9

Niche–Regime Interactions

Post-Automation in the Fourth Industrial Revolution

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9.1 Introduction

Niches provide 'protective space' for people and organisations to innovate more radically compared to incremental innovation typical in socio-technical regimes (Chapter 5; see also Kemp, Schot, & Hoogma, 1998; Smith & Raven, 2012). Niches foster experiments using diverse organisational forms and novel technological arrangements that typically seek to be path-breaking. Indeed, experiments often pursue alternative norms or rules for what it means to be sustainable. Sustainability in regimes, for example, is seen synonymously with green growth to be pursued through ecological modernisation and eco-efficiency. Path-breaking innovations in niches can be informed by radically different visions for sustainability. Experiments might, for example, emphasise post-growth ideas for human well-being and ecological flourishing instead of endlessly increasing production and consumption (Fitzpatrick, 2022; Pansera & Fressoli, 2021).

Niche–regime interactions are a key process in sustainability transitions: interactions lead to a reconfigured structure and operations in the regime (Chapter 2). In this chapter, niche–regime interaction is defined as those processes by which enduring relationships are built between path-breaking niche spaces and incumbent socio-technical regimes. Interactions can include alignments, exchanges and conflicts between niches and regimes and can result in changes to one or the other or both. Differences between conceptions of sustainability in niches and regimes will affect the way they interact. Differences can build tensions as well as synergies into the kinds of interaction that arise as a result. Research into niche–regime interaction is vital for understanding reconfiguration processes and the kinds of sustainability realised (Smith, 2007).

Niche–regime interactions are illustrated in this chapter with an example that contrasts sustainability strategies in the automation regime of the Fourth Industrial Revolution (4IR), with a niche space that we call post-automation. The latter subverts ostensibly automating technologies for purposes radically different to the

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rules of the regime. Where sustainability under the automation regime follows green growth rules for renewing capital accumulation, boosting labour productivity, and enhancing managerial control in production and consumption, experiments in the post-automation niche spaces practice diverse kinds of sustainability through technological activity based in creativity, care and conviviality.

Section 9.2 provides a short review of key themes in niche–regime interaction. Interactions are illustrated for the post-automation case in section three. Section four considers debates about appropriate analytical perspectives and policy approaches towards niche–regime interactions. Section five concludes with observations relevant for further research.

9.2 Historical and Thematic Development

The multi-level perspective on sustainability transitions conceives potentially path-breaking innovation originating in niche spaces (Chapter 5). Opportunities open for niche innovations to scale-up and exert wider influence whenever and wherever regimes find themselves under concerted pressure to become more sustainable. Pressure arises through a combination of the regime's own ecological and social contradictions and developments in the wider landscape. Under such circumstances, niche innovations become more prominent and contribute to a socio-technical reconfiguration of the technologies, actors and institutions that constitute the structure and operation of regimes: a sustainability transition (see Chapter 2). Research into niche regime interaction tries to understand this reconfiguration process and improve strategies for niche development and influence (Smith, 2007).

In thinking about interaction, it is important to keep in mind the reason why the niche concept developed. It was intended to push the attention of innovation studies and policy beyond the economic diffusion of cleaner technologies in conventional innovation systems, and move analysis into real-world experiments already exploring fundamentally different approaches to sustainability (Hoogma, Kemp, Schot, & Truffer, 2002). Niches were conceived as protective spaces where experimentation for sustainability could be both radical and diverse. The idea was to reframe analysis beyond the economic diffusion of cleaner technologies and study instead the development of path-breaking socio-technical configurations across an expanding network of experimentation (Rip & Kemp, 1998). The aim was that sociologically richer research would help unlock fundamentally genuinely transformative sustainability transitions (cf. incremental eco-efficiency in regimes) (Kemp et al., 1998).

Emphasising protective niche spaces was important for transitions because promising ecological and social initiatives tend to perform poorly relative to

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economic criteria institutionalised in regimes (Smith & Raven, 2012). Regimes consist of criteria for technological success whose historical evolution has had little concern for environmental sustainability and social justice. Regimes tend to lock out sustainability and instead lock in unsustainability. Today, as more regimes integrate environmental considerations into their operations, the challenge shifts to the form and depth of sustainability at stake (Section 9.3 and 9.4).

