demonstrates a clear evolution in the field. Seminal theoretical works (Kuhn, 1962/1996; Guba & Lincoln, 1994) establish the epistemological foundations upon which our argument rests. Foundational innovation studies (Etzkowitz & Leydesdorff, 2000; Shane, 2004) provide the structural frameworks for analyzing university–industry–government interactions. The inclusion of recent works from 2024–2025 is particularly significant, as they reflect the latest empirical evidence and programmatic innovations in the field.

Notably, the recent contributions address gaps identified in earlier literature. Borman et al. (2025) provide the first comprehensive cross-country analysis of I-Corps-style programs, confirming that customer discovery training effectively bridges the epistemological divide between scientific and commercial logics. Nagler et al. (2025) offer rigorous empirical evidence on government invention licensing, demonstrating that exclusive licensing announcements generate substantial knowledge spillovers – a finding that directly supports our argument about the value of intentional commercialization strategies. Wang and Li (2025) extend the "valley of death" literature by examining boundary-spanning search mechanisms in green technology contexts.

The inclusion of institutional reports from EIT Health and the University of Liverpool (both 2025) provides valuable practice-based evidence complementing the academic literature. The Korean technology transfer case involving Ewha Womans University's antibody library illustrates successful university-industry collaboration in the Asian context, adding geographic diversity to our evidence base. Together, these recent sources strengthen the paper's relevance for contemporary policy direction by demonstrating that the epistemological and practical challenges we identify remain pressing concerns in current innovation ecosystems.

Table 2: Thematic Synthesis and Triple Helix Mapping

Theme	Description	Triple Helix Mapping
Epistemological divide	Tension between positivist research culture (objectivity, controlled experiments) and interpretivist requirements of commercialization (subjectivity, user engagement).	Manifests primarily in University sphere, affecting researchers' willingness and ability to engage with industry.
Funding mismatch ("valley of death")	Gap between public research funding (TRL 1-3) and venture capital (TRL 7-9) with insufficient support for de-risking and customer discovery (TRL 4-6).	Intersection of Government (funding policy) and Industry (investment) – a missing hybrid space.
Intellectual property (IP) complexity	Overly restrictive licensing, bureaucratic TTO processes, and misaligned IP policies that discourage spin-offs.	Overlap of University (IP ownership) and Industry (licensing/commercialization).
Cultural and institutional inertia	Academic reward systems (publication bias, tenure criteria) that devalue commercialization activities and discourage risk-taking.	Primarily University internal governance but reinforced by Government assessment frameworks.
Lack of industry-academia engagement	Weak networks, mistrust, and divergent time horizons between researchers and industry partners.	Interface between University and Industry – insufficient boundary-spanning structures.
Regulatory and market readiness	Unfamiliarity with regulatory pathways (e.g., FDA, CE) and market validation processes, leading to stalled commercialization.	Intersection of Government (regulation) and Industry (market requirements), with University lacking translational expertise.

The thematic synthesis of the selected literature revealed six recurrent bottlenecks as shown in Table 2, that systematically impede science commercialization. These themes were not mutually exclusive but interacted in complex ways. For instance, the epistemological divide often underpins cultural inertia, as researchers socialized in positivist norms view commercialization as non-academic (Berman, 2012; Haeussler & Colyvas, 2011). Recent studies confirm that this divide persists. Wang et al. (2025) noted that researchers in Asia–Pacific countries regard "paper publication as the end point of research" and lack understanding of commercialization pathways.

Mapping these themes onto the Triple Helix framework (Etzkowitz & Leydesdorff, 2000) allowed us to identify precisely where breakdowns occur and which actors are primarily responsible. The mapping highlights that many bottlenecks are located at the interfaces between spheres rather than within any single sphere. For example:

