ECOLOGICAL TRANSFORMATION: pathways to frugal and responsible innovation[1]

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An ice stupa is a type of artificial glacier designed to combat the water shortage caused by global warming in the Himalayas (Ladakh).

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1 This article is inspired by a recently published book: *L'innovation, mais pour quoi faire? Essai sur un mythe économique, social et managérial [Innovation, but for what purpose? Essay on an economic, social and managerial myth]*, Franck Aggeri, Seuil 2023.

Innovate, constantly and at an ever-growing pace. This is the order given to individuals, businesses, and states alike. When it comes to ecological transition, this blind faith in innovation's benefits has a name: "green" technological innovations (electric cars, renewable energies, and so on). These innovations are presented as pre-conditions for green growth, a model that promises to create financial wealth free from negative environmental impacts. But this model is dangerous for three reasons: it fails to properly estimate pollution transfers between lifecycles; it fails to allow for the effects of scale and the systemic effects associated with mass adoption of these innovations, and it leads people to believe they can maintain their lifestyles and consumption habits because technology will solve the ecological crisis. The negative effects of these technological innovations are proven, so how can we innovate differently to avoid undesirable impacts and help create a society that is truly sustainable? This article explores two complementary approaches: making innovators more responsible for the long-term consequences of their projects, and promoting innovation projects that are more frugal, centering on transforming lifestyles and modes of production and consumption in ways that are compatible with planetary boundaries and the needs of future generations.

INTRODUCTION

Electric cars, positive energy buildings, renewables from wind turbines, and photovoltaic panels: in the collective imagination, environmental transition is generally thought to center on the adoption of a bouquet of so-called green technologies. This techno-optimism is echoed not only in the media but also by policymakers and businesses that present technological innovations as the solution to present-day environmental problems, the climate emergency in particular. This blind faith lies at the root of the green growth model that claims economic growth without environmental impacts is possible via the mass adoption of these innovations. But this vision of the future is problematic as it underestimates pollution transfers resulting from the widespread adoption of these high-tech innovations during their life cycles and because it overlooks the question of frugality, the changes in lifestyles needed to avoid overconsumption caused by the frantic race for innovations.

Does this mean pulling the plug on innovation? Such a choice would not be sensible, as it would result in upholding the status quo, i.e. the current economic model, which is incompatible with planetary boundaries. In that case, how can we innovate differently? After highlighting the blind spots of green high-tech innovation, this article explores two complementary approaches: making innovators more responsible for the long-term consequences of their projects, and promoting innovation projects that are more frugal, centering on transforming lifestyles and modes of production and consumption in ways compatible with planetary boundaries and the needs of future generations.

THE BLIND SPOTS OF GREEN HIGH-TECH INNOVATION

Why should we doubt the benefits of green technological innovations? To understand the cognitive bias we are prey to, we must first set out the criteria used to define whether an innovation is "green". On release to market, an innovation has to successfully pass a process of technical standardization to ensure it complies with regulations and standardized environmental assessments. Standardization processes vary by product and sector. But the focus tends to be on certain types of emissions (atmospheric pollutants, CO_2 emissions, recyclability, etc.) while ignoring other aspects, such as material footprint (use of resources) and biodiversity. Furthermore, they rarely examine the complete lifecycle of a product or infrastructure, only looking at specific phases such as production, use and end-of-life. Lastly, assessments are systematically limited in scale to each individual technology, meaning they fail to examine scaling effects linked to the mass uptake of a particular innovation. The problem with standardization is not only to do with bias; it is also reliant on guidelines that are often badly out of date and unsuited to the challenges raised by modern-day innovations.

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For instance, in the automotive world, electric vehicles are said to be "zero emission" because regulations focus on the phase when the vehicle is in use, which is where most pollution by internal combustion vehicles occurs. But this assessment does not include emissions linked to the extraction and transformation of materials, vehicle manufacture, or production of the electricity used to power it, which may be more or less decarbonized depending on each individual country's energy mix. What are the blind spots of green technological innovation assessments?

