1. Towards a sustainable, circular, innovative and socially fair economy: an introduction

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Humanity is faced with the major challenge of solving the environmental and climate crises while maintaining a healthy economy, a challenge that becomes even more difficult in the face of the resurgence of large-scale international security threats (EEA 2019; OECD 2021; UNECE & UN Environment 2022). Innovations, ranging from technological to organisational and behavioural changes, together with human resource investments, are historically behind the economic and human development of countries and regions (Spinozzi & Mazzanti 2018) and are key tools to address this present challenge. According to the IPCC AR6 report (IPCC 2021), more radical and systemic innovations are required if we are to meet the target to keep global GHG emissions below the +1.5°C target (Matos et al. 2022). Similar demands for innovation arise in other areas of the sustainability transition, for instance in the areas of sustainable transport and mobility, sustainable agri-food and healthy soils, bio-economy, circular economy (CE), blue economy, and the social and solidarity economy.

Innovation is probably one of the most misused terms in modern scholarship and practice.¹ The academic community is not the exception; it widely uses innovation to describe novel things.² In economic theory, the Schumpeterian understanding of radical innovation through the entrepreneur-innovator has long dominated the literature. According to this seminal author, innovation is about combinations of new and existing knowledge and other factors that result in profit maximisation solutions, developed by companies with a commercial purpose so that they are ultimately adopted by the market (Schumpeter 1934; Ruttan 1959). The OECD follows a similar view of innovation in business, defining it as ‘products and services that offer new or significantly new features that bring a company to increased market value’ (OECD 2018). In management studies, the term innovation is often seen both as a process and as an outcome. According to Nooteboom and Stam (2008), innovation as an outcome constitutes a novel function or a novel way of performing an existing solution. Innovation as a process leads to the creation of value by means of the design, development and diffusion of novel solutions to ‘wicked’ problems, including those related to society, climate change, ageing populations, etc. Under this view, innovations are supporting societies in order to achieve a more environmentally sustainable outcome together with better human development. It is the latter view of innovation that guides the main question of this book to know how innovation supports a transition to a sustainable, circular and socially fair and inclusive economy. This vision of innovation for the common good can also help to identify those effects of innovations
that can adversely affect the public good, especially when introduced in a complex dynamic system having uncertain feedback.

This chapter presents the overall conceptual framework behind the Handbook. This is followed by a section dealing with messages about fundamental uncertainties and the avenues of research guiding this book. The concluding section presents the different chapters included in this Handbook.

1.1 THE CHALLENGE OF MULTIPLE TRANSITIONS IN AN UNSTABLE WORLD

The sustainability transition is driven by the coevolution of different transitions, occurring at different geographical and sector levels (EEA 2019; Barbieri et al. 2021): (i) demographic and social transitions, including migrations, ‘one health’ and ‘social innovations’; (ii) technological transitions, including digitalisation and ‘disruptive’ innovations such as robotisation and artificial intelligence (AI); (iii) environmental sustainability transitions taking place in local territories (e.g., use of resources) and at global levels (climate change and energy); (iv) fiscal and public budget transitions, under the pressures of fiscal revenue constraints, increasing spending for population ageing and increasing indebtedness; and (v) financial transitions, particularly towards ‘sustainable finance’ (Figure 1.1).

![Figure 1.1 Interactions in a multiple transition setting](https://www.elgaronline.com/)

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The transitions are partly endogenous and partly driven by major forces that are exogenous for the territories (e.g., demography, technological progress, international crises, energy shock). Some transitions are guided and shaped by major governmental policies and/or international treaties and agreements (e.g., the European Green Deal or the Paris Agreement), and they interact with one another in a web of synergies and possible conflicts that may either favour or hinder a full sustainability outcome. The objective of economic development across territories (UNDP 2020) must guide the governance of the transitions: the diffusion of wellbeing should be pursued through new forms of competitiveness that can reduce inequalities and favour the emergence of ‘forgotten territories’, especially looking at the uneven effects of innovation and urbanisation.