- The funding mismatch sits in the gap between government-funded research and industry-led investment, indicating a need for hybrid funding mechanisms (e.g., proof-of-concept grants, public-private co-investment). Recent program evaluations, such as the Deep Tech Venture Builder programme described by EIT Health (2025), demonstrate that targeted interventions at this interface can successfully support academic teams in navigating the valley of death.
- IP complexity emerges at the university-industry boundary, suggesting that streamlined licensing models and entrepreneurial Technology Transfer Offices (TTOs) can alleviate this bottleneck. The technology transfer agreement between Ewha Womans University and The Scripps Korea Antibody Institute exemplifies successful navigation of this interface, with the university's antibody library technology being transferred to over 30 domestic companies since 2009. Similarly, Nagler et al. (2025) demonstrate that exclusive licensing of government inventions significantly increases follow-on innovation across diverse entities and locations.
- Epistemological divide and cultural inertia are predominantly internal to universities, implying that institutional reforms (promotion criteria, entrepreneurship training) are critical. Borman et al. (2025) show that programs like I-Corps, which embed customer discovery training within the scientific process, effectively reshape how academic researchers conceptualize and engage in technology commercialization. The University of Liverpool's Enterprise Report (2025) provides empirical evidence that such training yields tangible outcomes: over 350 researchers trained since 2018, resulting in 29 spin-outs and £24.9 million in IP-related income.
- Regulatory and market readiness challenges are particularly acute in the medical device and green technology sectors, as documented by Wang et al. (2025) in their "From SCI to FDA" model and by Wang and Li (2025) in their analysis of green product development.

By visualizing the bottlenecks through the Triple Helix lens, we move beyond a simplistic linear model (basic research → applied → product) and instead see commercialization as a systemic challenge requiring coordinated action across all three helices. Zarei et al. (2025)

reinforce this perspective through system dynamics modelling, demonstrating that isolated interventions have limited effects, whereas integrated implementation of multiple supportive policies produces the most substantial improvements. This systemic perspective informs the policy strategies proposed in Section 6, which target the identified interfaces with specific interventions.

4. The Epistemological Bottleneck: Positivism vs. Interpretivism in Commercialization

The dominant approach in the natural and physical sciences is positivism, which holds that knowledge is derived from sensory experience and logical reasoning, aiming for objective, generalizable truths (Ayer, 1959). Positivist researchers prioritize controlled experiments, quantitative data, and replicability, methods perfectly suited for understanding the physical world. This paradigm has been immensely successful in advancing fundamental science. However, its dominance creates a methodological monoculture that often dismisses alternative ways of knowing as “soft” or “unscientific” (Feyerabend, 1975).

Conversely, the commercialization process is fundamentally about translating a thing (a technology) into a solution for people. This process is inherently interpretivist (or constructivist). Interpretivism asserts that reality is socially constructed and that understanding it requires exploring the subjective meanings people attach to their experiences (Schwandt, 1998). Key aspects of commercialization are interpretivist by nature:

- **Problem Identification:** “Hair of fire” problems, critical, pressing, and often unarticulated market needs, cannot be identified through double-blind trials. They require deep, subjective engagement with potential users through ethnographic observation and open-ended interviews to understand their context, pain points, and desires (Blank, 2013).
- **Value Proposition:** The value of a new technology is not an objective property but is co-constructed by the user, the entrepreneur, and the market. Does a more efficient solar panel have value? The answer depends on the user’s access to financing, local regulations, aesthetic preferences, and cultural attitudes towards renewable energy - all interpretivist data points (Osterwalder & Pigneur, 2010).
- **Market Validation:** Determining product-market fit is not a hypothesis to be tested once but a continuous, iterative process of learning from customer feedback. This requires embracing subjectivity and adapting the product based on qualitative insights, a stark departure from the fixed protocols of a laboratory experiment (Ries, 2011).