POLLUTION TRANSFERS

The first assessment blind spot: pollution transfers. If we were to change the guidelines used so that in future we considered all emissions over the entire lifecycle, using lifecycle analysis (LCA) methods, the environmental balance sheet for these green technologies would look very different. This type of multi-criteria lifecycle assessment would then highlight pollution transfers between pollutants as well as between lifecycle phases. The production of so-called green technological innovations consumes more resources (raw materials, energy, water, land, etc.) than the conventional technologies being supplanted. For an equivalent power output, it takes far more concrete, steel and land to manufacture and erect wind turbines or solar power plants than a thermal power plant. Similarly, electric cars as considerably heavier than equivalent internal combustion vehicles as they have to carry a heavy battery, weighing at least 250 to 300 kilos. And the forms of pollution generated by these innovations differ from those of preceding generations of technologies. Although they emit zero CO_2 at the point of use, they depend on a great many strategic metals, such as cobalt and lithium for vehicle batteries, rare-earth elements for wind turbine magnets, etc. Not only are the known reserves of these metals limited, but also, critically, they pose new geostrategic supply problems because their production is concentrated in a handful of at-risk countries such as Democratic Republic of Congo for cobalt and China for rare-earth elements. Technological innovation thus does not solve all the world's ecological problems, it merely relocates them.

TEMPORAL AND SCALE EFFECTS

The second blind spot lies in scale effects. An incremental mindset when thinking about a product or infrastructure results in the scale and systemic effects being overlooked. In the early 20th century, the arrival of the first internal combustion vehicles was hailed by scientists of the day as a technology that would improve the quality and cleanliness of air in cities whose streets were strewn with strong-smelling horse manure that also kept streets very dirty. A hundred years later, we can measure how badly cities are being suffocated by pollutants from a global fleet of 1.4 billion vehicles. And while the arrival of the first electric vehicles was hailed as an innovation that would do away with these atmospheric pollutants and cut CO_2 emissions, what will be the judgement of future generations when faced with the scarcity of rare-earth elements and the environmental and social consequences of their extraction? What will be their reaction if the global vehicle fleet continues to grow and wind and solar farms spread unstoppably in all regions of the world, resulting in ever-growing land take and urban sprawl?

"All other things being equal" is no longer an acceptable attitude when confronted with the ecological crisis. Assessments of innovations must incorporate their temporal, scale and systemic effects as well as the irreversible nature of the social and environmental changes they may engender. The fact is that once they have been adopted, it is often very difficult to turn back the clock due to the considerable social and environmental costs of certain innovations.

THE FRUGALITY BLIND SPOT

Frugality is the third of the blind spots. According to the green growth myth, all these technological innovations will, taken together, allow people to maintain their lifestyles and indulge their endless thirst for the latest consumer goods. However, the green-growth myth fails to recognize that technological innovations have environmental impacts and that we must act on the demand side to reduce consumption of material goods. Ever since the pioneering work in the early 20th century by economist and sociologist Thorstein Veblen, we have known that conspicuous consumption is a social process driven by more than the requirement to meet essential needs. How can we move beyond this mindset of unfettered growth in consumption? This is the challenge

New technologies reach the countryside. Solar energy production on the roof of a home in Mungun Morit, Mongolia. Source: Dave Lawrence.

posed by frugality. Valérie Guillard defined it as an individual and collective attitude that seeks to moderate what is consumed.[2] In terms of individuals, she observed an uptick in public awareness of frugality.

Various studies all indicate that more and more consumers want to have their products repaired or to carry out repairs themselves, to buy pre-owned or reconditioned items, and to rent or share goods and equipment rather than buy a new product. Adoption of more frugal behaviors, she notes, requires changes to be made on three levels: personal norms (each individual's emotional and psychological reactions); social norms (social representations the individual has of themself and the image that they seek to convey), and physical mechanisms (available public resources, such as bicycle routes and composting services that allow individuals to alter their behavior).

