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THE QUANDARY OF SUSTAINABILITY-ORIENTED INNOVATIONS

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1 Introduction

Contemporary academic and policy discourses on sustainability quickly converge around innovation. Why? Because the power of innovation is time tested: innovations have enabled seven billion of us to meet our existential needs and live longer than the people in any other period in recorded history. By defying Malthusian predictions of collapse, innovation has taken centre stage in the Western worldview to such an extent that it is often the foremost, if not the sole, source of hope for humanity as it faces a crisis. It is worth noting here that we are writing this chapter in the hope that the breakthrough vaccines against COVID-19 will end the pandemic and normalise our lives. In this technology-dominated or rather technology-defined period of human history, it is not surprising that we so heavily rely on technological innovations to resolve environmental problems, including climate change. What is surprising, however, is that despite over half-a-century-long experimentation with sustainability-oriented innovations, the state of the environment has only deteriorated. The reader will have heard countless times that climate change has now become an emergency. It is time to examine the disconnect between innovation and sustainability. This is the broad aim of this chapter.

Innovation is defined in myriad ways. Here, we refer to innovation as new products, processes, and businesses systems, including new business models and new value creation systems. Innovation is typically viewed as a tool for economic growth and so it underpins unrestricted material consumption. As long as this expansionist paradigm prevails, profitability-oriented companies will innovate to encourage us to consume more so that they can generate higher profits (see Chapter 12). This paradigm needs scrutiny – and disciplining – as the unsustainability of

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our production and consumption systems becomes increasingly obvious and their perilous effects on planetary boundaries become scientifically validated.

We facilitate this scrutiny in this chapter. Fundamentally, our contention is that, while innovation is typically considered a firm-level phenomenon, a complex multi-layered system actually governs the ultimate effectiveness of innovations in addressing sustainability concerns (Geels, 2018). The dynamic between firm-level innovation activities and system-level environmental outcomes results from complex interactions among multiple technical, social, political, economic, ecological, and interactional actors (Smith et al., 2005). In other words, the professed power of technological innovations to solve societal and environmental problems is curtailed by a host of non-technical factors over which an individual firm – or even a collective of firms – does not have much control. The dominant thinking, that innovations can lead to desired environmental outcomes, appears to assume that environmental problems are contained within a small homogenous geography, economic systems are localised or selectively global, political will is focused on problem solving, and human behaviour is not rationally bounded. In other words, the notion that innovation can address environmental problems makes numerous unrealistic assumptions, which must be illuminated. In the rest of this chapter, we clarify the disconnect between sustainability-oriented innovations and sustainability, identify the underlying hurdles, and propose a way forward.

2 The Labyrinth of Innovation-Driven Sustainability

There are numerous building blocks and obstacles between the emergence of an innovation and the macro-outcome of sustainability. In his widely acknowledged conceptualisation, Geels (2018) captured the multi-layered turns and dead-ends of this complex journey in what he calls a *socio-technical transition* (see Chapter 6). Geels argues that the process of large-scale transitions can be decomposed into three mutually related but hierarchically distinct phenomena: socio-technical landscape, socio-technical regime, and niche-level innovations. The *socio-technical landscape* is the bedrock on which innovations rest and is shaped by both slow-changing trends (e.g., demographics, geopolitics) and exogenous shocks (e.g., wars, economic crises, major events). A changed landscape requires compensatory interventions to maintain landscape stability. The onset of COVID-19 is an illustrative example of how changes in the socio-technical landscape necessitate innovation; in this case, the development of a vaccine. A vaccine is a *niche-level* innovation that involves activities of individual firms (or entrepreneurs). For niche-level innovations to function as a landscape-level intervention, they must pass through the *socio-technical regime*. The regime comprises numerous actors (e.g., consumers, regulators) and their actions (consumer willingness to change behaviour, regulators enacting conducive policies) – essentially an infrastructure of actors that exist in alignment (or not) with each other. Geels (2018) does not explicitly state so, but essentially the socio-technical regime is a market-level phenomenon and the alignment is essentially what

economists would call a well-functioning market, which has suppliers, buyers, and intermediary entities to facilitate transactions between the two. Project Warp Speed, the Centers for Disease Control, the healthcare system, and the public are all elements that coalesce to form the socio-technical regime (US context). With this as a backdrop, illustrating that innovations and broader societal outcomes are tied within a complex milieu, we now turn to explain the disconnection between sustainability-oriented innovations and sustainability.