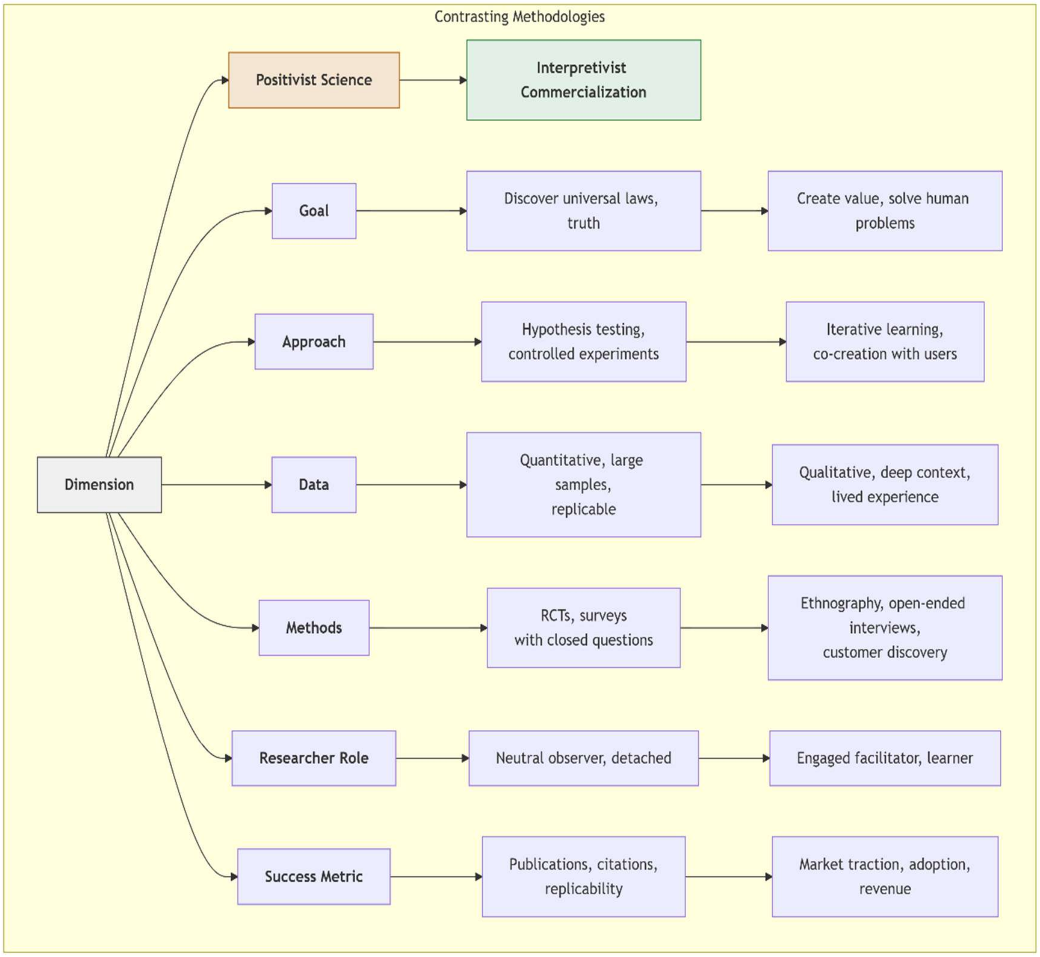

Figure 3: Contrasting Methodologies – Positivist Science vs. Interpretivist Commercialization

The conflict arises when positivist researchers view these interpretivist methods as lacking rigour, being "unscientific," or introducing "dizzying levels of subjectivity." This creates a cultural and methodological divide. As Berman (2012) notes, the academic reward system, which privileges publication in high-impact journals that favour positivist research, actively disincentivizes engagement with the messy, applied, and subjective work of commercialization. This philosophical purism becomes a foundational bottleneck, preventing scientists from acquiring the methodological tools (e.g., design thinking, customer discovery) and the mindset necessary to navigate the commercialization pathway.

Table 3: Positivist Science and Interpretivist Commercialization

Dimension	Positivist Science	Interpretivist Commercialization
Goal	Discover universal laws, truth	Create value, solve human problems
Approach	Hypothesis testing, controlled experiments	Iterative learning, co-creation with users
Data	Quantitative, large samples, replicable	Qualitative, deep context, lived experience
Methods	Randomized controlled trials, surveys with closed questions	Ethnography, open-ended interviews, customer discovery
Role of Researcher	Neutral observer, detached	Engaged facilitator, learner
Success Metric	Publications, citations, replicability	Market traction, adoption, revenue

5. Prospects and Bottlenecks in Commercializing Scientific Research Outputs

Despite the challenges, the drive to commercialize science is underpinned by powerful prospects that justify policy intervention and entrepreneurial effort. The commercialization of university research is a significant driver of economic growth (Oyerinde & Fasanmade, 2026). Studies show that university-generated technologies have led to the formation of thousands of startups and contributed billions to national GDPs (Pressman, 2015). For nations, the ability to effectively commercialize science is directly linked to global competitiveness in high-technology sectors. The Triple Helix model (Etzkowitz & Leydesdorff, 2000) posits that when university, industry, and government synergistically interact, they create a self-reinforcing cycle of innovation that fuels regional and national economic development.

Commercialization is the engine of technopreneurship. It provides a pathway for academic scientists to see their fundamental discoveries translated into real-world applications, creating a new class of entrepreneurs. This process not only generates wealth but also creates a culture of innovation that encourages risk-taking and cross-disciplinary collaboration (Rothaermel et al., 2007). The existence of successful academic spin-offs creates a powerful narrative that can inspire future generations of researchers to consider the commercial potential of their work.