In strategic niche management, a degree of niche compatibility with regimes is recommended. Niche developments need to make sense and appear promising for those entrepreneurs, businesses, investors and policymakers in the regime open to green reforms. Niches must offer reasonable, sustainable solutions and be easy to interact with (Schot & Geels, 2008; Weber, Hoogman, Lane, & Schot, 1999). This poses a paradox for niche–regime interactions (Smith, 2006). Interaction will be easiest when there is already good alignment between niche and regime, but such alignment will by definition not demand very great changes in the regime. Conversely, more radical sustainability alternatives cannot develop beyond the protective niche space when their configurations place too many demands upon powerfully institutionalised regimes.

A key research question arises: how can niche spaces at radical odds with incumbent regimes interact with them productively and help induce deeper sustainability transitions? Empirical research into niche–regime interactions identifies four broad types of interaction that permit a more dynamic and nuanced way of understanding the reconfigurations involved in transitions (Meijer, Schipper, & Huijben, 2019; Mylan, Morris, Beech, & Geels, 2019; Smith, 2007; van Summeren, Wieczorek, Verbong, & Bombaerts, 2023). These four interactions help answer the key question above and are summarised below.

9.2.1 Interaction 1: Differentiation

Niches protect, nurture and empower experimentation in sustainability in ways that regimes either ignore or address only superficially. In other words, a founding interaction between niche and regime is one of opposition and differentiation. Niches try to do things in profoundly different ways and there is a clear aspiration to stretch and transform regimes in fundamental ways. Niches reject the regime ways of innovating and seek alternatives. Niche spaces contain antagonistic features in relation to regimes.

9.2.2 Interaction 2: Appropriation

Whilst niches are defined through differentiation, it is often the case that specific elements of their socio-technical configuring activities offer readily appropriable

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innovations for regimes. Those elements can be specific technological or organisational innovations that can be inserted into regimes without too much disruption. This involves processes for diffusing that innovation out of the supportive context of the niche and adapting and embedding it within the regime. A fit-and-conform dynamic dominates this interaction (Smith & Raven, 2012). The regime is more eco-efficient as a result, but is not fundamentally changed.

9.2.3 Interaction 3: Hybridisation

Hybridisation involves interactions that generate stretch-and-transform reconfiguration processes in the regime. Elements of the novel technologies, organisational forms and norms experimented with in niches are not simply appropriated into regimes but retain the capacity to alter some broader dimension of the regime in a quite fundamental way. A new technology design becomes dominant, for example, or the organisation of actors in the regime becomes more decentralised, say, or some regime rules are rewritten. Policy advocacy and intermediary support are important enablers of hybridisation (Chapter 20). Both serve as bridges between, on the one hand, adaptations to niche practices so that these can influence the regime which, and on the other hand, supports accommodating changes in the regime that makes it receptive to the niche innovation.

9.2.4 Interaction 4: Criticism

Even when hybridisation leads to regime transformation, the results can be disappointing when compared to niche aspirations. More radical experiments remain stuck in the niche space. However, this does not necessarily equate to a lack of interaction. Niche experiments can embody radical ideas, values and practices that are vital to the deeper politics of sustainability transitions (Smith, Hargreaves, Hielscher, Martiskainen, & Seyfang, 2016). Radical alternatives in niche spaces confront the compromises of hybridisation by maintaining radical difference and resisting co-option. Experiments are seen as demonstrative of the political and economic power relations that need changing (e.g. the way capital is invested, the ideology of the state, the quality of democracy), and thus experiments are emblematic anticipations of deeper sustainability transformations. Critical niches are important for keeping political and economic transformations in view and in debate.

Even this simple list of four interactions makes it difficult to talk about reconfiguration as a single process originating in niches and transforming regimes. Interactions take different forms, work in both directions simultaneously, and they are likely to have varying consequences.

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9.3 Empirical Application

We illustrate niche–regime interactions in the case of regime of automation and its role simultaneously as a key technology, organisational form and rule in the Fourth Industrial Revolution. Automation is also central to sustainability in this so-called revolution. After describing the automation regime and its contradictory approach to sustainability, the post-automation niche space is introduced, and four niche–regime interactions are illustrated. We refer readers to Smith and Fressoli (2021) for full analysis and references.