However, as long as managers in industry and manufacturing continue to be judged on the basis of unrealistic production and sales growth targets, there is little chance that frugal practices will develop spontaneously. For these to take root, proactive public policies are needed to spur fundamental changes in lifestyles and production practices by limiting advertising and all other techniques intended to artificially stimulate consumption. With the spate of recent crises (Covid, the invasion of Ukraine, repeated environmental crises), the idea of frugality as a way of avoiding shortages of energy or water is beginning to become more acceptable; frugality is now associated less systematically with degrowth. However, it remains a topic that is too often approached from an overly narrow perspective, relegated to simply a matter of energy frugality that can be summed up in a handful of "eco-gestures", such as turning down the heating or investing in insulating buildings. But there is far more to frugality than this. It involves root-and-branch reviews of our lifestyles and production methods, seeking to systematically reduce unnecessary needs and the environmental impacts associated with our economic activities and shift our attitudes to time.

HOW CAN WE INNOVATE DIFFERENTLY?

Against this backdrop, how can we innovate differently? Two avenues can be explored: making innovators more responsible for the long-term consequences of their actions, a process we will call *responsible innovation*, and exploring *frugal innovations*, which are explicitly focused on changing lifestyles and consumption habits so they become more frugal.

PATHWAYS TO RESPONSIBLE INNOVATION

This first avenue of exploration is responsible innovation. The problem with the main environmental responsibility mechanisms used at present, whether judicial, financial or legal, is that most of them focus on retrospective responsibility. They are based on the problems of attribution, i.e. the search for a causal link between a type of pollution and actors that originally created the pollution, following the polluter pays principle. However, as we are reminded by philosopher Hans Jonas, the challenge underpinning the development of a technology is the implementation of future-facing projective responsibility.[3] This involves anticipating possible negative medium- and long-term consequences associated with the introduction of new innovations, because the potential power associated with technologies has become so great that they may endanger the survival of the human race, if not the whole planet. Given this reality, a whole series of mechanisms must be updated or invented. Extended producer responsibility policies and processes could increase innovators' responsibility by focusing on targets for prevention, eco-design and extended product lifespans rather than on collecting and recycling waste, as is currently the case in most countries. Equally, we might imagine changes in accounting frameworks, the cognitive infrastructure of our economic activities, by adopting the idea of the triple bottom line, whereby economic organizations have debts to nature (natural capital) and employees (human capital) and must protect these in the same way as their financial capital. Governance of research and innovation is another avenue. This is where responsible and democratic innovations have a role to play: getting concerned parties (users, NGOs, public bodies, etc.) involved in discussions about the ultimate purpose of an innovation, its mechanisms, and the associated technological choices. The responsible innovation concept has gained traction in political, academic and economic circles. This is conceived as an approach that is anticipatory, reflective, inclusive and attentive to stakeholders' expectations (responsive in English), whose

2 V. Guillard, *Du gaspillage à la sobriété. Avoir moins et vivre mieux? [From wastage to frugality. Living better with less?]*, Louvain-la-Neuve, De Boeck Supérieur, 2019.

3 H. Jonas, *Le principe responsabilité. Une éthique pour la civilisation technologique, [The Responsibility Principle. An Ethical Framework for a Technological Civilization]*; Paris, Champs essais (first published 1979).

missions are structured around the UN's sustainable development goals; an approach summarized by the acronym ARIR[4]. When considered from this angle, innovation is no longer synonymous with progress. It has to demonstrate its positive impact within a dialogical process that seeks to provide tangible proof rooted in assessment techniques such as LCA. However, these principles remain entirely voluntary; they must be rendered compulsory and subject to improved oversight to avoid the risks of greenwashing.