The sustainability transition is a structural change that connects the transitions of old sectors and those of the new techno-organisational systems (UNIDO 2016, 2018). In Europe, policy drivers have been and still are particularly relevant in triggering and guiding these transitions through the combination of (i) the endorsement of the UN Agenda 2030 for Sustainable Development Goals (SDGs); (ii) the high-level policy priority attached to the European Green Deal (EGD) (which includes strategies and a range of policy provisions on carbon neutrality, circular economy, zero pollution, farm-to-fork, and just transitions) and the European Climate Law; (iii) the EU strategies on the Digital Agenda and the digital transition; (iv) a wide range of policies on innovation and on social and territorial cohesion, and (v) EU policies on sustainable finance (e.g., the EU Taxonomy) and financial system integration (e.g., Capital Market Union).

In the present historical phase, both the above-mentioned transitions and high-level policy actions are hit by major exogenous shocks, especially the ongoing COVID-19 pandemic, with geographically uneven and non-linear effects in time, and the shocking European military crisis that started in 2022. The macro-policy responses to the COVID-19 crisis, that is the NextGenerationEU (NGEU) package, contribute to accelerating some of the transitions (green and digital) but may have uncertain effects on the social and fiscal/financial transitions. The military and international security crisis that started in 2022 with the Ukraine war seems to suddenly redirect the EU and national strategies towards military and energy security, while also changing the EU food security strategies, and this may represent a watershed for Europe. The idea of ‘open strategic authonomy’ is now reshaping the highest level strategies of the European Union.

This transitional and shock-prone framework raises unprecedented challenges to the economy and society. On the one hand, there are several opportunities for socio-economic modernisation, new sustainable growth sources, and new approaches to competitiveness. On the other hand, the combination of transition paths and shocks can increase the risks of exacerbating inequalities between territories and inside territories (e.g., urban/rural divides), put social stability at risk (increasing gaps between winners and losers), meet the inability to manage multiple risks, increase future debt-related constraints on development, and create uncertainties in the EU and other regions to support sustainable transition priorities. Therefore, we see the capacity of
innovation for sustainability and the inequality issue as the key topics of this phase. At the same time, we see policies as the major actor in pushing forward the transition. (Eco)innovation, inequality and policies will be addressed in the next sections by highlighting the state of play in research literature together with the different uncertainties that mark the interaction between innovation inequality and sustainability policies.

1.2  ECO-INNOVATION STRATEGIES AND SYSTEMIC TRANSITIONS

Analyses of the socio-economic effects of eco-innovation (EI) strategies, in particular for energy, climate circular economy and related issues (EEA 2018; EEA 2019) by using an integrated analysis of technological, organisational and social innovation adoption and diffusion are highly relevant.3 ‘Technological Systems of Innovation’ (Carlsson & Stankiewicz 1991), ‘Sectoral Systems of Innovation’ (Malerba 2002), ‘Regional Systems of Innovation’ (Cooke 2001) and ‘National Systems of Innovation’ (Lundvall 1992), as developed in the field of innovation economics, are relevant concepts, given the possible pervasiveness of changes across industrial and consumption systems (Zoboli et al. 2019).

The systemic approach to innovation is highly relevant for transitions because of the focus on system-wide, large-scale and sustainability-oriented transformations of systems of production, distribution and consumption (Coenen & Díaz López 2010). In systems-level transitions, policy addresses market and system failures and the strengthening of the innovation ecosystem with the aim to support the diffusion and ‘up-scaling’ of green technologies – where the removal of barriers to (eco)innovation is of particular interest (Hekkert et al. 2007; Jacobsson & Bergek 2011). Systemic innovation policies also aim to correct the structure and functions of an innovation system (Klein Woolthuis et al. 2005). Such policies are informed by dedicated research into weaknesses of the overall innovation system and of innovation systems for specific technologies (Wieczorek & Hekkert 2012). As a result of an intervention, the functioning of the system can be better understood, framework conditions can be enhanced, specific intervention areas can be targeted, broad (technology) areas can be developed, market and societal penetration can be facilitated and system-level change can be promoted (Smits & Kuhlmann 2004).