9.3.1 Automating Sustainability

The automation regime is an important enabler of sustainability in the Fourth Industrial Revolution. As Klaus Schwab, Executive Chairman of the World Economic Forum puts it:

> The fourth industrial revolution creates a world in which physical and virtual systems of manufacturing globally co-operate with each other in a flexible way. This enables the absolute customization of products and the creation of new operating models. The fourth industrial revolution, however, is not only about smart and connected machines and systems. Its scope is much wider. Occurring simultaneously are waves of further breakthroughs in areas ranging from gene sequencing to nanotechnology, from renewables to quantum computing. It is the fusion of these technologies and their interaction across physical, digital and biological domains that make the fourth industrial revolution fundamentally different from previous revolutions. (Schwab, 2017, pp. 7–8)

Management consultants, research institutes, governments, investors, industrialists and politicians argue that advanced deployments of cloud computing, the Internet of Things, robotics, 3D printing, big data, machine learning, synthetic biology, and smart materials will enable the automated control over sustainable systems of production and consumption. This activity constitutes the automation regime and its sustainability. A proponent of an earlier wave of automation provided a useful definition that is still relevant:

> A concept through which a machine-system is caused to operate with maximum efficiency by means of adequate measurement, observation, and control of its behaviour. It involves a detailed and continuous knowledge of the functioning of the system, so that the best corrective actions can be applied immediately when they become necessary. Automation in this true sense is brought to full fruition only through a thorough exploitation of its three major elements, communication, computation, and control – the three 'C's. (Bagrit, 1966, p. 14)

The automation regime today encompasses vastly more complex systems. The kinds of feedback and interactions are more sophisticated, and the scope of application is more ambitious. Automation spreads beyond established workplace and

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household settings and is applied to the control of urban systems, farming and food, health services, energy grids, policing and warfare, mobility and logistics, social welfare and public affairs.

Sustainability will be achieved through the automated engineering insertion of the environment into cyber-physical systems of production and consumption. The integration of computation into physical processes in real time is being developed through the widespread use of embedded sensors and control exerted over digital platforms and data centres. Environmental sustainability is seen in terms of an automation regime that uses natural resources, controls waste sinks and manages ecosystem services efficiently and productively within these systems (Dauvergne, 2020).

Political leadership, institutional power and economic investment is committed to the automation regime. Everyone and everything are expected to integrate and conform to the new cyber-physical systems. The way the technologies of automation are deployed and actors organised is framed by the promise and drivers of the Fourth Industrial Revolution, which is capitalism's fundamental need for renewed capital accumulation, increased labour productivity and enhanced managerial control for green growth. And yet, empirical analysis of the automation regime questions the wisdom of this pathway to sustainability.

9.3.2 Automated Unsustainability

There are deep uncertainties and widely debated concerns about the social impact of automation – notably its consequences for employment, equality and inclusion. Automation has already taken jobs, stoked divisions and undermined communities. However, the precise picture is much more complicated. Empirical analysis finds firms can, for example, find it easier and more profitable to deploy the 3Cs for micro-managing workers and intensifying human tasks. Labour becomes controlled like robots rather than being replaced by robots. Even within automated systems, their smooth operation requires human operatives undertaking 'ghost work' (usually exploitative), such as cleaning data, training algorithms, overseeing platforms, and tending to uncertain interfaces with society. In contrast to the workerless factories, fields, infrastructures and even cities promoted by management consultants, automation has historically led to the emergence of new classes of human tasks and occupations. However, even the higher-skilled jobs can be alienating, undignified and increasingly precarious (cf. Sustainable Development Goal Eight).

In terms of environmental sustainability, it is questionable whether and how the improved efficiency and controls afforded by cyber-physical systems will offset the resources and contamination required to build the automation regime and its seemingly limitless expansion of production. Observations of the rebound effect in cleaner technologies beg questions about whether and how aggregate increases

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in production and consumption risks outstripping the relative eco-efficiencies of individual system components. Moreover, escalating upgrades typical in digital systems can draw into ever faster cycles of obsolescence the material components of cyber-physical systems. Green growth, upon which the automation regime is founded, shows few signs globally of decoupling economic growth from ecological collapse (Hickel & Kallis, 2020).