THE POTENTIAL OF FRUGAL INNOVATIONS

The second avenue of exploration involves looking at frugal innovation: innovations that are more able to produce wealth and create employment with a smaller environmental and material footprint. Frugal innovation centers on twin pillars: the eco-design of products and equipment to extend lifespans and increase use, and the development of service-based activities and new business models leveraging these sustainable products and equipment. Eco-design is critical because most current products and equipment are not designed to last, be repaired or recycled. They are primarily designed to be as cheap as possible to manufacture or install. Almost everywhere, it is the quest for the lowest cost that dominates, the ultimate expression of a short-term perspective that seeks immediate revenue with no thought to the medium- and long-term environmental and social impacts. Restoring durability to the heart of the design process could entail additional costs linked to the use of higher-quality materials and components. These extra costs could be absorbed by generating income streams linked to maintenance, repair, reconditioning, remanufacturing or recycling services. This does not necessarily imply that solutions will be more costly, it simply requires the adoption of simple principles: modularity, to facilitate the repair or replacement of defective components; the simplification of fixing systems and halting the use of unnecessary adhesive or solder; the selection of non-polluting and recyclable materials, and the adoption of robust technological systems that are not pointlessly sophisticated. This approach is not a rejection of high-tech. There is certainly a place for connected devices, provided they facilitate preventive and predictive maintenance and improve understanding of how product performance alters over time so that designs can then be improved.

Taking this strategy for built-in sustainability as the starting point, it then becomes possible to imagine strategies for new services. Such approaches are becoming more common, including among major corporations that are pivoting their business models to embrace a circular model. Michelin, for instance, has used this strategy for over 20 years in its relationship with business customers (fleet managers) on several continents, offering performance contracts whereby it handles all aspects of tire maintenance, repair and retreading. Signify (formerly Philips Lighting) applies a similar approach to lighting, managing its clients' lighting energy use, quality and lightbulb recycling. In terms of repairs, retailer Fnac-Darty launched a subscription repair service for its products in 2019, leveraging its unrivalled aftersales service and repair network and its position as leader in the French market for electronic goods and household appliances. It also applies the repairability index introduced into French law in 2020 to five families of electrical and electronic products. The company hopes these services will account for a third of its turnover by 2025 It is also making efforts to guide consumer choice and supplier offerings by creating a ranking of the most sustainable products, based on a publicly available methodology. These examples show that other strategies for creating wealth exist that do not simply rely on the manufacture and sale of ever-greater quantities of new products. They are, however, very difficult and demanding to put in place because they require new skill sets such as repair specialization, maintenance, and financial and services engineering. Retraining may also be needed for people in roles associated with high-volume selling, adoption of new performance indicators, the establishment of new eco-design reflexes, and the restructuring of value chains and business models with the associated transformation of revenue and capital asset structures.

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For the potential of frugal innovations such as these to be fulfilled in macro-economic terms, breaking the link between the production of wealth and the associated economic and social impacts, it is important to avoid rebound effects, meaning we need to move beyond the model of the consumer society. Buying a pre-owned or reconditioned product is only environmentally virtuous if the purchaser refrains from using the money saved to buy other items they have absolutely no need for. Limiting impulse buys is key to shifting to the more frugal lifestyles whose importance we have highlighted.

CONCLUSION

The transformation of production and consumption models will not happen spontaneously because both are deeply anchored in our cognitive and cultural frameworks. To change them first demands transformation of the cognitive infrastructure used to assess economic actors, such as national and international wealth indicators, business financial indicators, and production growth targets. Such a change will require support from policymakers at every level (local, national and supranational) and will need to make use of all available levers: education policies, systems to incentivize and inform consumers, tax regimes, and state investment. It is only under these conditions that this model of frugal and responsible innovation will have any chance of emerging.

4 J. Stilgoe, R. Owen and P. Macnaghten, *Developing a Framework for Responsible Innovation;* Research Policy, Vol.42, no.9, 1565-1580, 2013.