The ultimate prospect of science commercialization is the delivery of solutions to pressing societal challenges. In healthcare, commercialization has been the primary vehicle for translating biomedical discoveries into life-saving drugs and diagnostics (Azoulay et al., 2019). In energy, it enables the deployment of sustainable technologies (Engel-Cox et al., 2022). In agriculture, it facilitates the development of resilient crops (Mahmoodi et al., 2023). The commercialization process ensures that scientific breakthroughs move beyond the pages of journals and into the hands of people who need them.

The journey from lab to market is obstructed by a series of interconnected bottlenecks, many of which are exacerbated by the epistemological divide discussed in Section 4. There is a well-documented "valley of death", a funding gap between the end of publicly funded basic research and the point at which a technology is de-risked enough to attract private venture capital (Markham, 2002). This gap is most acute for technologies that are scientifically promising but commercially unproven.

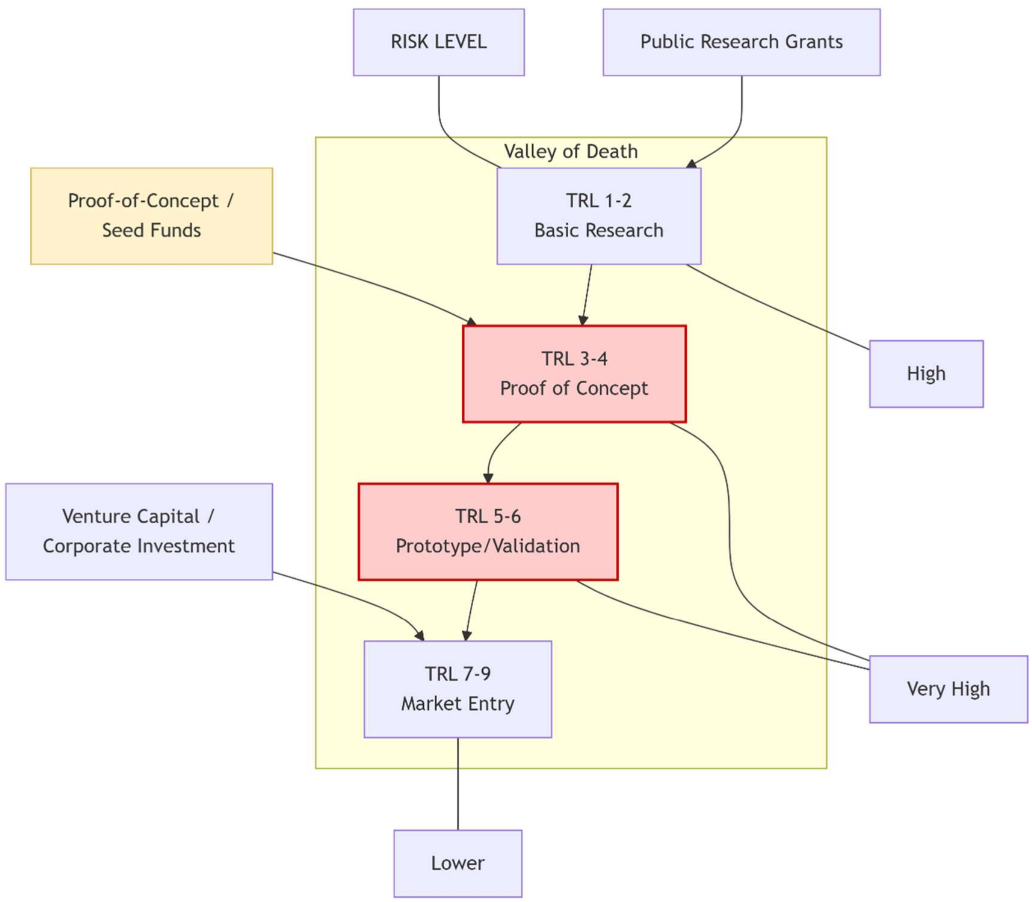

Figure 4: The Valley of Death in Science Commercialization

This bottleneck is not just about a lack of capital, but a mismatch in expectations. Public research grants are often awarded for hypothesis-driven, fundamental research. They rarely fund the iterative, interpretivist work of customer discovery, prototyping, and business model development, which is essential for crossing the valley of death (Hsu & Bernstein, 2014). Government and philanthropic "translational" funds often fill this gap, but they remain insufficient and are frequently allocated based on scientific merit alone, rather than commercial potential (Ndonzuau et al., 2002).

