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The new logic of financing innovation: from uncertainty reduction to shaping the unknown

Handbooks in finance, as well as literature reviews, recall that financing innovation and financing productivity investment differ in their level of uncertainty.[1] Students learn that financing production investment requires a positive net present value (NPV), whereas financing innovation requires taking into account multiple uncertainties by computing *expected* NPV. Models of decision-making in uncertainty helped to compute the value of *reducing uncertainty*.[2] This approach is considered the best way to value investment in research and development (R&D)—R&D being considered an activity to reduce uncertainty.[3]

In this time of "disruptive innovation" in the context of multiple socioeconomic and technological changes—such as energy transition, aging, and digitalization—it is tempting to consider that innovation dynamics tend to be characterized by an increase in uncertainty. Investments would, therefore, become much riskier, and financing might seem almost impossible. Fortunately, this "wisdom" misses a critical feature of contemporary innovation: it is not mainly about uncertainty but much more about "the unknown". In contemporary innovation, one has to deal not only with uncertain events, such as unstable markets and technological advances, but also partially unknown chimeras, such as inclusive mobility, smart cities, and sustainable energy. Therefore, it is critical for innovation success to deal with these initially unknown situations and shape them in a beneficial direction.[4] This distinction between *uncertain* and *unknown* has major consequences on innovation investment: the financing approach must not only consist of reducing uncertainty but also of *shaping the unknown*, i.e., through a capacity to design new alternatives, worlds, opportunities, markets, and usages.

Paradoxically, shaping the unknown is not necessarily "worse" in terms of risks and financing. While an increase in uncertainty might lead investors to become gamblers, dealing with the unknown requires investors to understand design logic and adopt a perspective on the new potentialities to be explored. If markets and technologies are unknown, good design does not consist of multiplying risky trials—it consists of designing technologies and markets that correspond to a winning lottery. One critical result of recent advances in design theory is that the unknown, forward-looking statements might become self-fulfilling and performative; they create a common language that supports innovation. Confronted with sacrificial dilemmas, where all given decisions seem doomed to unacceptable uncertainties, design logic enables the design of new and better decisions in the unknown.[5]

Risk from uncertainty versus risk from the unknown

Let's give a simple illustration of the difference between risk from uncertainty vs risk from the unknown: Famous French cartoonist Jacques Rouxel imagined strange creatures, called the Shadoks, whose rockets had one chance in a million to succeed. Consequently, they "rushed to fail the first 999,999 first trials". By contrast, design logic consists of shaping the unknown to redesign a rocket that has a 100% chance to succeed—which is actually what is expected from engineering designers in disruptive innovation! Investing in deep tech today would require similar reasoning. Deep tech refers to research-based technologies whose market applications are largely unknown, with each market opportunity having a very low probability of success. But what if designers were able to design a so-called generic technology that, for

example, might be generic to several markets? Then the probability that at least one market succeeds becomes high, since the probability that all the markets fail is low. This shows how design logic differs from a gambler's logic.[6] It also explains the success of platforms that are ecosystems based on a generic technological "core" made available to multiple complementors for multiple micro-applications.

Virtual universes to explore the unknown

To support this transition from uncertainty reduction to shaping the unknown, new financing approaches and new investment models are required. How do we act in the unknown? Can we orchestrate large teams developing breakthrough innovation despite the lack of knowledge on the necessary steps? How can we just pretend that all of these people are working on the same project? And why would an investor finance such a project?

Virtual universes are the keystone for these new collective behaviors. They do more than provide a shared representation: as a tool for shaping the unknown, they provide a shared capacity to present the unknown. In addition, they provide an objective basis for a comprehensive discussion of every aspect; even though the considered objects are not physically there and may be inconsistent from a scientific perspective, virtual representations don't have to obey every law of nature to be useful. Virtual universes act, therefore, both as a factual proof point—the dimensions of the virtual object can be objectively "measured"—and as a political or managerial reference, because their power comes from people believing in their performative value. In this perspective, the virtual world is not a computer game. Virtual exists because it extends and improves the real world.

Advances in research on generativity logics and design theory have shown two critical results, hinting at how virtual universes are key resources to enable and catalyze the exploration of the unknown:

1) Exploration is doomed to severe fixations—both individual and collective ones—provoking orphan innovation phenomena and speculative bubbles. But once fixation is overcome, then risk is considerably lowered by the fact that rigorous exploration of the unknown leads to the discovery and generation of diverse opportunities—across short- and long-term horizons with low and high capital expenditures (CapEx). Hence, exploration capabilities and methods that help overcome individual and collective fixations are a key resource. Today, some business units have developed such capabilities of "unknown shaping". Preliminary statistical studies analyzing their profitability show surprising results: a recent case study showed how one invested euro can bring 6 euros back to the corporation, and more than two-thirds of projects initially considered "too uncertain" to be funded are made profitable by rigorous design methods.[7] Because they provide an objective anchor for vivid imagination, virtual universes are crucial for overcoming fixations and, therefore, accelerate explorations.