The CE is a case in point of strategies in need of systemic and integrated approaches to (eco)innovation. CE can be viewed as a business and policy strategy that targets the redesign of production and consumption through pervasive technological and behavioural changes that revolve around new (uses of) materials and products (EMF 2015). As de Jesus et al. (2019) argued, CE refers to a systemic innovative strategy that emphasises the role of being innovative in order to be circular. Additionally, the link between CE and eco-innovation requires a deep analysis accounting for different heterogeneous dimensions, such as design, production processes and governance. The heterogeneity of these aspects and their possible combinations can play a strong
proactive role in fostering the transition. In this setting, EI has the chance to enhance new business opportunities and strategies, thus helping to generate a change in the whole economic system (Chioatto et al. 2020). The introduction of eco-innovation in a circular context translates into the practical application of circular business models that encompass environmental, economic and social sustainability dimensions (Managi & Kumar 2018), with a specific role for technology and innovation in inclusive and sustainable industrial development (UNIDO 2016).

The implementation of CE eco-innovations, requiring a complete rethinking of supply chains and business models (BMs), allows companies to change the way to create value by introducing BMs capable of including the circular objective in their strategies. Lüdeke et al. (2019) identified a broad range of BMs with the potential to support the closure of resource flows, highlighting the role of eco-innovation in this change of perspective. The implementation of business model innovation (BMI) in the domain of CE represents a strategic value-added for businesses receiving increasing attention over the past 15 years. According to Bocken et al. (2018), BMI refers to a strategic and innovative change in BM, which guarantees a novel way to create, deliver and capture value while ensuring companies’ survival and growth. However, achieving systemic change from the implementation of new BMs is very challenging in practice (Díaz López et al. 2019). Eco-innovation has great potential to contribute to transformations in the activity, company, value-chain and entire production and consumption systems, requiring new organisational capabilities and changes to BMs, infrastructure, institutions, etc. (Kemp et al. 2020). Therefore, there is a need to generate evidence about the real power of BMs to promote systemic and radical change at all levels, together with improved methods and frameworks to design and operate circular BMs that effectively generate system-level effects in the manufacturing systems and the economy as a whole (cf. Fehrer & Wieland 2021).

Resource efficiency is the key overarching concept behind CE. Innovation is among the relevant factors behind resource efficiency (Mazzanti & Zoboli 2009a, 2009b). Conceptually, the IPAT (Impact=Population-Affluence-Technology) identity shows how sustainably-oriented technological development (resource/emission efficiency of production) can compensate for scale economy-driven effects (Marin & Mazzanti 2013). Given the heterogeneity of technological and environmental performance across sectors, an understanding of the underlying forces requires in-depth meso- and micro-level analyses, which reveal the macroeconomic determinants (UNIDO 2015). EI is crucial for creating synergies between sustainability and competitiveness towards a green economy (Kemp 1997, 2010). Technologies per se, and specifically EI, are not self-sufficient to ensure broad sustainability achievements (EEA 2019). The potential of EI must be enriched and embedded within a very broad set of innovation- and knowledge-related factors as well as economic, social and environmental effects (Díaz López & Montalvo 2015; Kemp & Pontoglio 2011; De Marchi 2012; Kesidou & Demirel 2012). Although innovation is commonly regarded as the most effective response to sustaining current standards of living while overcoming serious environmental concerns (EEA 2014), a broad picture of the innovative potential in CE-related technologies is lacking.
Social scientists have actually scrutinised the market and regulatory drivers of EI since the late 1990s, with attention given to static and dynamic issues (Kemp 1997). Over the past two decades, research has intensified to specifically examine the various forces that underly EIs and inventions in firms (Horbach 2008). Among others, recent analyses (Barbieri et al. 2017) have focused on the complementarity of EI, human resource practices and organisational change (Antonioli et al. 2013), as well as on financial barriers (Ghisetti et al. 2017), global-local drivers and foreign ownership (Cainelli et al. 2012), relationships between innovation and EI dynamics (Colombelli et al. 2021) and geographically localised spillovers, which may affect EI adoption and productivity (Ghisetti & Quatraro 2017; Cainelli et al. 2015; Antonioli et al. 2016) and specific policies (Borghesi et al. 2015a, 2015b; Calel & Dechezlepretre 2016).

