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EDITORIAL

Navigating Uncertainty in Innovation Ecosystems

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In a world overshadowed by uncertainty, technologically mediated connectedness can leave us feeling isolated and powerless. With so much geo-political ambiguity, it is useful to recognize that innovation offers a useful response. Here, breakthrough technologies are often highlighted as the primary goal of innovation. Yet, a deeper understanding of innovation increasingly points towards the crucial, sometimes underestimated, role of human and social dimensions. Human creativity and ingenuity are vital ingredients for generating unconventional solutions and a cornerstone of innovative thinking.

Creativity, however, is not solely an individual trait but is heavily influenced by the surrounding organizational context of human interactions. Amabile (2011) identifies four components necessary for any creative response, three individual: skills, processes, and motivation; and one social-environmental. She suggests that nurturing creativity is often more effective through environmental levers, rather than individually-focused interventions. It follows, therefore, that research on how to promote supportive educational settings and designing work environments is vital to stimulate motivation and creativity (see Vignoli et al., 2018, for a special issue on this topic published in CIJ).

Supportive environments are especially crucial when promoting open innovation in scientific communities where cross-institutional collaboration is key (Beck et al., 2021). To address complex societal and environmental challenges, scientific breakthroughs need to be transformed into tangible societal or economic benefits. This journey involves navigating diverse institutions and engaging with various stakeholders – a fundamentally political process. Thus, understanding the holistic nature of scientific infrastructures – including educational programs, technology transfer offices, and large research facilities – is crucial for effectively advancing innovation ecosystems. This starts with small research teams and extends to mega-scale detection and computational infrastructures that generate fundamental data.

The potholed thoroughfare that innovation follows encounters diverse organizational boundaries, from academia, incubators, VCs and industry, surfacing strong cultural differences. In university-industry collaborations, divergent perspectives, motives and goals are often highlighted as a significant barrier to successful technology transfer. Academic cultures often prioritize individual recognition and publishing, while industry focuses on financial goals, intellectual property, and the more pragmatic aspects of bringing a product to market. Time, for example, is often a source of contention: traditional university administrations can be perceived as bureaucratic, operating with a hierarchical culture that clashes with the speed required for commercializing innovation. Bridging these cultural divides is essential (Gambi & Debackere, 2025).

At an even more fundamental level, ingrained professional identities manifest as significant barriers to bring great ideas to fruition. It is well documented that even within and across scientific and academic communities, diverse tools, platforms, theories, or simple ways-of-working produce different epistemic cultures (Cetina, 1999; Pujol Priego, et al. 2022; Rheinberger, 1997). Hence, when presented with something outside of one's standard toolbox, normal human behavior can lead to the "Not Invented Here" (NIH) syndrome – the reluctance to adopt external knowledge – and the "Not Shared Here" (NSH) syndrome – the hesitancy to share internal knowledge – actively obstructing knowledge exchange and collaborative efforts. Overcoming identity-driven resistance requires surfacing the unwritten codes of professional merit to directly negotiate their effects. Indirect strategies that enhance perspective-taking offer a promising approach to mitigate these biases (Dosi, 2025).

Overcoming individual and cultural barriers often sets the stage for valuable outcomes, including the emergence of serendipity. Distinct from mere luck, technological serendipity, understood as finding applications for technologies outside their original domain through a combination of accident and sagacity, can be viewed as a capability that can be intentionally developed (Wareham et al. 2022). Experiments like the ATTRACT project aim to systematize serendipity, highlighting the potential for large research infrastructures to foster unexpected discoveries actively (Gastrow et al., 2025).

As ATTRACT has demonstrated, the nature of the output itself can shape the path to impact (Vignoli & Wareham, 2024). Large-scale research infrastructures (RIs) are powerful engines of scientific discovery, pushing the boundaries of fundamental knowledge. However, their full socio-economic impact extends beyond traditional metrics such as publications and patents. Secondary outputs, such as open datasets or nascent technologies emerging from basic research, can unlock new value (Romasanta et al., 2025). Exploring how these diverse outputs move from the lab, gestate, and subsequently mature into broader social goods requires a holistic understanding of both traditional economic measures, alongside of more generative educational and cultural impacts.

A key question in science policy, then, is how to maximize the broader effects of these facilities and the knowledge they generate. Embracing uncertainty is intrinsically linked to the potential for serendipitous findings. Unlike routine processes with predictable outcomes, pioneering new solutions or technologies often means stepping into the unknown, dealing with ambiguous problems, and facing a future that is not well defined.