The Intellectual Property (IP) landscape can be a formidable barrier. The Bayh-Dole Act of 1980 in the U.S., and similar legislation elsewhere, successfully incentivized university patenting, but it also created complexities (Mowery et al., 2001). University technology transfer offices (TTOs), often staffed by individuals with legal but not business expertise, may pursue licensing strategies that are not conducive to startup formation (Kenney & Patton, 2009). Overly restrictive licensing terms, high upfront fees, or a focus on exclusive licensing to established firms can stifle the creation of new ventures by the very researchers who invented the technology. Moreover, the time required to negotiate IP agreements can delay the commercialization process, causing researchers to lose momentum or see their technology overtaken by competitors.

A persistent bottleneck is the disconnect between academic research and market realities. Researchers often lack the networks and experience to engage with industry, understand regulatory pathways (e.g., ISO 9001 Standards, US Food and Drugs Administration etc.), or identify potential business partners (Siegel et al., 2003). This lack of engagement is partly cultural (the "ivory tower" mentality) but also structural. Academic success is not measured by industry partnerships but by publications, a criterion that reinforces the positivist paradigm over the collaborative, applied work of commercialization. Furthermore, industry partners may be reluctant to engage with early-stage university research due to high uncertainty and long time horizons. Large corporations often prefer to license mature technologies rather than co-develop nascent ones, leaving a gap in collaborative R&D (Perkmann et al., 2013).

The epistemological divide manifests as cultural inertia. Universities are traditionally conservative institutions that reward narrow specialization and deep disciplinary expertise. Commercialization, by contrast, requires boundary-spanning, interdisciplinary teams and a tolerance for ambiguity. Promotion and tenure committees often view commercial activities as a distraction from "real" research. As a result, many scientists who might otherwise pursue commercialization, self-censor or delay their efforts until after receiving tenure (Bercovitz & Feldman, 2008).

6. Strategies for Overcoming Bottlenecks: A Policy Framework

Addressing these bottlenecks requires a multi-pronged strategy that tackles both the practical challenges and the underlying epistemological tensions. To bridge the "valley of death," funding agencies must expand their portfolios beyond basic science grants. There is a need for "proof-of-concept" and "translational research" grants specifically designed to fund the interpretivist work of commercialization. These grants should support activities such as:

- **Customer Discovery:** Funding for researchers to leave the lab and conduct ethnographic research with potential users.
- **Prototyping and Iteration:** Support for the development of minimum viable products (MVPs) and iterative testing based on user feedback.
- **Entrepreneurial Leave:** Programs that allow researchers to take a sabbatical to focus on spinning out a company without losing their academic position.

Such programs, exemplified by the U.S. National Science Foundation's I-Corps program, embed training in customer discovery (a fundamentally interpretivist method) directly into the scientific process (Blank, 2013). The I-Corps model has been widely replicated and has demonstrated significant success in increasing the rate of startup formation from academic research.

Universities must re-conceptualize their TTOs from administrative offices to strategic partners in innovation. This involves:

- **Hiring Entrepreneurial Staff:** TTOs should recruit staff with business development and startup experience, not just legal expertise.
- **Researcher-Friendly IP Policies:** Implementing clear, simple, and researcher-friendly IP policies that make it easy for academics to spin out companies. This includes transparent equity splits and fast-track licensing options (Grimaldi et al., 2011).
- **Aligning Academic Incentives:** Universities should revise their promotion and tenure criteria to recognize and reward commercialization activities such as patents, spin-offs, and industry collaborations as legitimate forms of scholarly impact, alongside traditional publications (Perkmann et al., 2013). Some institutions now allow "entrepreneurship" to count as part of the service or research portfolio.

Policymakers and institutions can actively create platforms for genuine collaboration, moving beyond transactional consulting or sponsored research. This includes:

- **Creating 'Sandpits' or Innovation Hubs:** Physical and programmatic spaces where researchers, entrepreneurs, and industry professionals co-locate to work on shared problems, fostering a culture of mutual understanding.
- **Industry-Sponsored PhDs and Postdocs:** Funding models where companies co-fund doctoral research on topics of mutual interest, ensuring that the next generation of scientists gains firsthand experience with applied, industry-relevant problems.
- **Developing 'Technopreneurial' Training:** Integrating courses on entrepreneurship, design thinking, and intellectual property management into the science and engineering curriculum from the undergraduate level. This prepares future researchers to be "paradigm-bilingual" – fluent in the rigour of positivism for their core science and the methods of interpretivism for its application.