3 A Tripartite Framework of the Disconnect Between Innovation and Sustainability

Here, we use a tripartite conceptualisation (Figure 11.1) to depict three settings in which innovations struggle. Our contention is that these settings act similarly to a multi-layered barricade restraining firm-level innovations from realising macro-level sustainability outcomes. Myriad challenges face an innovation on its journey from idea to adoption/use. We call these firm-level hurdles, system-level hurdles, and the system-sustainability chasm.

3.1 Firm-Level Hurdles

3.1.1 Shareholder Orientation

Despite the prominence that stakeholder management has gained in the business lexicon over several decades, most firms' primary guiding philosophy remains shareholder-centric. The prominence of shareholder centralism is so deeply entrenched in corporate thinking that sustainability is embraced to the extent that it is aligned with shareholder interests. In some cases, striking this 'win–win' is possible, but often, sustainability and business benefits pose trade-offs, which firms almost invariably settle in favour of financial considerations. In the literature, multiple compelling arguments have claimed (e.g., Pinkse and Kolk, 2010; Barnett, 2019) that a win–win focused stakeholder orientation in fact prioritises the firm, but not society or the environment. Societal and environmental interests are, at best optimised, but optimisation occurs within such a large, complex set of constraints that very few firms are able to strike a meaningful balance between producing environmental good and making financial gains.

Consider this: our instances of environmentally exemplar companies have remained more or less the same for the last two decades. As educators in the field, we are constantly searching for more examples to share with students about how companies can strike a win–win. We are rarely able to go beyond the Patagonias and Interfaces of the world. Every time we hear of their innovative practices (which have been an ongoing saga for the 20 years), we feel like screaming. How can one ignore the fact that most business sectors usually only have one or two environmentally sound companies, while we have been thumping our chests about mainstreaming stakeholder orientation? Is this extremely niche