2) In "unknown exploration", a critical resource is independent knowledge. This is counterintuitive for two reasons. First, it means that the unknown cannot be shaped on a "blank slate"—it requires knowledge and expertise. Second, knowledge is much more valuable if it is not self-evidently related to the issues to be explored. This second aspect is counterintuitive because, in a model of uncertainty reduction, the value of knowledge comes from dependent variables—if Y depends on X, then knowledge of X enables us to reduce the uncertainty of Y. By contrast, in design, the value of knowledge comes from independent variables—if the known Y is independent of X, then knowledge of X enables the design of disruptive Y.[8] The

> confrontation of these diverse sources of knowledge across many disciplines requires a shared “presentation” capacity—enabling the composition of apparently independent knowledge and expertise—which virtual universes provide.

These two results show how shared virtual presentation techniques and tools are much needed to support “de-fixation” and access to independent knowledge for the exploration of the unknown. This explains why virtual universes have a critical role to play. Not only do they contribute to the reduction of uncertainty through validation and optimization techniques—computer-aided design (CAD) systems historically played this role by decreasing costs of experimentation—but, moreover, they offer a natural “compass” to orient and support the exploration of the unknown in all its forms, from new scientific phenomena to emerging technologies, novel uses and usages, and business models. These virtual universes for generativity should not be conflated with validation techniques—their value is much more in their capacity *to* generate surprising alternatives. They do so by connecting apparently independent dimensions and by helping users connect heterogeneous (independent) knowledge through new uses, technologies, complex systems, basic research, production, and creation. This phenomenon is already visible in aeronautics and the automotive industry, and is now spreading to all industries—most notably to life sciences, healthcare, construction, and services. Virtual universes contribute to support design logic, and they are the fuel of contemporary innovation.

A direct consequence is that, from a macroeconomic perspective, investments for shaping the unknown will develop in independent areas. For the design process, there are at least two well-known sources of independent knowledge: downstream users and upstream research.

On the one hand, virtual universes open up the possibility of much more integration for users and usages as an engine for exploring the unknown—not only by bringing knowledge from existing uses and users but also by enabling the creation of knowledge of alternative users and usages, individual and collective experiences, and emotions. Virtual universes strengthen the possibility of integrating the demand side into the design process. One could think of virtual universes as replacing the traditional proof of concept (POC), allowing the systematic generation of (virtual) prototypes at a very large scale to explore the multiple potential applications of generic technologies.

On the other hand, the value of investing in basic research might precisely come from the fact that basic research provides independent knowledge—knowledge that is neither the result of deductive problem-solving nor of optimized strategy! Basic research appears as a critical actor able to explore the unknowns of science—and, doing so, it brings back unexpected knowledge. The value of this knowledge is not in its applicability—this would correspond to dependent knowledge—but in its originality and unexpectedness. This mechanism is virtuous if two conflicting constraints are met. First, basic research has to be maintained independently from innovation, meaning it is neither application-driven nor problem-driven. Second, basic research should also be closely related to innovation so that 1) basic research knowledge can be used in innovation processes, and 2) innovation processes can provide basic research for new unknowns to avoid fixations by scientific communities and the laws of “publish or perish”. Here again, virtual universes have a role to play: they can support basic research explorations, help identify basic research questions in innovation endeavors, and help import basic research results into innovation processes. Hence, even in basic research, virtual universes transform the scientific approach and support efficient exploration of the unknown.

Institutions to support shaping the unknown

It has been largely noticed that innovation requires a trusted environment in order to blossom and spread.[9] Institutions are needed to provide this trusted environment for shaping the unknown. Because they offer common reference points for groups of people, *virtual twins* act as new forms of institutions, creating the conditions for shared understanding, debate, and action. For instance, an infrastructure project related to new public transportation can be represented through a virtual twin of the city: the whole mobility system and related dimensions, such as building development policy, energy, and economic development on a given territory, can be modeled and simulated in a multi-factor approach. Third parties, such as contractors, local businesses, and administrations, can contribute by providing inputs and expressing constraints, and citizens can understand the project and contribute to design choices. When coherent with the logics of unknown exploration as explicated by design theory, virtual universes can be considered as assets with infinite value because not only are they non-rival goods, but also their value increases with usage.

For instance, the generative capacity of the virtual twin of a city can increase with the number of people accessing it and contributing to enriching its exploration paths. Virtual twins are, therefore, potentially "public goods". However, they are likely to be appropriated, for instance, if their creators or owners misuse them to bias explorations, fixate on certain paths, or hide exploration paths in the unknown. The concept of the unknown might thus require new protection mechanisms, such as a new legal status for "common and non-appropriable unknowns". Intellectual property might also be useful, probably in new forms, ensuring the publication of exploration paths and ensuring forms of recognition and rights for scouts, pioneers, or providers of the ways and means of unknown exploration. Patent law has evolved regularly over time to integrate new forms of inventiveness—new IP law might support the development of capabilities to explore the unknown and leverage the power of virtual twins.[10] The global response to the coronavirus disease 2019 (COVID-19) pandemic has shown how research could share vast amounts of data and intellectual property to accelerate the creation of knowledge on the disease and the discovery of new treatments. In this context of exploring the unknown, major research institutions offered a "no-fee, royalty-free license" to their work involving the diagnosis and treatment of COVID-19 patients. Some initiatives were launched, such as the "Open COVID Pledge", urging researchers and companies to sign on "to make our intellectual property available free of charge for use in ending the COVID-19 pandemic and minimizing the impact of the disease."