Analyses have predominantly looked at EI drivers in a first phase of this literature development at the firm level (Horbach et al. 2012). Despite some analyses on EI performance effects, for example, those of Lanoie et al. (2011), who exploited OECD surveys, the socio-economic effects of EI have been relatively overlooked. In addition, country-based evidence has prevailed. Martin et al. (2014) analysed the carbon tax effects on revenue, employment and energy intensity in UK manufacturing plants, whereas Ghisetti and Rennings (2014) investigated the link between EI adoption and profitability in Germany, Marin and Lotti (2017) analysed the productivity effects of EIs on Italian manufacturing firms and Gagliardi et al. (2016) studied

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**Figure 1.2   Systemic change, eco-innovation and business models**

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the link between green patents and employment in Italy. Cecere and Mazzanti (2017) analysed the correlation between EI adoption and green job creation in SMEs in the EU, using Eurobarometer surveys. Within this stream of literature, the integration between environmental/ecological economics studies on EI, innovation economics and industrial relations/labour studies can be fruitful, adding a regional studies/eco-

cnomic geography perspective as well.

1.3 WELLBEING, SOCIAL EFFECTS AND INEQUALITY RISKS

In connection with the ‘beyond GDP’ debate (EEA 2019), wellbeing-oriented analyses are relevant to analysing innovation impacts. Inequality is considered a crucial factor for a green economy, in connection with the diffusion of green innovations and environmental policies. Although research and policies have progressed with respect to the integration of the social and environmental pillars of sustainable development (SD), the interaction between social and ecological issues still remains uncharted terrain (Lehtonen 2004), with many interesting interdisciplinary avenues for research and policy-oriented assessments (Spinozzi & Mazzanti 2018). Far from being a ‘natural’ evolution, the relation between growth and inequality and the environment is dependent on factors such as policies and institutional quality (Arvanitis et al. 2016).

When considering this background, current and future research should extend the analysis of EIs in the realm of sustainability and circularity by analysing how EI strategies impact workers’ wellbeing through a multi-dimensional and multi-tool research agenda.

A pillar of wellbeing in the sustainability transition is in fact ‘worker satisfaction’, which is a driver of economic productivity (Antonioli et al. 2009). As noted by Antonioli et al. (2011), widespread endorsement of the benefits that are linked to high-performance work practices and labour-related innovations on workers first emerged during the 1990s, especially in the US context. Specifically, wider discretion, a greater opportunity for using worker skills to facilitate thorough job rede-

sign, a decreased level of control via management and greater worker involvement in decision-making processes have been perceived as being aspects that can increase workers’ wellbeing (see Handel & Levine 2004, for a review). However, some scholars (Gallie 2005; Green 2004; Askenazy & Caroli 2010) have highlighted that there are costs to workers associated with techno-organisational changes, especially if the changes are disruptive as digital and green waves of technological progress (Mazzanti & Rizzo 2017). Such costs include the intensification of the working activity, a reduc-

tion in working dead-times and psychological and physical pressures.

Within the spectrum of innovation impacts, one key aspect of integrated sustain-

ability is to specifically consider and investigate the impact on workers’ wellbeing of the adoption and diffusion of EIs, which can cause both positive and negative effects. Workers’ wellbeing includes monetary and nonmonetary factors, such as health, safety, job empowerment and stress. All of these factors are subsequently
related to impacts on the productivity and overall sustainability of a firm. Wellbeing assessments at the firm level should be addressing worker involvement through direct participation, industrial relations and cooperative firm governance, which are elements that characterise different models of capitalism across economic systems. Nonconflicting industrial relations can be a method for creating synergies and for innovating sustainability, especially through green Human Resource Management (Antonioli & Mazzanti 2017; Renwick et al. 2013). Indeed, cooperative measures have also demonstrated that it is possible to support inclusiveness, social fairness and environmentally sustainable growth while also remaining economically successful (Cheney et al. 2014; Iuviene et al. 2010; Castilla-Polo & Sanchez-Hernández 2020; Sustainability Solution Group 2013). The new challenges posed by the circular economy and decarbonisation ambitions generate the necessity to investigate whether and how these types of worker involvement can develop and change to manage the sustainability transition, wherein enhanced worker wellbeing is a pillar of win-win firm strategies.