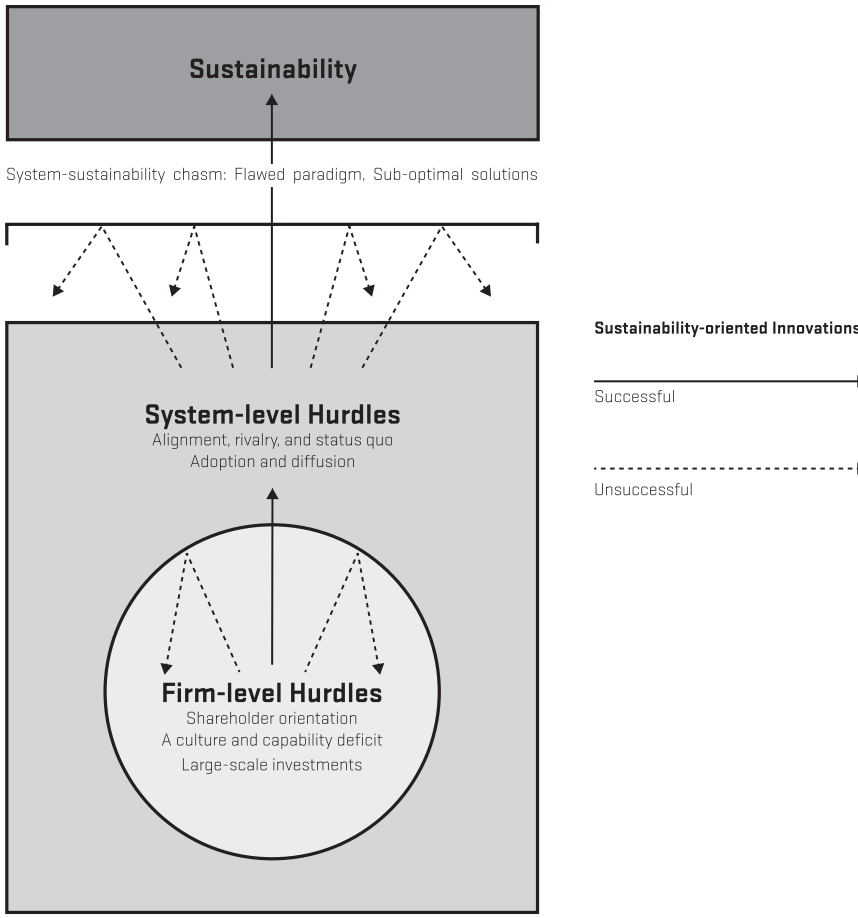

FIGURE 11.1 Tripartite framework of disconnect between innovation and sustainability.

phenomenon really mainstreaming? How long can we afford to celebrate the best without truly moving the rest; how long can we remain wishful? Panwar et al. (2017) claimed that the win–win argument was an academic necessity in the 1970s, to shield corporate sustainability/social responsibility from the brutal arsenal of Friedman and his ardent coterie. Now, win–win is a liability; it prevents us from seeing things as they really are. Escaping its clutches is an absolute necessity.

Given that the prioritisation of profitability is essential for firms operating within capitalist economic systems (which now also dominate traditionally socialistic societies), the firm-level win–win paradox can only be overcome through changes in structural and governance architectures that can buffer firms against their primary duties to shareholders (see Chapters 12 and 13). B Corps (https://bcorporation.net/), for example, could be one alternative, but

their slow growth makes us apprehensive about the veracity of the claim that they can supplant traditional corporations. Despite growth in recent years, B Corps still remains restricted to a narrow niche. In any case, we need to recognise the smokescreen of stakeholderism: because it is no more than a disguised shareholderism. In their acerbic critique, Doane and Abasta-Vilaplana (2005) described this smokescreening as charming the corporate psychopath. The point is that shareholder orientation often reigns over stakeholder orientation, and for most companies this is a fundamental barrier to pursuing sustainability-oriented innovations. As a way forward, we need new forms of organisations that have higher degrees of freedom to prioritise sustainability.

3.1.2 A Culture and Capability Deficit

The strategic management literature has explored many theoretical approaches to explain why some firms are more competitive than others. Dynamic capabilities, being able to adapt, orchestrate, and innovate (Teece, 2014), are especially relevant in our context. A full exploration of dynamic capabilities is not possible here, but two cultural characteristics of a firm may be especially relevant for formulating sustainability-oriented innovations, innovativeness, and collaborative(ness).

An innovative firm possesses a strong propensity to create and/or adopt new products, processes, or business systems. Innovativeness can characterise entire industry sectors: software is seen as inherently innovative, whereas the forest sector, in contrast, is seen as traditional, conservative, and risk averse (Guerrero and Hansen, 2020); in other words, suffering from an innovativeness deficit. This is important, because innovativeness leads to successful innovation as well as social, environmental, and economic performance (Kuzma et al., 2020).

Like innovativeness, the inclination to collaborate is also a cultural phenomenon. Effective sustainability-oriented innovation may require rethinking competition and collaboration among the actors involved in evolving innovation networks (Boons and Lüdeke-Freund, 2013). The agency and behaviour of actors and their interactions and relationships have been an emerging area of sustainability-oriented innovation literature (Avelino et al., 2016; Savaget et al., 2019). Sustainability-oriented innovations are inherently complex and require multiple bodies of knowledge, something that may only be accomplished via collaboration across industry sectors, in order to obtain the diversified expertise and knowledge necessary for success.

Collaboration between large and small players sharing complementary resources and knowledge helps develop entire value networks (Geels, 2014). Small firms may, for example, lack the resources to push their products or services in the markets and benefit from a large firm's supplier and customer networks, financial assets, and interdisciplinary knowhow. Biotechnology and other rapidly changing fields are particularly attractive for developing entrepreneurial partnerships between large and small companies and we can see this in the bioeconomy

transition; for example, in Metsä Fibre's Äänekoski bioproducts mill in Finland, where small firms are co-located and rely on the mill for supply.