The exploration of the unknown and the work in virtual universes are increasingly collective endeavors—with inevitable fixations and biases emerging either at the firm level or the ecosystem level. Appropriation, short-term profit, and shortsighted strategy can lead to severe pathologies and crises related to contemporary innovation. Examples include speculation bubbles on "killer applications" and "miracle technologies", forever technologies of the future, low success rate of market adoption, or even orphan innovation, i.e., situations where an innovation is expected by society, but companies fail to provide it.[11] Hence new institutional logics might be required, both at the firm level and the ecosystem level.

At the firm level, new governance principles might help protect and support firm capacities to shape the unknown. For instance, this has been one of the objectives of a new legal status for companies in France: the status of "profit-with-purpose company" protects and reinforces the capacity of the company to explore certain unknowns.[12]

At the ecosystem level, researchers have identified the emergence of original institutions such as "colleges of the unknown" and "architects of the unknown".[13] These actors ensure that, in a given field of innovation, explorations are launched in all imaginable directions, are

rigourously generated to avoid cognitive fixations, and cover a variety of alternatives with several time horizons. These actors also create a common language in the unknown, help measure and compare progress, and support coordination and interactions between designers. In a time of sustainable development goals (SDGs) and global transitioning to new technologies in areas such as energy and the digital economy, such organizations are very useful. However, not every self-appointed group can be a relevant college of the unknown. Virtual platforms could become game changers supporting efficient collaborative exploration and the development of quality criteria for the de-fixed, complete, and robust exploration of the unknown.[14] Quality criteria for collective exploration would systematize the identification of fixation at the ecosystem level and support the development of capacities to overcome those fixations.

Investing to build the "creation heritage" of future generations

Sustainability and other planetwide challenges are the domains demanding investment in the unknown today. The available solutions to face such contemporary threats are too limited, leading to unbearable sacrificial dilemmas such as agronomic pollutants vs. famine, carbon-intensive energy vs. social riots, or, more recently, lockdown vs. epidemical diffusion. Going beyond sacrificial dilemmas is exactly the role of designers shaping the unknown. This requires huge investment—not only in intangible assets but also tangible assets, such as innovative long-term infrastructures for home improvement, mobility, cities, public health and care, etc. Digital also requires material infrastructure investment. The major question will thus be to orient rightly these investments towards challenges of the 21st century by correctly taking into account their intangible dimensions. Do these investments support unknown shaping, and are they overcoming collective fixations? Do they create long-lasting virtual assets able to capitalize on knowledge and know-how?

Moreover, how are these investments adapted to future generations? They should not only satisfy the predicted needs of future generations, but they should also provide future generations with the creative capacity and "creation heritage" to invent their own future.[15]

Investing in virtual universes is a precondition to shaping the unknown and allows us to build a creation heritage. By this logic, investment in education is strongly needed as it is the key to unlocking these virtual universes and ensuring accessibility for the largest audience. From the perspective of investing in the capabilities for shaping the unknown, could there be anything more efficient than educating people to help de-fix themselves, develop capabilities to collectively and rigorously explore the unknown, and enable them to deal with virtual universes in a powerful and creative way? Perhaps the priority in terms of financing innovation today should be to invest in a collective culture of design based on shaping the unknown with virtual universes.

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Notes:

[1] Kerr et al., 2015.

[2] See the famous reference book of Raiffa and Schlaifer (1961) with a preface by Bertrand Fow, the Director of Research at Harvard Business School.

[3] See the seminal works by Charles S. Peirce, who proposed to undertake research on the basis of the value of uncertainty reduction. This text was largely ignored when Peirce wrote it, and it was rediscovered and published in the 1960s (Peirce, 1879; reproduced in 1967 in Operations Research, 15, pp. 643-648). See also, more recently, the literature on real options.
[4] Loch et al., 2006; Feduzi et al., 2014; Kokshagina et al., 2015; Faulkner et al., 2017; Jensen et al., 2017; Gillier et al., 2018; Grandori et al., 2018; and Elmquist et al., 2019.
[5] Hatchuel et al., 2009; Le Masson et al., 2018.
[6] Hooge et al., 2016.
[7] Gilain et al., 2019.
[8] Hatchuel et al., 2018.
[9] Mazzucato, 2013.
[10] Landers, 2010; Valibhay et al., 2018.
[11] Agogué et al., 2013.
[12] See in France the new corporate law on “entreprise à mission”/“mission-oriented company”; Levillain et al., 2019; Levillain et al., 2019; Segrestin et al., 2020; and Parpaleix et al., 2020.
[13] Le Masson et al., 2012; Agogué et al., 2013.
[14] Rémondeau et al., 2019.
[15] Hatchuel et al., 2019.