Case studies and examples originate from many different sectors. Our capability of governing this transition process is based on a proper understanding of the related determinants (Cainelli et al. 2020) and their effects. Tangible (wage, health) and intangible (quality of life and jobs) dimensions of welfare can be enhanced or diminished by EI. Participatory processes, working through workers’ direct involvement, unionisation and industrial relations, cooperative approaches might enhance workers’ wellbeing and the firm’s overall sustainability performance. The mechanisms must be analysed as benefits and costs to characterise innovation adoption and participation schemes. The wellbeing effect related to workers is an overlooked area of research that connects innovation, labour and environmental economics.

Developing out of those streams of literature, research should aim at extending the analysis of EIs in the broadly defined realm of circularity (Zoboli et al. 2019, 2020), by analysing how EI strategies impact on workers’ wellbeing through a multidimensional and multitools research agenda, connecting to studies on employment and green skills (Marin & Vona 2019; Vona et al. 2018).

Along with the connection between environmental and labour issues through innovation practices, it is worth noting that widespread endorsement of the benefits to workers associated with high-performance work practices and labour-related innovations emerged during the 1990s, especially in the US context: wider discretion, greater opportunity for using their skills through job redesign, decreased level of control by management and greater worker involvement in decision-making processes were perceived as aspects that increased workers’ wellbeing (see Handel & Levine 2004, for a review). However, some scholars (Gallie 2005; Green 2004; Askenazy & Caroli 2010) have highlighted that there are costs to workers associated with techno-organisational changes, especially if disruptive, such as digital and green waves of technological progress (Mazzanti & Rizzo 2017), in terms of intensification of the working activity, reduction in working dead-times, and psychological and physical pressures.
A firm’s activities potentially influencing the working conditions cannot be limited to the techno-organisational changes, but they involve other forms of innovations and the specificities of the labour/industrial relations, such as cooperative relations between management and workers or their delegates. Cooperation is not automatic as conflicts do emerge along the transition between labour and environmental goals. As an example, if firms get savings from CE strategies, which group within firms will benefit most (managers, workers)? Who decides on the reinvestment of savings or value creation? What is the goal of the investment (e.g., disruptive skill training)? The complexity of the issue is increased by the diversity of current HR practices (Boon et al. 2019), the different conceptualisations of wellbeing and performance (Edgar et al. 2015) and the large number of significant contextual factors (at different levels: individual, social, cultural and market) including labour market conditions, industry and business strategy (Brinck et al. 2019; Farndale & Murrer 2015; Hauff et al. 2018).

The overall picture of the sustainability transition also includes the risk of increasing inequalities (Barbieri et al. 2021). These effects may arise when transition policies induce regressive distributional impacts through increasing costs of essential goods (food, energy or mobility) (Marcu & Vangenechten 2018; Mercure et al. 2018; IMPACT 2017; Ürge-Vorsatz et al. 2014; World Health Organization 2011). In particular, low-income households tend to spend a larger proportion of their income on energy-intensive services, such as space and water heating, electricity and fuel, and there is a lack of options for substitution (Hayer 2017; OECD 2015). Policies that have regressive distributional impacts can also exacerbate health inequalities (Ekins & Lockwood 2011; Walpole et al. 2009). These risks can be faced by adopting mitigating strategies, such as subsidies, exemptions and various types of revenue recycling mechanisms, as in the case of the Social Climate Fund proposed within the EU ‘Fit-for-55’ package. An extensive set of distributional positive and negative issues are associated with green infrastructure and nature-based solutions (Botzat et al. 2016; De la Barrera et al. 2016; Wachsmuth et al. 2016). Very often urban regeneration leads to environmental displacement of people and gentrification (Beretta & Cucca 2019).