To produce the volume of sustainability-oriented innovations necessary to move the sustainability needle requires firms across the economy to develop more innovative and collaborative cultures. Centuries of effort have honed the skills and tools necessary for effective competition. However, what remains highly underdeveloped are the skills and tools necessary to collaborate, an ingredient essential for creating next-generation innovations that benefit environmental sustainability.

3.1.3 Large-Scale Investments

Innovation requires significant capital investments, which are not easy to obtain given the fact that the majority of new products introduced to the market are ill-fated. The failure rate depends on the industry and the nature of the product or service, but in some cases it can be as high as 90% of all newly introduced products (Christensen et al., 2005). Thus, to develop a large enough number of sustainability-oriented innovations – whether related to products or processes – which are ultimately accepted in the market requires a tsunami of innovations, given the very high degree of pre-market mortality. This clearly entails colossal risk capital which in today's economically constrained and volatile times remains a major challenge in most countries.

Innovation projects can be financed through external sources (e.g., debt, grants, crowd sourcing) or internal sources, which mainly consist of retained profits or (new) equity (Hottenrott and Peters, 2012). The intangible nature of innovation projects renders them more costly for external financing than alternative projects (Alderson and Betker, 1996). Hence, raising capital for innovation projects becomes even more difficult for a company: investments are risky due to high rates of failure, and investments are more costly. Moreover, innovation projects often have considerably long gestation periods, which means that returns are not immediate and hence internal investments in innovation projects may cause short-term cash flow problems (Hall, 2002). What is a rather ironic situation is that companies with higher innovativeness face greater fundraising challenges (Hottenrott and Peters, 2012), which makes innovation a rarer occurrence than we need to be able to make a dent in environmental degradation.

A key proposal, then, is to strengthen private and public financing programmes to foster sustainability-oriented innovations. Cecere et al. (2020) argue that focusing on small and medium-sized enterprises through public financing can provide the needed impetus. Channelling green finance through public lending programmes to small companies in developing and the least developed countries is important. More importantly, such finance should prioritise innovations leading to business model changes rather than bolt-on sustainability initiatives that tend to wither away during financially volatile periods (Panwar et al., 2015).

3.2 System-Level Hurdles

3.2.1 Misalignment, Rivalry, and Status Quo

Beyond firm borders, sustainability-oriented innovation faces a complex system of actors and interactions. Perhaps the most immediate challenge comes from competing firms (inter-firm rivalry). Incumbent firms, of course, defend their position in the marketplace against start-up innovations and can squash sustainability-oriented innovations before they even get off the ground. Large firms that are heavily invested in a particular product and its manufacturing systems are partially locked into a pathway of continuation (path dependency). Kodak's failure to react to developments in digital photography is a good example of the results of path dependency. Traditional steel companies with large, integrated mills, in turn, were slow to react to the introduction of mini-mills (Verespej, 2004), a different, small-scale production technology.

In addition to inter-firm rivalry, a host of other system actors impact the viability of an innovation. Regulations and codes, for example, can be key hurdles and are typically slow to change. North American building codes have been a key impediment to the adoption of mass timber in multi-storey buildings. Code changes take place at a glacial pace and vested interests often fight against change. The inclusion of multi-storey wooden buildings in building codes was clearly not embraced by, for example, the cement industry. While the above examples are only a sampling of the actors and dynamics in the complex system, they illustrate the labyrinth that innovations must successfully navigate from the domain of the firm to market acceptance. It is only when the right set of actors is aligned correctly that an innovation can successfully break through to market success.

3.2.2 Adoption and Diffusion

Final consumers are the ultimate arbiters for the destiny of many products. As most humans are averse to change, this creates long time lags between the introduction of an innovation and eventual large-scale adoption. Complex interdependencies underlie the process of innovation diffusion, including key factors influencing how innovations are taken up in the marketplace. Early sustainability-oriented innovations in consumer goods, such as household cleaning products based on 'natural' ingredients, often performed poorly compared to their chemically based cousins. Lacking a relative advantage, they were relegated to a small market segment of especially environmentally oriented consumers. The adoption of electric vehicles (EVs) is constrained on multiple fronts. First, high cost means they are accessible to only an extremely thin slice of society. Beyond this, they are not compatible with the existing, petroleum-based infrastructure. Limited range and recharging station availability hinder larger-scale adoption.