Faced with sustainability questions, advocates and investors of the Fourth Industrial Revolution redouble their automation strategies by extending controls further and deeper into ecological and social systems. Environments continue to be perceived instrumentally, as mixtures of raw materials, waste sinks, and ecosystem services. Complex and uncertain environments appear as objects within cyber-physical systems and over which managers have synoptic control. Similarly, people and societies are presumed to comply with the system behaviours envisaged by designers. Empirical research problematises these assumptions. Feminist research reminds us how automation's objectification of natures and people must eventually confront realities in which systems are only ever partially comprehensive of the situations in which they are entangled. The automation regime tries to objectify into its operations a diversity of sometimes troublesome and lively subjects. The automated race into the Fourth Industrial Revolution overwhelms reasonable questions about repair, care and sufficiency of systems towards these subjects. Why do sustainability transitions have to follow this path? Just how essential is automation for our futures?

9.3.3 A Post-Automation Niche Space

The post-automation niche is constituted globally by very different protagonists compared to the research organisations, venture capitalists, management consultancies, governments and businesses promoting the Fourth Industrial Revolution. Post-automation experiments are cultivated by hackers, citizen scientists, coders, free culture activists and artists, grassroots innovators, social entrepreneurs, and informal petty-producers occupying what sociologist Adam Arvidsson calls an industrious (cf. industrial) space (Allen & Potts, 2016; Arvidsson, 2019; Benkler, 2016; Smith, Fressoli, Abrol, Arond, & Ely, 2017). This space provides our example for niche–regime interactions. The niche uses ostensibly automating technologies in radically different organisational arrangements, and based on very different norms, compared to the regime.

9.3.3.1 Subverting the Foundations of Automation

In the post-automation niche, digital design and fabrication technologies (and other tools), arising originally in industrial automation, are used in pursuit of informal economic livelihoods, social activism, artistic work, community building,

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popular education, and simply for fun and recreation. Design software, digital fabrication, social marketing tools, code, online repositories and guides, video, computer numerical controlled machine tools, 3D printing, and so on, are all put to collaborative work by entrepreneurs, activists and artists. A commons of skills, know-how, tools, creativity, instructions, code, activism, designs and experiments is shared globally through online platforms. The creativity in this diverse activity is astonishing, but marginalised by industrial power. The label post-automation is applied in an attempt to make visible the collective significance of diverse experimentation in this niche space. Post-automation is used in a social theoretical sense of phenomena that unsettle foundational assumptions and grand historical narratives, such as the Fourth Industrial Revolution and the automation regime.

An emblematic post-automation phenomenon is the proliferation globally of hackerspaces, makerspaces and fablabs since the turn of the century. These community-based workshops open popular access to digital design and fabrication technologies, as well as traditional tools, and provide inclusive spaces for training and skills acquisition, as well as facilitating whatever creative initiatives participants wish to pursue. Emphasis rests in learning-by-doing and learning-through-collaboration. Workshops combine, for example, small-scale prototyping and manufacturing with wood-working facilities, spaces for ceramics and machines for sewing and fabrics, and in some cases, even studios for video and music production and labs for biohacking and citizen science. There is an ethos of peer-to-peer collaboration, sharing ideas, openness, design and knowledge as a common good. Whilst rooted in neighbourhoods and cities around the world, these workshops also network and collaborate internationally in shared online projects. Design global, manufacture local has become a guiding aspiration.

In some cases, workshops receive institutional support. Some libraries are reinventing themselves through the provision of makerspaces, enabling popular participation in twenty-first-century material culture in ways analogous to their historical role in mass participation in literary culture. Business development agencies invest in workshops as part of their commitments to cultivating entrepreneurship and start-ups. Schools and universities adopt workshops as new forms of pedagogy, research and training. Even large corporations have opened workshops as part of their strategies for open innovation.

However, it is important to remember that underlying all this activity are radically different norms for organising ostensibly automating technologies. A striking difference with the automation regime, for example, is the commitment to commons-based approaches to technology in direct confrontation with the intellectual property that remains central to the Fourth Industrial Revolution. Another contrast is the emphasis upon creative openness and widespread participation. Post-automation is driven by human creativity, collaboration, and care for a people-centred material culture.