This often requires a mindset that not only tolerates - but actively engages with uncertainty with a combination of both variance decreasing and variance increasing strategies (Wareham et al. 2014). It demands that humans cultivate creative thinking to generate non-conventional solutions in the face of ill-defined problems. However, relying solely on spontaneous creativity may not be sufficient. The innovation process, particularly in complex settings, needs structured approaches and direction-giving to foster learning and progress, even when the final objective is unknown. The articles in this issue deepen various dimensions of open innovation in science, highlighting case studies and research findings that illustrate effective strategies for overcoming barriers and enhancing collaborative efforts. By examining the role of supportive environments, cognitive bias mitigation, and exploring the purposeful cultivation of technological serendipity, these contributions provide valuable insights into how we can navigate uncertainty and drive meaningful progress out of science and beyond. Together, they set the stage for a deeper exploration of the levers that push the boundaries of knowledge and translate innovation into tangible societal benefits.

This issue starts with a methodological note on design principles by Chandra Kruse (2025) as a means of capturing knowledge. A design principle is defined as encapsulating knowledge about creating instances of sociotechnical artifacts, specifying what to create and, to some extent, how to create it, based on empirical evidence. Design principles are invaluable for codifying design knowledge and providing partial direction when navigating the unknown in design science research. Design principles can be articulated using structured schemas that outline the aim, mechanisms, and context. This knowledge can be captured at any phase of research and iteratively refined. While design principles offer guidance, they should not be followed rigidly like a recipe; designers should combine their expertise and experience with both codified and implicit knowledge. Examples described by the authors illustrate their application in sustainability transformation and digital actor engagement platforms.

The case study by Paez et al. (2025) investigates the impact of social environment stimuli management on creativity during a three-week summer school with multidisciplinary teams. The research used a survey to analyze participants' views on how social environment stimulus affected their creativity. Key findings indicate that the prototyping process and interaction outside the team benefited creativity. Relational rewards, breaks, and icebreakers also had a positive impact. By contrast, supervisor influence and presentations were found to be detrimental or ineffective. The study suggests a need for a more nuanced perspective on icebreakers, considering their quality, timing, and flexibility. Additionally, supervisors should consider individuals' mental resilience and coping mechanisms when providing feedback, emphasizing empathy. In conclusion, the social environment is crucial in the creative process, and managing social environment stimuli can be integrated into design thinking methodology to enhance team creativity. Findings highlight the importance of supervisors acting as facilitators, promoting free communication with outsiders, and optimizing breaks and icebreakers.

Grigorescu et al. (2025) conducted an exploratory study examining how participants perceived different art activities' impact on stimulating creative thinking and problem-solving within group settings. A survey was conducted among students from Dutch universities participating in the CERN IdeaSquare Summer School in 2023, where they worked on technology and business ideas using the Design Thinking methodology. The survey aimed to understand how art activities influence the development of novel ideas and solutions. Preliminary results indicate that visual art activities, such as drawing and physical prototyping, seem to have a significant impact on students' self-perceived innovation. This effect might be due to these activities enhancing empathy towards users and improving understanding of technology interaction. Conversely, activities like music and dance only showed a marginal or even negative impact in this context. The paper offers insights into how artistic strategies, particularly visual ones, could stimulate creative thinking and problem-solving in interdisciplinary STEM environments.

Gambi et al.'s (2025) original article explores the importance of an inclusive technology transfer office (TTO) culture in linking university and industry. The existing literature highlights cultural differences among stakeholders as a significant barrier in the technology transfer (TT) process. The study employed a systematic literature review to identify research on TTOs and culture, and an exploratory case study of a successful European TTO using the Competing Values Framework (CVF). Findings from the literature review suggest that the culture of a TTO should be inclusive, embracing an interrelated and ambiguous set of characteristics to accommodate the cultures of its various stakeholders in a pragmatic, professional, and service-oriented manner. The TTO is an essential bridging institution, dealing with cultural differences and bridging information/interpretation asymmetries. The case study TTO demonstrated a "service mind culture" and the need for a pragmatic mindset. Here, having interdisciplinary teams with expertise in both business and academia is important. The study concludes that TTO managers need to understand and assimilate the cultural characteristics of different stakeholders and embrace paradoxical cultural characteristics to bridge differences and improve TT success. U-I collaboration is a powerful source of innovation, but understanding the cultural dimensions and developing an inclusive culture for efficient connectivity is required.