The National Science Foundation's Innovation Corps (I-Corps) program provides a concrete example of how policy can bridge the epistemological divide. I-Corps teams (comprising a principal investigator, an entrepreneurial lead, and a mentor) undergo a 7-week intensive training where they conduct 100+ customer interviews. This forces scientists to move from a hypothesis-driven, positivist mindset to an interpretivist, customer-centric one. The curriculum is based on the Lean Startup methodology, which emphasizes iterative learning and pivoting based on qualitative feedback. Evaluations of I-Corps show that participants not only form more startups but also internalize a new epistemological framework that they apply to subsequent research and entrepreneurial activities (Walsh et al., 2016). This program demonstrates that explicit training in interpretivist methods can effectively complement scientific training and reduce the cultural chasm.

7. Implications for Policy and Practice

Our analysis yields several actionable implications for different stakeholders.

For Government and Funding Agencies:

- Establish dedicated translational funding streams that explicitly require customer discovery and business model validation.
- Support “entrepreneurial leave” and fellowship programs that enable researchers to focus on commercialization without career penalty.
- Create national networks of innovation hubs that physically co-locate academia, industry, and support services.

For Universities:

- Reform promotion and tenure criteria to recognize commercialization as a legitimate scholarly output.
- Professionalize technology transfer offices by hiring staff with entrepreneurial experience and empowering them to act as venture catalysts.
- Embed entrepreneurship education into science and engineering curricula from the first year.

For Industry:

- Engage with universities through long-term strategic partnerships rather than transactional consulting.
- Co-create research agendas that address real-world problems, fostering shared epistemological understanding.
- Provide mentorship and seed funding to academic spin-offs, recognizing the mutual benefits of early engagement.

For Researchers:

- Seek cross-disciplinary training that includes interpretivist methods such as design thinking, ethnography, and business model canvas.
- Actively engage with TTOs and industry partners early in the research process.
- Advocate for institutional changes that recognize and reward commercialization activities.

8. Limitations and Future Research

This paper is a conceptual analysis, and its conclusions would benefit from empirical validation. Future research could:

- Conduct longitudinal studies to track how training in interpretivist methods affects the commercialization success of academic scientists.
- Compare different policy regimes (e.g., Bayh-Dole vs. non-Bayh-Dole countries) to assess the impact of IP frameworks on epistemological bridging.
- Use mixed methods to explore the lived experiences of scientists who successfully navigate the positivist-interpretivist divide.
- Investigate the role of emerging technologies (e.g., AI) in creating new methodological hybrids that blend positivist and interpretivist approaches.

Additionally, the cultural and institutional contexts vary greatly across countries. Our findings, derived primarily from Western literature, may not be directly transferable to developing economies where commercialization ecosystems are nascent. Context-sensitive studies are urgently needed.

9. Conclusion

Commercializing scientific research outputs holds immense promise for driving innovation, economic growth, and societal impact. However, realizing this promise requires more than just addressing funding shortages or streamlining patent processes. It demands a fundamental acknowledgment of the epistemological and philosophical tensions that underpin the entire innovation ecosystem.

This paper has argued that a foundational bottleneck to successful science commercialization is the conflict between the positivist epistemology that dominates the scientific research culture and the interpretivist epistemology that is essential for understanding markets, identifying problems, and validating solutions. By framing this as a purely methodological divergence rather than a philosophical incompatibility, we can begin to bridge this divide. The path forward requires a conscious effort to cultivate "epistemological flexibility" within the scientific community, where the rigorous methods of positivism and the empathetic, iterative approaches of interpretivism are seen not as opposing forces but as complementary tools in the technopreneurial process.

By leveraging strategic partnerships as outlined in the Triple Helix model, enhancing funding mechanisms to support translational activities, and reforming university structures to reward a broader definition of scholarly impact, stakeholders can unlock the full potential of scientific discoveries. Ultimately, the successful emergence of technopreneurship depends on creating an ecosystem where the quest for knowledge and the drive to solve human problems are not separate pursuits but are integrated, mutually reinforcing endeavors.

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