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9.3.3.2 Post-Automation and Sustainability

Whilst sustainability is not inherent to the post-automation, it nevertheless is of considerable interest to many niche participants. Examples include:

- Prototyping sustainable designs and systems for a wide variety of goods and services from cargo bikes to urban food
- Popularising issues of sustainable energy through hacking solar panels and building DIY smart energy systems
- Incubating upcycling businesses, for example in furniture and clothing, and creating local hubs for closed loop materials use
- Hosting Repair Cafés and Restart Parties that empower people to fix and maintain their devices and explore what a less wasteful, more caring material culture could mean in practice
- Critical making projects whose activities reveal the political and economic issues behind the artefacts they consume, such as product tear downs or speculative prototyping that explores alternative futures
- Citizen science initiatives using open hardware and operated by communities
- Hosting workshops and events that make visible a global commons of sustainable design know-how and the sustainability possibilities of local production and technological sufficiency
- Running technology outreach activities locally that connect with sustainability groups, and encounters that mobilise new thinking and action about innovation, sustainability and people
- Cultivating post-consumer subjectivities, social innovations and new material cultures through tool libraries and the above activities.

Different kinds of sustainability possibilities open up through such experiments. Technology and sustainability are seen differently compared to sustainability in the automation regime. Where the automation regime emphasises computation, communication and control as techniques for controlling and exploiting environments for green growth, post-automation innovations rest in well-being and care that put is values closer to those in post-growth (Pansera & Fressoli, 2021).

9.3.4 Niche–Regime Interactions

How can a marginal post-automation niche space, radically different to automation in conception and practice, interact with such a powerful regime? What kinds of transformations might emerge, and with what implications for sustainability transitions?

9.3.4.1 Differentiation

Participants in the post-automation niche feel less compelled to follow the rules of the automation regime, and are less compelled to use technology to accumulate,

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control and produce. Niche participants are freer to build innovations on a radically different basis, including for sustainability. This is most pronounced amongst hacking and free culture activists in the niche space, but even informal entrepreneurs and petty producers follow a technological ethic based in norms of collaboration, creativity and care that is self-consciously not the automation regime. Participants make use of hacks shared online and open discussion fora; they collaborate and contribute to a vast technological commons. One must not romanticise this situation. Niche participation and niche initiatives are often precarious and involve struggle. Differentiation (and exclusion) from the regime rules out access to even a fraction of the economic investment and political will committed to the automation regime.

9.3.4.2 Appropriation

Despite these differences, some niche innovations arising from difference are appropriable by the regime (notably prototype designs and organisational innovations). The popularisation of entry-level 3D printers is one example. An initiative started amongst commons-based peer-producers in 2005 is RepRap. A global network of participants has developed open-source 3D printers and their uses in prototyping and decentralised manufacture. A fundamental idea is that each RepRap printer can manufacture (and adapt) further printers (RepRap is a contraction of self-replicating rapid prototyping machine). Consistent with principles of commons-based peer-production (in free software and open hardware), users are free to make use of designs so long as they similarly share their own modifications. As a result, the RepRap has evolved quickly in terms of versatility and application.

Participants in RepRap began selling kits. The MakerBot 3D printer was an example, with developers contributing designs to the RepRap community. However, the founders decided to commercialise MakerBot as an affordable entry-level 3D printer by introducing (controversially) innovations protected as intellectual property. They attracted over $11 million in venture capital funding in 2011. By 2013, over 40,000 MakerBots had been sold. Useful aspects of the RepRap ethos were retained – starting and running the 'Thingiverse' online community for share printing projects and file repositories – but the contradictions became stark as the MakerBot became increasingly commodified. The business was sold to industrial 3D printer manufacturers Stratasys for $403 million in 2015. They merged the business with competitors at Ultimaker, and MakerBot is now marketed to the education sector.

One aspect of this appropriation example is the organisational innovations through which the printer developed. Hackathons and other collaborative practices pioneered in the niche are being appropriated by open innovation business strategies. Organisational processes similar to commons-based peer-production are orchestrated by firms as a means of gathering design ideas and creative inputs, but

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in open innovation the firm retains rights for their eventual enclosure and appropriation as intellectual property. Whilst some participants gain – hackathon winners are compensated or even hired, for example – there is little investment in the wider niche community generating the original ideas and, specifically, the social reproduction of the commons that enabled such innovation originally.