1.4 DRIVERS OF THE TRANSITION: RESOURCE SCARCITY AND PRICE SIGNALS

In general, price signals and, in particular, relative prices do matter for EI and then for environmental sustainability strategies. In the experience of the past fifty years, the main triggers of large-scale and stable decarbonisation and material-saving technological trajectories have been energy and material prices. The energy and commodity price revolution of the early 1970s was the single most important factor in starting a generalised techno-economic process of energy saving and material efficiency that, interacting with general techno-economic and macropolicy changes, has become structural in nature and global in scale during the past few decades, thus generating
Towards a sustainable, circular, innovative economy

the present energy-emission and material-use technological setting of our economies (Quadrio Curzio et al. 1994; Quadrio Curzio & Pellizzari 2018). From the 1990s onwards, in a framework of weak energy and material real prices, climate change policies and waste policies now embodied in the ‘circular economy’ paradigm, took the lead in pushing for decarbonisation and material efficiency trajectories through the signals described above (see also Quadrio Curzio & Zoboli 2020).

In the most recent phase, the weakness of real prices of energy and materials – that is relative prices traditionally referred to as scarcity prices of natural resources – as market signals that justify resource efficiency innovations have been clear. After a phase of high but highly unstable prices in 2000–2017, in 2021 the international real price of energy commodities (World Bank indexes) was still below the levels prevailing in 2008–2013. Real prices of minerals and metal in 2021 were at the levels of 2007 and those of industrial raw materials were below the levels of the early 1960s. From 2021, a combination of factors belonging to the geopolitics of energy and materials, combined with the military crisis in Ukraine in 2022, generated sudden jumps in energy and commodity prices, including the prices of food commodities. However, even looking at nominal prices, the prices of May 2022 were not at a historical peak with the exception of natural gas in Europe after the crisis between Europe and Russia.

In short, in spite of the deep uncertainty, the markets and prices for commodities and energy are not giving signals that we are entering an age of scarcity of productive natural resources, thus giving weak signals for innovating in energy and material efficiency. This conclusion can be supported by looking at non-renewable natural resource reserves. In the case of oil and gas, the world proved reserves continuously increased during the past few decades and the reserve-to-consumption ratio – i.e., the years of consumption of the year covered by world proved reserves – was more than 53 years in 2020 with respect to about 30 years in 1980 for oil and the same ratio was about 43 years for natural gas. Looking at the world reserves of 33 minerals and metals, on data from the US Geological Survey, the ratio reserves/production in 2019 was greater than 40 years for 19 minerals/metals, and for ten of them it was greater than 100 years, while for only eight of them it was lower than 20 years. With respect to 1994, reserves increased more than 100% for 12 minerals/metals whereas reserves were reduced for only five minerals/metals. The reserve availability is not ‘critical’ even for some ‘critical’ minerals/metals; for example, in the case of lithium, in spite of a huge increase in demand – 13 times from 1994 to 2019 – reserves also increased substantially – eight-fold in the same period – and, in 2019, reserves covered 244 years of world production. Of course, the geographical location of such reserves can create ‘critical’ geopolitical issues and artificial – or speculative – scarcity phases in world markets.

However, even the application of price-based policies, or Market-Based Instruments (MBI), is very weak in spite of the robust support from high-level policymaking and international organisations: IMF, OECD, European Commission, World Bank. The carbon prices actually arising from carbon taxes and emission trading schemes in Europe and elsewhere are very low. According to IMF (2021), the global average
carbon price is US$2/tCO\(_2\), and half of the GHG emissions covered are priced at less than US$10/tCO\(_2\). A significant part of the emissions are subsidised, thus giving rise to negative prices of CO\(_2\). These carbon price levels are much too low to trigger significant jumps in decarbonisation, and are far from the carbon prices recommended by the High-Level Commission on Carbon Pricing established by the World Bank in 2017 – in the range of 40 to 80 US$/tCO\(_2\) by 2020 and 50 to 100 US$/tCO\(_2\) by 2030 (CPLC 2017).

Similarly, in spite of the support it receives in high-level policy recommendations, environmental and energy taxation, a matter still in the hands of individual countries, is decreasingly important within the European fiscal system, with a share of less than 6% of total tax revenues in EU27 countries (EEA 2019).