Even in an ideal situation, with an attractive innovation and close compatibility with existing systems, innovations take time to diffuse into the marketplace.

In terms of sustainability-oriented innovations, this means that positive environmental contributions remain unrealised. In a world where the metrics of environmental degradations are trending in the wrong direction, we can ill afford slow diffusion of sustainability-oriented innovations.

3.3 The System-Sustainability Chasm

Unfortunately, humans desire 'stuff'. Society and economies rest on a flawed foundation of ever-increasing consumption. Beyond the firm and the system are macro phenomena that impact sustainability-oriented innovation and may thus mitigate contributions to greater sustainability. At its more fundamental level, the challenge to sustainability rests on these disconnects.

3.3.1 Flawed Paradigm

The foundations of our economic systems are tied to continuous, unlimited growth. The primary macro measures of the health of an economy are gross domestic product (GDP) and GDP growth. The shortcomings of GDP as a metric are numerous and well documented, as it 'ignores social costs, environmental impacts and income inequality' (Costanza et al., 2014, p. 283). A common management mantra refers to being able to manage only what is measured. As there is no simple measure of sustainability, it is often ignored or approached in an insufficiently holistic fashion.

A harsh reality facing sustainability efforts is the rapidly expanding global population, accompanied by advancing affluence. Global population growth and imitation of Western lifestyles and consumption levels by consumers in developing economies make sustainability outcomes practically unattainable. Innovation, combined with globalisation, makes new products universally available in the world and fuels consumerism. The European Commission (2019) estimates that middle-class spending will grow from about USD 37 trillion in 2017 to USD 64 trillion by 2030. The consumer paradigm of 'more is better' is eating away at the earth's resources. Busy lifestyles based on the availability of disposable 'take-away' products and services, faster cycles of fashion, and the shortening lifespans of products cause massive amounts of waste. Innovation is not sustainable if it fosters overconsumption. As we progress to an anticipated population of over ten billion in 2100 (UN, 2020) and the affluence of all people increases, the planetary deficit will multiply. In fact, it is claimed that current levels of resource consumption require 1.77 planet earths (The World Counts, 2020).

3.3.2 Sub-Optimal Solutions

An often ignored yet important disconnect between innovation and sustainability is the unintended consequences of technology and the rebound effect, in which increased eco-efficiency translates into greater consumption (Herring and

Sorrell, 2009). It must also be recognised that efficiency is generally a strategy for cost reduction rather than an idealistic philosophy of conserving resources (York and McGee, 2015). Sustainability gains from technological improvements are often cancelled out by distortions in human behaviour. For example, automobile fuel efficiency gains tend to be nullified by increased driving. This phenomenon (Jevon's Paradox) is said to be the result of price reductions, in this case making fuel and driving less expensive. Closer examination of the phenomenon reveals it to be multifaceted, with both direct and indirect effects increasing resource use (York and McGee, 2015).

Solar and wind energy are changing the global energy sector, providing distinct environmental benefits. However, these energy sources also have negative impacts. Sulphur hexafluoride is a synthetic gas used in electrical installations. It is nearly 24,000 times as warming as carbon dioxide and persists in the atmosphere for at least 1,000 years. Unfortunately, power grids that facilitate the distribution of solar- and wind-generated electricity also leak sulphur hexafluoride (BBC, 2019). Therefore, the very technology designed to combat global warming is in effect contributing to the problem. Added to this are other environmental impacts such as the production of solar panels and their end-of-life disposal, whether through dumping, recycling or refurbishing. We are not suggesting that wind and solar power are worse for the environment than fossil-based energy; we are merely pointing out that sustainability-oriented innovations are riddled with inherent limitations of their own which can generate problems that must be monitored. At the minimum, it is important to recognise the likelihood of a considerable gap between the stated and realised potential of a given technological breakthrough in addressing a given environmental problem.