9.3.4.3 Hybridisation

Whilst appropriation reinvests little into the niche conditions that nurture post-automation, differences between post-automation ideals and regime realities can sometimes open to hybridisation. The 'design global, manufacture local' ethos pioneered amongst makerspaces is illustrative. In the manufacture of furniture, for example, industrial businesses are investing in commercial platforms that connect international designers with local manufacturing workshops close to customers. Inspired by commons-based peer-production, this innovation allows customers to buy their favourite designs on the platform, which sends production files to a local digital fabrication workshop contracted to manufacture it in a locality close to the customer. In time, local maintenance and repair could be integrated into this furniture product-service model, or designs adapted so that local and reclaimed materials can be included and upcycled. The platform owner profits and the designers and manufacturers take a share in this hybrid arrangement. Added value circulates more widely. Employment is distributed. Shipping is reduced. Technical and organisational knowledge pioneered in the post-automation niche attracts venture capital – although now interested in the asset-based possibilities for profit of a centralised platform for controlling distributed furniture making. Even mass retailers of flat-pack furniture have shown interest in hybrids that convert some of their network of retail warehouses into local (re)manufacturing facilities.

Given the continuing dominance of the automation regime, these hybridisations could easily morph into a cyber-physical system of global design and local (re)manufacture that concentrates ownership and automates processes. As Klaus Schwab noted in his advocacy for the Fourth Industrial Revolution, the 'great beneficiaries … are the providers of intellectual or physical capital – the innovators, the investors, and the shareholders, which explains the rising gap in wealth between those who depend on their labour and those who own capital' (Schwab, 2017, p. 251). The risk is that power and wealth will be further concentrated to even less socially sustainable degrees than today.

9.3.4.4 Criticism

The final interaction involves a critical reiteration of niche–regime difference. Critical niches challenge the constraints on transformative sustainability

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transitions. Such critique is an essential ingredient in change because it holds open alternative problem framings and challenging experiments in sustainability. A practical illustration of this are environmental digital sensing initiatives in the post-automation niche space. Digital sensing involves citizens, artists, activists and technologists in collaborative explorations of the environments they care about. Sensors, code, communication and platform technologies are used to make data about local environments sensible, visible and measurable to communities. Co-designed activity brings people together in workshops and through in person and online events. The activity makes use of open designs, software, hardware, and collaborative methods shared online. The data and experiences are also shared through online platforms. These platforms circulate information and support local capacity building for making sensible that which is otherwise overlooked, invisible or under-appreciated.

Educational and science policies have caught on to these participatory sensing practices and begun supporting hybrid initiatives. However, what imbues post-automation with its critical edge is the way sensing activities seek not only to popularise awareness of environmental phenomena but also to re-signify these phenomena, by building caring relationships and mobilising activism. Citizen sensing generates data and awareness of situations that official monitoring ignores, fails to reach, or approaches quite differently: from noise and pollution, through to animal species and radiation; from mapping cycle routes, to sensors for food growing; and from overlooked histories of places, to imaginative augmentations that envision those places from the perspective of other species. There is a critical politics to mobilising activity around these matters of concern and to seek transformative social relations with what is being sensed. More caring and less exploitative connections are made compared to the controlling resource imperatives typical of sensors in the automation regime. Digital sensing technologies in the niche criticise the objectification of natures in the regime.

In sum, enabling the exploration of alternative material cultures and different political and economic arrangements, post-automation makes subversive use of ostensibly automating technologies. Critical interactions insist upon reconceiving (and redistributing) the capacities these technologies bring for experimenting radically with what sustainability means in society and democratising social choices over how this technology is deployed. Niche interactions with the regime become agonistic and confrontational.

9.4 Ongoing Debates

Researchers are increasingly recognising how important it is to analyse the interdependent relationships between these varied interactions and their consequences

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in sustainability transitions (e.g. Meijer, Schipper, & Huijben, 2019; Mylan et al., 2019; Smith, 2007; van Summeren et al., 2023). Often niche–regime interactions result in reconfigurations in which narrowed-down innovations are appropriated into regimes. Disappointment in the thinner and shallower sustainability that results can frustrate some, but it can also reinvigorate radical niche alternatives. Critical reflection about initial differentiation and subsequent hybridisation opens debates about building more transformative strategies. Debates can mobilise strategic action for more promising hybridisations in future.