### 1.5 DRIVERS OF THE TRANSITION: THE ROLE OF POLICIES

Policies have so far been the major drivers of the sustainability transition. In the case of the EU, already before the European Green Deal (EGD) was introduced in 2019, the system of targets and objectives in EU environmental and energy policies was huge. There were 159 legally binding targets and 87 non-binding objectives up to 2050 across 11 environmental policy areas (Paleari & Reichel 2019). The EU EGD is generating a huge flow of new policy signals for innovators across all sectors. Even before the ‘Fit-for-55’ proposal of July 2021, the EGD provided for an expected 177 measures, strategic documents and legislative proposals, new or revised, of which 28 were for climate change and energy, 15 for waste and resources, 17 for chemicals, and 28 for industry, products and value chains. The greatest number was to be introduced in 2021 and 2022.

The EGD reinforces the ‘new policy style’ which had already emerged over the past few years. A pillar of this policy style is the use of science-based binding targets, such as those of the Paris Agreement for climate, as major signals given to the economic and innovation system. These targets are not ‘socially optimal’ and instead they follow a cost-effectiveness approach (Baumol & Oates 1988) which forces the system beyond its present capacity, thus creating a huge potential for ‘disruptive innovation’. An example of forcing policies is the proposal of stopping the production of internal combustion engine cars by 2035, as included in the ‘Fit-for-55’ package.

A second feature is the increasing complexity of broad policy packages. An example is the EU ‘Fit-for-55’ proposal (July 2021). It includes 13 pieces of legislation on a range of sectors already covered by old and new (i.e. EGD-induced) policies (climate, energy and fuels, transport, buildings, land use and forestry). The same complexity and mixture of instruments emerges for specific policies. An example is the ‘Directive on Single-Use Plastics’ (2019). It goes product by product and provides prohibition to place on the market, measurable reduction in consumption, collection targets, marking requirements, separate collection targets, extended producer responsibility and mandatory targets on the recycled content (for beverage containers).
A third feature is the emergence of an approach by ‘strategies’ and policy-led industry/innovators partnerships. The European Commission stimulated a number of initiatives rooted to the research and innovation policy that directly involve industrial stakeholders under EU co-funding. This is the case with the eight EIT Innovation Communities that are endowed by significant budgets (more than €3 billion under Horizon Europe) for industry-led cooperative efforts towards ‘disruptive innovation’. A recently launched industry-policy initiative is the very ambitious EU Hydrogen Strategy, which plans the development of the hydrogen economy through a series of joint undertakings between EU funding and industrial innovators.

In this phase, the policy signals for the sustainability transition are coming from beyond conventional policies, up to a constellation of ‘other’ policies that, together with a new attitude by businesses, generate ‘systemic signals’ able to stimulate, directly or indirectly, the EI transition. The range of sources encompasses industrial and innovation policies, the green transition attitudes of the global business, the development of ‘sustainable finance’, the macro-recovery policies (post-COVID-19) and the greening of social attitudes.

In industrial and innovation policies, there is a trend towards a ‘green industrial policy’ (Tagliapietra & Veugelers 2020). A general push towards greening the businesses is coming from the surge of the ‘sustainable finance’ process and the inclusion of climate risks in financial risk assessment. In the EU, sustainable finance is policy led. The ‘renewed sustainable finance strategy and implementation of the action plan on financing sustainable growth’ (2020), together with the diffusion of ESG criteria and the EU regulations on non-financial reporting by enterprises, established a process which is affecting the whole financial sector and thus the whole industrial and business sector.

In the most recent years, the move towards green industrial policy and towards the alignment of businesses on sustainability criteria has been strongly reinforced by the macroeconomic policies in response to the COVID-19 crisis. The combination of the €1,074.3 billion of the EU budget 2021–27 (Multiannual Financial Framework, MFF) and the €750 billion put in place by the NextGenerationEU (NGEU) created a combined package worth €1.8 trillion which has a significant green orientation: 30% of total MFF and NGEU budgets must be allocated in favour of climate change, which generates €547 billion for the green transition in the period 2021–2027. This mass of dedicated resources can reduce, at least in the short term, the uncertainty on the effectiveness of the ‘implicit contract’ for transition between public policies and industry in Europe.

