THE METAMORPHOSES OF INNOVATION: systemic, intensive and responsible

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This article offers insights into present-day challenges facing businesses by examining key stages in the metamorphosis of innovation. There are three clear phases: the pivot to modernity with the systemization of design (1860-1947); intensive innovation rooted in disruptive design and the formation of new ecosystems (1947-2010), and present-day responsible innovation (since 2010), which is rooted in new business models and the formulation of civilizational commitments. In each case, the focus is on sources of new knowledge, underlying principles, and the main actors involved. Furthermore, none of these phases can be a substitute for another. Each of them creates mechanisms that stay in place as the following phase emerges. The third phase, although it points to a new path, is founded on the two previous phases. Present-day businesses need to combine these different approaches if they are to meet stakeholder expectations.

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INTRODUCTION

In 1918, Henri Fayol wrote: "Combining the efforts of academics and practitioners is not the easiest of tasks facing the business leader. There are countless obstacles to overcome: I cited them in my publication on General and Industrial Management; but at the same time I also proclaimed the indispensable necessity for industrialists to organize and make a success of the collaboration between science and the world of business. This notion so full of promise that is now in high regard has been close to my heart for many years, and I can affirm that, in this matter, my company has set an example"[1].

The author of these words, founder of the science of business administration, was entirely justified in flaunting his remarkable innovation policy. In 1896, his collaboration with Charles Edouard Guillaume (winner of the 1920 Nobel prize for physics) had resulted in the discovery of Invar steels that had extremely high dimensional stability. And the laboratory he entrusted in 1911 to Pierre Chevenard went on to become a leading name in precision metallurgy.[2]

1 Henri Fayol, *Notice sur les travaux scientifiques de M. Henri Fayol [Note on the Scientific Works of M. Henri Fayol]*; Dunod, 1918.

2 Pierre Chevenard, *L'installation et l'organisation d'un laboratoire sidérurgique [Installation and organization of a steel-making laboratory]*, Mémoires de la société des ingénieurs civils de France, 1933.

Yet Henri Fayol never used the word "innovation". In his famous treatise, he emphasized "improvement in every domain" as the first duty of an industrialist. His choice of words was far from insignificant, since during his century "progress in the arts and sciences" was considered to be the precondition for "human improvement." These variations in vocabulary are instructive because they lead to a twofold observation:

- changes in innovation and innovation processes continue today;
- the knowledge, values and organizations involved in the design and implementation of innovations undergo constant metamorphosis themselves.

In this article we will look at the three main phases in the metamorphosis of innovation, because this evolution provides valuable insights into the methods and challenges of present-day innovation. We will consider three phases: the pivot to modernity (1860-1930); intensive innovation (1947-2008), and responsible innovation (today) which demands new civilizational commitments. In each case, we will focus on sources of new knowledge, underlying principles, and the main actors involved. Furthermore, none of these phases can be a substitute for another. Each of them creates mechanisms that stay in place as the following phase emerges. What we actually observe are processes rooted in complementarity and diversification: the third phase, although it points to a new path, evolves from the two previous phases.

PIVOT TO MODERNITY: THE SYSTEMIC DESIGN OF INNOVATION

It is an irony of history that current thinking about the start date of the Anthropocene – the era marked by human activity disrupting the planet's ecology – points to the period (the early 19th century) when innovation became an activity that was systemic and organized. This systemization had a major effect, strengthening the close relationship between machine power and energy sources.

The exponential growth in the use of fossil fuels such as coal, oil, gas, etc. in the years from 1800 to 1930 was a direct consequence of this development. New industries systematically designed, again and again, new machines that simultaneously improved production of energy (steam, internal combustion, electricity, etc.) and production of the new goods and services (steel-making, metal-working, construction, chemical engineering) that used these energy sources. What was termed "industrial revolution" corresponds primarily to the amplifying impacts of these design and engineering activities.

This systemization of innovation strengthened the close relationship between machine power and energy sources

The number one organizational innovation of the period was the creation of "design offices", comprising groups of technicians and engineers capable of designing, building and testing machines, or assemblies of new machines (the new factories). As vital partners to design offices, the "testing and research laboratory" also came to the fore thanks to the need to develop

instruments able to validate materials, calculations and designs from the design office. Design offices and laboratories, whether third-party or in-house, mushroomed throughout the 19th and 20th centuries, and were responsible for innovations such as automobiles, airplanes, and gas, water and electricity networks (Cf. figure: special issue no. 58 of *Entreprises et Histoire*, 2010).

This pairing of design office and laboratory formed a unit that revolutionized and stimulated manufacturing's two traditional main functions: upstream, the workshop or factory had to adapt and obey its instructions, while downstream, sales activities were tasked with supplying design offices with orders and information about their clients' future needs. The modern company that crystallized in the period between the two world wars, and whose governance was theorized by Henri Fayol, was born of the process of systemic innovation that established itself at the interface of these three functions: commerce, design, and production.