Ongoing debates turn on the analytical perspective one adopts towards these interactions and hence recommendations for policy (Smith et al., 2016). A strategic niche management perspective emphasises appropriation interactions. In the absence of analysis and strategies for addressing niche–regime power imbalances (Shove & Walker, 2007), a fit-and-conform strategy prevails that pragmatically aligns niche experiments to given regime possibilities. Interaction policies recommend improving the performance of technological and organisational innovations in the niche in ways that make them compelling and appropriable to a wider constituency of regime actors and the mix of conventional market criteria and sustainability reforms to which they are committed.

A niche policy advocacy perspective emphasises stretch-and-transform strategies. The most significant interaction is considered to be hybridisations that help institutionalise in regimes some of the norms demonstrated in niche innovations. Policies that reset the regime context for interaction are recommended. Improving technical and organisational innovations remains important, but it is the task of transforming the criteria through which performance is understood and innovation develops that is decisive for this perspective. Niche policy advocacy emphasises the political work needed to build alliances, gather evidence and construct persuasive narratives for realigning regime institutions with niche norms. Whether interactions lead to stretch-and-transform reconfiguration depends upon the success of niche advocacy negotiating favourable institutional changes.

Ultimately, only if power relations shift radically and permanently in ways favourable to niche norms will the latter unsettle incumbent regimes fundamentally (Smith & Raven, 2012). A critical niche perspective emphasises this political reality. Hands-on experimentation can raise awareness about the concrete ways that wider social structures inhibit the full flourishing of niche alternatives. A critical niche perspective addresses directly and practically the distribution of power that favours regimes over niches, and which constrains transformational hybridisations. For example: Why must scaling-up always be market-based? Why not scale-down and decentralise institutions and empower local innovation capabilities instead? Why should historic access to capital privilege some positions over others? Niche experiments address in very material ways the reasonableness of

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political and economic questions like these. The interactions that matter for critical niches are differentiation and criticism.

We see in the post-automation example appropriation and hybridisation interactions of interest to the above perspectives. But post-automation should not be reduced to a curious generator of commercially promising innovations or entrepreneurial policy ideas. Critical interactions exist that anticipate and insist upon more radical transformations (e.g. political and economic institutions that prioritise co-operative work and the democratisation of technology). There is a dialectical relationship here through which niches are formed as the antithesis of problematic regimes and later become sources of innovation for appropriation or selective hybridisation (synthesis). A dynamic is created which generates a renewed round of differentiation and critical transformative effort (Smith, 2007). In practice, niche–regime interactions are far more complex and dynamic than this dialectic suggests, and debate turns on how to simplify matters and where to focus policy attention.

9.5 Emerging Research and Further Needs

In sustainability transitions research, niche spaces are conceived as being fundamentally different to regimes but needing to provide valuable innovations amenable to mainstream reforms. Given power asymmetries between niches and regimes, hybridisations are likely to be partial and skewed towards regime. Only when counter-veiling pressures arise, for example when niches become emblematic for social movements demanding political and economic transformation, can the really radical sustainabilities in niches break through and exert wider influence (Chapter 20). Which niche–regime interactions count and prove influential depends upon wider social movement dynamics and the ability of niches to exploit those dynamics favourably.

Sustainability transitions research is (after considerable effort) beginning to inform innovation policymaking (Chapter 3). However, experience to date suggests policy supports appropriable alignments with regimes more than policy simultaneously empowers critical niches. Democratic public policy is an especially important counter to power relations in hybridisation. Organised progressively, policies can provide recognition and resources for niche alternatives that help push hybridisations further, and policies can use regulatory pressures to push the regime further than would otherwise happen.

The experience of post-automation reminds us that it is not only policymakers and business leaders who are interested in technological futures. Social activists are too, but in deliberately different ways. However, building institutions that align with activist norms in the post-automation niche requires much more ambitious and concerted political programmes. Dismantling intellectual property arrangements

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and creating commons-based technology policies, for example, or inserting the right to repair into manufacturing requires powerful political programmes and alliances (Lloveras, Pansera, & Smith, 2024; Chapter 12).

In becoming more attentive to niche–regime interactions in terms of contexts, consequences and perspectives, the politics of technology and sustainability becomes more evident. Future research engagement needs to help turn technological innovation from an easily dismissed fix and distraction for social movements and into a vital stage for conducting their genuinely transformative sustainability politics.

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