Gastrow et al.'s (2025) article focuses on assessing the impact of investment at the science-technology interface in fundamental physics research infrastructures. It specifically examines the ATTRACT project, which provided resources to technology projects aiming to commercialise technologies from research infrastructures (RIs). This study is part of the ATTRACT Socio-Economic Studies Special Section (Vignoli & Wareham, 2024) where the project CASEIA aimed to conduct a comparative analysis of the socio-economic impacts achieved by the ATTRACT phase-1 support mechanism compared to similar projects without such support, focusing on innovation ecosystems, commercial applications, and broader social benefits through case studies of engineering projects in large-scale basic physics. This study used a case study analysis, drawing on secondary data from ATTRACT and primary data from in-depth interviews with key role players across universities, RIs, supplier firms, and technology partners. An innovation system structure is used as the analytical framework, employing six dimensions to model causal pathways. The comparative analysis of socio-economic impact leads to conclusions in three broad areas: routes to impact, technological serendipity, and reflections on the CASEIA pilot study. The study provides methodological recommendations for ATTRACT's monitoring, evaluation, and learning efforts.

Romasanta et al.'s (2025) article explores the impact of research data infrastructures, focusing on the AlphaFold (AFDB) database as a significant secondary output from the EMBL research infrastructure. This study is also part of the ATTRACT Socio-Economic Studies Special Section (Vignoli & Wareham, 2024), where the COMPUTE IMPACT project investigated how industrial partners derive benefits from the public datasets and computational technologies developed by the European Research Infrastructure-Innovation Ecosystems, with a particular focus on bioinformatics advancements in the life sciences. The study aims to understand the broader effects of secondary outputs like datasets and computational resources, which are often overlooked when assessing RI impact solely through publications and patents. Using a quantitative case study strategy with bibliometric analysis, the study compared publications citing the original AlphaFold paper with those citing the AFDB. The theoretical background draws on the Open Innovation in Science (OIS) framework, theorizing that accessible data infrastructures can lower barriers to entry and democratize access. Empirical findings offer evidence that accessible infrastructures facilitate knowledge flows into new application domains. However, the AFDB papers show a stronger orientation towards downstream areas like drug discovery than the original paper's focus on machine learning. The study also found a significantly lower average number of organizations per paper citing AFDB, tentatively supporting the idea that such resources can enable contributions from fewer institutions and potentially broaden access beyond top global research producers. The study contributes initial insights into the ripple impact and downstream value of open-access resources for funders and highlights opportunities for experimental researchers using public databases.

Dosi et al. (2025) explore the use of Acceptance and Commitment Training (ACT) to support open innovation behaviors in researchers. It focuses on overcoming individual-level barriers like the Not Invented Here (NIH) and Not Shared Here (NSH) biases, which stem from rigid professional identities and obstruct knowledge exchange in academic and research environments. This study is the last one belonging to the ATTRACT Socio-Economic Studies Special Section (Vignoli & Wareham, 2024), where the ABC4E project investigated whether psychological flexibility-based training can enhance scientists' open innovation attitudes and knowledge exchange behaviors, thereby improving collaboration across disciplines and industries. The study developed and refined a training intervention using an Action Research Innovation Management Framework across five institutions. The training integrates ACT principles, which are rooted in Relational Frame Theory (RFT) and utilize cognitive diffusion to enhance perspective-taking. The findings indicate that the training effectively reduces cognitive biases related to knowledge flows and highlights how activating perspective-taking facilitates the adoption of open innovation practices. The study provides practical implications for university administrators and Knowledge Transfer Offices, emphasizing the need to address psychological barriers alongside structural incentives for effective open innovation implementation. It notes that the effectiveness of the training in reducing biases appears generalizable mainly to individuals genuinely motivated to enhance collaborative capabilities.

This issue delves into these interconnected themes, exploring how managing our environment, understanding cultural dynamics, overcoming individual barriers, and even systematizing serendipity can push the boundaries of creativity and drive societal innovation. The articles presented offer insights and experimental evidence for fostering these crucial elements in pursuing groundbreaking ideas and solutions.

This issue closes with a coffee paper that discusses uncertainty. The concept emerged during a discussion by the IdeaSquare Self-Appointed Innovation team (ISSAIT, 2025). The team researched to understand this conundrum, starting from the very beginning. As a result of their research journey, the ISSAIT formulated an adagio intended as "food for thought" for visitors, collaborators, and students. This adagio is: "EMBRACE UNCERTAINTY; THE BEST UNFOLDS ALONG THE WAY". To provoke deeper reflection, the paper starts from the beginning, the “hot soup” of quarks and gluons, where transformation was the rule, and turns to philosopher Robert Nozick's "Experience Machine" thought experiment. To understand the message, while sipping your daily caffeine dose, you should be ready to unlearn, letting go of your rigid beliefs and outdated knowledge, cultivating flexibility and adaptability. As always, to discover more, you need to be ready to enter the rabbit hole… the real question is: are you ready?

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