The same period saw the development of public institutions devoted to scientific research, using equipment that benefited from business' newfound design capabilities. These institutions made a great many discoveries and drove the internationalization of academic research. In a handful of cases (military activities, major infrastructure, medical projects), the design prowess of the private sector and the research strength of the public sector combined to give rise to previously unseen achievements. But fruitful collaboration between these two innovation regimes remained problematic and as early as 1918, as we have already mentioned, Henri Fayol described this question as the major challenge facing modern industry.

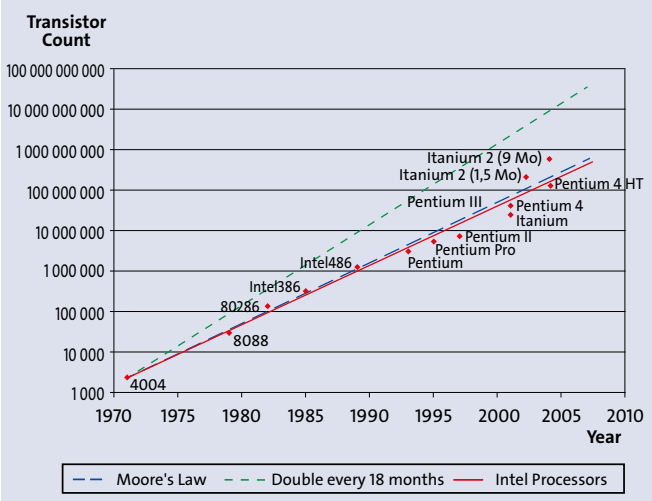
In the years following the Second World War, innovation was all too often thought to involve public research alone, whereas conceptual and technical revolutions originating in the business world were already appearing. These revolutions would have an impact across society as well as on academic research itself.

INTENSIVE INNOVATION: DISRUPTIVE DESIGN AND NEW ECOSYSTEMS

Between the wars, the telegraph, radio (also called the wireless), telephone, record player, photography and the cinema radically altered how news, advertising and culture were presented and consumed. Then the new information processing machines that arrived in the wake of the 1947 discovery of the transistor paved the way for waves of successive disruptions that swept across every conventional technical system. The fact was that all social and societal practices, public and private alike, were revolutionized. The previous design system, centering on design office and

laboratory, could now be opened up to new sciences and new techniques. However, it nonetheless struggled to justify – via conventional financial analysis – and organize the exploration of an unknown multitude of new concepts for products and services, made conceivable by the new information-processing techniques.

This unknown territory led to the 1965 observation by former Intel head Gordon Moore of what would become known as Moore's law, which posited a constant rate of microprocessor miniaturization (see fig.).



This was in fact simply a self-fulfilling prophecy concerning future innovation. However, it encouraged a number of projects and companies to collaborate to ensure their survival, ensuring that the prediction became a reality (laptop computers, cellphones, internet, social media, and so on).[3] This orchestration of innovation led to products and ecosystems that had never previously existed! Innovation would henceforth become intensive. All actions in an individual or collective life could potentially lead to the creation of new tools or services connected to personal devices. This effervescence also triggered a tidal wave of startups, some of them going on to become giants of the internet.

It was a quest that resulted in the uptake of new design-related approaches. Initially, these approaches were not sufficient to adapt design principles to the unknown, encourage scientific research that drew on more distant fields, and manage these diverse explorations coherently. A substantial research effort went into formulating a design theory (known as C-K theory) and design methods suited to the continuous disruptive design of objects and business models and collaboration with the academic world (cf. image, M. Agogue et al. *Introduction a la conception innovante [Introduction to Innovative Design],* Presses des Mines 2013).

By organizing guided innovative design workshops, these approaches helped to consolidate the creative capacity of design offices, testing laboratories, and marketing teams. What they did in particular was move away from the usual product and business models, helping to build new consortia for exploration and innovation partnerships with other businesses as well as universities and public bodies.

This new intensive innovation regime revolutionized the foundations of culture, commerce, politics, and businesses. It resulted in the emergence of a new world, with innovation incorporated into all regimes of existence and action. But it would be wrong to think it signaled the disappearance of the systemic design model. This model was called on more intensively and more stringently, but it also had to find its place among vaster and increasingly digitalized technical and social transformations. Connected cars still need high-quality tires, but the wheel now has new features and is a component of new control and monitoring mechanisms. For most objects and machines, intensive innovation means multiplying their modes of existence and interaction with the rest of the world. We could say that the spheres most dramatically affected are the arts and the workplace: the production of audiovisual works has undergone major changes in how they are accessed and experienced. And we are all now familiar with the opportunities and threats of working from home. Additionally, the digital world has provided artificial intelligence with fertile ground, allowing it to take root and spread.

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The combination of systemic design and innovative design is pushing out the organizational boundaries of innovation. Businesses are turning to in-house startup mindsets, but a startup ecosystem can spread far beyond its initial parent company. France's Dassault Systèmes, world leader in digital engineering and the 3D experience, began life as a Dassault Aviation startup, but is now also a front-runner in biological engineering and medical data.