Consider the example of EVs that are often touted as a solution to excessive emissions caused by an ever-growing automobile sector. EVs are also mired in unintended consequences: although battery-driven EVs help in cutting carbon emissions, several studies show that battery production and disposal processes result in increased soil toxicity. We are essentially playing 'whack-a-mole' with sustainability solutions (Cashore et al., 2019), as we address one problem only to find out that another has raised its head (see also Chapter 8).

In addition to such unintended consequences, technological advances also produce undesirable social implications, which may translate into environmental degradation. First, technological breakthroughs produce goods and services that can be accessed by privileged countries or sections of society, at least in the early phases. One of the co-authors has seen more Teslas parked outside a few dozen houses on Marine Drive in Point Grey, Vancouver than in the entire city of New Delhi. When anecdotes speak, they speak loudly. The haves and the have-nots that technological breakthroughs produce in the world is a critical divide. As long as there is a Sweden and there is a Somalia, technological solutions will continue to provide benefits that only a portion of the humanity will derive. Prahalad (2012), we feel, was a bit too enthused in seeing the *fortune at the bottom*

of the pyramid. When it comes to the distribution of the gains of environmentally friendly technologies, we see more *misfortune*. The world, as it is!

Reliance on innovation and technology is essentially rooted in Robert Solow's paradigm that sees resource exhaustion as an opportunity for innovation-based growth, not a catastrophe. It pushes to the margin the constraint-based philosophy that Malthus advanced through his scholarly work and has formed the very basis of life in many Eastern societies, among Indigenous People in particular. The domination of the Western worldview, which underpins the *technology-as-panacea* philosophy has led to an expansionist paradigm that all problems can be resolved through human ingenuity and innovations. At times, this has proven to be the case, but environmental problems are wicked problems which, we believe, require a trans-paradigmatic therapy that combines elements from collective human wisdom developed here and there, and beyond here and there.

4 How Can the Promise of Sustainability-Oriented Innovations Be Realised?

It should be clear at this point that sustainability-oriented innovation is complicated. Many actors play a role in successful innovation. In the case of sustainability-oriented innovations, especially influential actors are policymakers, firms, and consumers. We address the potential roles of each below, while acknowledging that myriad other actors are involved.

4.1 Innovation-Friendly Policies

Policymakers have many touchpoints in a complex system of carrots and sticks. In an intricate network of interactions among actors, it is essential that policy considers the bigger picture. For example, systems-level competition rather than materials competition is likely to provide more optimal sustainability solutions.

Thoughtful and effective legislation is required to move society towards improved sustainability. Legislation may be more effective when developed in concert with other key actors, such as firms. Columbia Forest Products, a major producer of hardwood plywood in the US, worked with the California Air Resources Board to adjust standards for allowable VOC (volatile organic compound) off-gassing from wood panel products destined for indoor environments. This corresponded to an innovation in adhesives technology that allowed Columbia to meet the standard, thus benefitting the firm as well as the air quality in the built environment. Legislation that impacts consumer behaviour is equally important. If consumers are forced to pay the full price, including externalities, this will have a concrete impact on purchase decisions. It is this idea that motivates carbon tax advocates. Mechanisms exist to convert efficiency improvement into conservation instead of increased production and consumption, such as taxes on natural resources (York and McGee, 2015).

Equally important are incentives that drive both firms and consumers towards sustainability-oriented innovations, incentives safe from unintended consequences. Government procurement policies are the low-hanging fruit in this realm. The EU's Green Public Procurement programme is an example of this, and most EU Member States have a National Action Plan associated with Green Public Procurement. Companies should participate in policymaking, such as establishing procurement rules and protocols. The approach should utilise a holistic, systems-level mentality, creating designs that benefit society first and their own operations second.

Policymakers also play a key role in education systems. Appropriate education, at all levels, is needed not only for the average citizen in terms of intelligent consumption, but sustainability-savvy managers, government servants, and other professionals are required across the economy. This suggests a deeper and broader coverage of the topic 'from the cradle to the grave'. Children influence purchase decisions by their parents, so early education is needed. As sustainability issues and knowledge are constantly evolving, lifelong learning is critical.