RESPONSIBLE INNOVATION: THE NOTION OF CIVILIZATIONAL COMMITMENTS

At first glance, phenomena such as the recent awareness of the importance of ecological issues and the dangers of unregulated digital globalization seem likely to put a stop to innovation that ignores its negative impact on human life and the planet.[4]

3 Le Masson, P., Weil, B., Hatchuel, A., & Cogez, P. (2012). Why are they not locked in waiting games? Unlocking rules and the ecology of concepts in the semiconductor industry. *Technology Analysis & Strategic Management*, 24(6), 617-630.

4 Franck Aggeri, *L'innovation, mais pour quoi faire? [Innovation, for what purpose?],* Seuil, 2023.

But it is a mistake to think that the resources constraints or social considerations curb innovation. Rather, they can act as powerful stimuli for innovation, with the proviso that design methods and ecosystems are suitable for these leaps into the unknown. In the Middle Ages, monasteries had to be built in isolated and hostile places which called for self-sufficiency. These obstacles fostered a series of innovations in construction, the use of water power and a variety of mechanisms, and farming and medicinal activities. To achieve their aims, monks looked for all potentially useful knowledge and expertise, including from the non-Christian world. Their inventions and libraries fed the "industrial revolution in the Middle Ages" and the Renaissance that followed.[5]

Innovation, on a significant scale, is vital in an era of frugality[6], decarbonization, and the dangers of the climate emergency. What we call energy, environmental and ecological transitions do not point to *any known destination*. Even drastic frugality cannot justify a decline in healthcare, the abandonment of pets, or the absence of heating in winter. Our era therefore calls for a ramping up of both systemic design and innovative design.

- Ramped-up systemic design because the eco-design approach, applicable to most products, requires the revision of all supplies, procedures, packaging and distribution processes used until now. Many of these links in the chain will become less dangerous to communal life.
- Ramped-up disruptive design in several cases: the use of CO_2 as a raw material is an area that remains to be explored, while wind and solar energy production techniques must continue to develop. As for research into new materials that are recyclable and less energy-intensive, or new sustainable farming models, this already needs innovative, intensive, and eco-systemic design. The achievements of systemic design and innovative design are therefore a major benefit when it comes to tackling contemporary innovations.

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The current phase differs significantly from the previous two. In the past, innovation was rarely a collective imperative. Society looked to talented researchers, risk-hungry businesses, and avant-garde consumers. However, these forms of stimulation are no longer enough to spontaneously guide innovation efforts toward ecologically sustainable solutions that offer no guarantee of profitability. The state therefore must multiply the indispensable frameworks – although ecological planning can only apply to known products and services and the state will not itself be able to lead the required innovations. Nor must we forget the essential pioneering work on climate justice.

We therefore need to innovate on a *civilizational* level, i.e. to redefine individual and collective commitments and turn ecological imperatives into goals that are *as natural* as profit-seeking.

Signs of this shift are visible in the emergence of new company law, as illustrated by two recent pieces of French legislation: the 2017 duty of care law, and the 2019 PACTE law. In both cases, companies are now responsible for their social and environmental impacts in France and throughout their international supply chains. They can also make specific commitments by publishing a statement of purpose in their statutes, or adopting the official status of mission-led corporation.[7]

This transformation of corporate missions and governance requires a new type of eco-systemic innovation, since it involves formulating a company's many purposes in consultation with its constituent parties and stakeholders (*cf.* image K. Levillain, *Les entreprises à mission [Mission-Led Businesses]*, Vuibert Frege 2017. It also involves promoting approaches rooted in design-led management[8] where exploring the unknown is accepted, encouraged and shared.

The switch to electric vehicles is an example of this type of transition. Long before the European commitment to halt ICE (Internal Combustion Engine) vehicles, Tesla and Renault began developing different innovative design strategies. But the transition to a complete electric mobility ecosystem that is both sustainable and accessible to the middle classes remains a work in progress. In the agricultural world, one of the biggest cooperatives, InVivo, has chosen to become a mission-led corporation and become involved in designing new food industry systems. Mutual insurance companies like MAIF (a mission-led corporation) or banks such as Caisse d'épargne Normandie (a purpose-led corporation) have committed to making substantial changes to their investment policies (decarbonization, territoriality, supporting the most vulnerable, etc.). Veolia (a purpose-led corporation) played a very active role in the PACTE law reform and has implemented an original management strategy that uses *multi-faceted performance*, focused on accounting for the interests of all its stakeholders in all its activities.

These are just the first steps in a system of innovation facing many unknown factors, but they prove that the current innovation phase is under construction, using the building blocks of the three design regimes: systemic, intensive, and civilizational.

5 Jean Gimpel, *La révolution industrielle au Moyen-Age [The Industrial Revolution of the Middle Ages]*, 2016 (reprint), Points histoire.

6 We have chosen to translate in this review the French word "sobriété" by frugality but could also be sufficiency, simplicity, efficiency...

7 https://www.entreprisesamission.org/

8 The notion of design-led management was propounded by Pascal Le Masson and Benoit Weil in a project presented at the ICED 2023 conference (Bordeaux, July 2023) as part of the design theory symposium.