Although this chapter has been critical of the sustainability performance of innovation, we acknowledge that more (not less), and better innovation is needed. Accordingly, policymakers must make wise investments in science and in research and development. Investments are needed across the board to improve sustainability, but there is a special need for more holistic systems for quantifying environmental impact, enabling comparisons across systems and approaches. As recent research shows, the Scope 3 carbon impacts of a company can represent the vast majority of a firm's overall impact (Panwar, 2020). Accordingly, tools such as life-cycle analysis based on a limited cradle-to-gate approach provide an exceptionally narrow picture of system impacts. Given these unintended consequences and this narrowness, we have a long way to go before arriving at a more holistic understanding of our actions. In a similar vein, improved approaches are need for understanding and then influencing consumer purchase decisions.

Visionary public procurement policies have great potential for driving sustainability-oriented innovations (Pellegrino and Savona, 2017). British Columbia's 'Wood First' policy requires consideration of wood products in government building projects. The US established the BioPreferred® Programme in 2002 and reauthorised it in 2018, with the goal of increasing the use of renewable materials. Transparency and labelling efforts influence consumer demand, such as the ENERGY STAR® programme that facilitates informed purchasing by appliance consumers via easy-to-understand labelling depicting energy use. The Tesla story in Norway shows what reduced taxes and other perks such as avoidance of road tolls and congestion charges can do for adoption in the marketplace.

4.2 More Capable Firms

It has long been argued that the primary reason for the existence of a firm is to increase profits for shareholders (Friedman, 1970). Clearly, a firm must be

profitable before it can invest in sustainability-oriented innovations. A modern view of the firm suggests it has a broader set of responsibilities to a wide set of stakeholders, and a responsibility for strong environmental performance. As previously emphasised, more, not less innovation is needed – and better innovation. Fundamentally, most firms need to be better at innovating. Innovative companies tend to be more competitive, which places them in a position to make more meaningful contributions to sustainability.

Firms must carefully consider the environmental impacts of an innovation as well as its profit potential. The unintended consequences of well-intentioned actions are too significant to ignore. In reality, firms require enhanced assessment tools in order to properly estimate the environmental impacts of their designs. It is important that companies instil cultures that are not only consistently and systematically sustainability oriented, but which are also watchful of the sustainability impacts that innovations can and cannot produce.

Firms should become more adept at managing consumer demand. Much remains to be learned about why and how consumers' behaviour can be aligned with sustainable consumption. Breaking free of incumbent firms, industries, and systems is not a trivial task, and innovation fails to promote sustainability if it does not serve the needs and practices of consumers. Alternative approaches, such as sufficiency/sharing economy innovations may provide preventive mechanisms to consumption, yet their ultimate sustainability contribution remains largely untested (e.g., Bocken and Short, 2016; Curtis and Mont, 2020). Recent evidence suggests that sharing economy approaches increase overall consumption (Laukkanen and Tura, 2020) as they evolve towards the separation of users and producers and more 'professional' business models which then translate into an increased focus on consumption (Geissinger et al., 2019). Consumption practices and innovations are co-dependent, meaning businesses must renew themselves along with changing consumer practices (McMeekin and Southerton, 2012).

4.3 Intelligent Consumption Required

As purchasing behaviour drives supply chain decisions, it can be said that consumers have the ultimate currency in sustainability progress. Intelligent consumption is a necessary ingredient for future sustainability, yet the authors are not overly optimistic. Given how society is susceptible to consuming misinformation, believing conspiracy theories, and thus engaging in outright idiocy, as became evident in the US for much of 2020 and the beginning of 2021, it is naive to assume that there is a critical mass of consumers who are informed and conscientious enough to make planet-friendly purchase decisions. Regardless of its currency in literature, ultimately, conscious consumerism is a niche phenomenon. Still, the importance of guiding consumers towards more meaningful involvement in environmentally friendly purchasing is undeniable. Environmental non-governmental organisations (ENGO) play a major role in increasing consumer awareness and driving sustainability-oriented innovation through

pressuring corporations to change practices. Greenpeace has a long history and a deserved reputation for battling large corporations and at the same time promoting stories to final consumers. An ongoing palm oil campaign now claims that multiple companies that committed to stop buying from 'rainforest destroyers' have failed to keep their promise and are buying 'dirty palm oil' (Greenpeace, 2020). Of course, in order to make its supply chains more sustainable, a firm needs to adopt innovative technologies and practices (Murcia et al., 2020).

As emphasised above, it is critical that policymakers and firms help lead consumers in the right direction. However, evidence suggests that the exact opposite is the norm – policies encourage green consumerism rather than address the structural changes needed to truly address sustainability (Akenji, 2014). Ultimately, individual consumers must take it upon themselves to become sufficiently informed to make sustainability-oriented decisions. This includes both less and smarter consumption. Consumers must play a larger role for sustainability to become reality (Martek et al., 2019). They must be engaged in innovation processes to integrate more sustainable products and services into everyday practices (Köhler et al., 2019). Similarly, involvement in policy creation can help build policy portfolios with greater consumer participation and greater impact.

Given the combined growth of population and affluence, intelligent consumption is unlikely to be sufficient. It is not just about consuming more smartly, it is also about consuming less. Ironically, approaches such as green consumerism may fuel consumption. If a product is 'green' then consumers feel freer to consume than they perhaps otherwise might. Various studies and organisations have segmented consumers based on their 'greenness'. A small segment of consumers have true green attitudes. Unfortunately, this segment also tends to be the most affluent, with a larger consuming profile. It is entirely possible that the overall environmental impact of the average 'brown' consumer is less than the average 'green' consumer. Often the most environmentally friendly action may be to simply use an existing product, even one not so environmentally friendly (old automobile), rather than purchasing something new with its associated resource requirements. A rather informative adage often circulates in the green building community: *the greenest building is the one that already exists*. The 'brown' consumer driving the same gas guzzler for a decade may possibly do less damage to the environment than the 'green' consumer who purchases three different environmentally friendly models in the same period.

5 Conclusions

Innovation has proven to be an effective approach to resolving numerous problems, yet it has so far been utterly ineffective in holistically addressing the environmental crisis. This chapter argued that the path from sustainability-oriented innovations to sustainability is not seamless, but riddled with complex dependencies and contingencies. Sustainability entails system-level changes on a global scale, which, we argue, are unattainable if we focus on innovations alone.

For a secure and sustainable future, it is critical that we shake the expansionist paradigm. To do so, it would be important to give up the deeply held assumption that we can simply innovate our way out of pending environmental disasters. Work on sustainability-oriented innovations has evolved from a focus primarily on individual technologies or products to entire production and consumption systems. This evolution must continue, but more quickly. Meaningful advances in sustainability require multiple actors working in concert to destabilise existing regimes, moving towards more sustainable ways of living. Collective problems, without a central redressal authority, require an 'all-feasible-tools' and 'all-hands-on-deck' approach. There is no single solution, and there is certainly no easy solution. Critical analyses are needed to develop a finer-grained understanding of the potential and the limits of innovation. Answers to questions such as when, how, to what degree, and under what conditions can innovation help the environment are important; as are the answers to questions such as how and when can innovation actually hurt the pursuit of sustainability, and which alternative approaches would be more suitable. Taking an inclusive approach is important: there is much to be learned from Indigenous communities and Eastern civilisation to make the planet more sustainable. Innovation certainly has a place in the transition to sustainability, but it is not a panacea.

George Bernard Shaw was not referring to innovations when he said 'there are two tragedies in life. One is to lose your heart's desire. The other is to gain it'. But if he had been, he would have been right. Sustainability-oriented innovations abound, but sustainability continues to elude us. Here is our final message: innovations need to be gauged against impact, not simply their promise. If they are not impactful on a global level, which is evident, alternative approaches must be explored. We must stop giving technological innovations undue glorification as the solution for achieving sustainability.

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