### 1.6 FUNDAMENTAL UNCERTAINTIES AROUND INNOVATION FOR SOCIETY AND THE ENVIRONMENT

While we have entered an age of deep uncertainty about the geopolitical and geo-economic equilibria within global governance, which deeply involve energy and natural resources, the most uncertain side of the sustainability transition and its two major dynamic processes, (eco)innovation and wellbeing, is the policy side.
In fact, the policy dominance behind the sustainability transition raises a number of questions on whether the set of present and upcoming policy signals is strong, clear and univocal, and possibly marked by super-additivity across the different signal sources, which would imply a low degree of uncertainty for eco-innovators and the societal actors. Otherwise, eco-innovators and society are facing a confused overflow of policy signals marked by a lot of ‘noise’, not easy to disentangle, full of fundamental uncertainties about, for example: the actual strength and radicalness of policy signals; the reliability of policy objectives, instruments and approaches; about where – in terms of sectors, regions, value chains and specific technologies – the strongest and more reliable policy signals are being directed. For example, in the case of climate policies, how credible are high-level policy commitments for emissions, in particular those from COP26 in Glasgow, which define the overall space for EI and societal change? What will be the outcome in the EU of the open political discussion on the ‘Fit-for-55’ package for climate neutrality, given that opposition clearly emerged even before the Ukraine war, with some paradoxical positions in favour of watering down the package instead of reinforcing it ahead of the energy and commodity crisis?

Other specific uncertainties may arise from the propensity of EU policies to push forward a policy-decided selection of green technologies (‘technological non-neutrality’), which do not necessarily reflect the relative environmental and/or economic advantages in a framework of imperfect information or methodologically weak section tools. In addition, there are dynamic uncertainties on the policy–industry ‘alliance’. On one hand, will private business actually invest in the transition? On the other hand, will the announced and promised public funding for the sustainability transition actually be delivered in spite of the macro-economic and financial scenarios of the coming years? Is green finance the new policy frontier, and, if yes, will finance obey policies or will it dictate policies based on risk assessment, which can translate into another issue of ‘technological non-neutrality’? Can policies avoid their internal cross-policy conflicts, such as the competition between policies on renewable energy sources and CE policies for the allocation of bio-residues from the bio-economy (energy vs. material pathways)? Can the Just Transition strategy and the Social Climate Fund solve the emerging risks of inequality from the sustainability transition? And finally, can policies be successful even without – or with very weak – market-based policy instruments?

1.7 CONTRIBUTIONS IN THIS BOOK

This introductory chapter is followed by Part II, dealing with ‘Eco-Innovation and Policies’. Within the policy framework at the EU level, Chapter 2 by Alquézar Sabadie analyses to what extent the ‘do not significant harm’ (DNSH) principle and other issues related to Green Deal implementation might play a role in shaping research and innovation (e.g., Horizon Europe programme). In a similar vein, Chapter 3 by Tagliapietra and Veugelers deals with policy design providing a set of key recommendations to develop and design a green industrial policy framework for
Towards a sustainable, circular, innovative economy

the European Green Deal. The following three chapters present examples of important topics for eco-innovation policy analysis: trade, collaboration and employment and public financing. Chapter 4 by Caravella, Crespi, Menghini and Monni investigates the (direct and indirect) effects of export on the introduction of (environmental) innovation. Open eco-innovation modes are explored in Chapter 5 by Fabrizi, Guarini and Meliciani with respect to the role of these modes in fostering employment within the Italian environment-related network. Chapter 6 by Díaz López, Rivera Delgado and Villavicencio Carbajal presents results from a study analysing a large qualitative dataset of R&D grants, a form of public incentives to innovation in Mexico acting as a barrier to the diffusion of eco-innovation.

Part III of this Handbook takes a territorial perspective connected to regions and cities: ‘Eco-Innovations in Cities, Regions and the Globalised Economy’. Chapter 7 by Horbach analyses the role of regional spill-over in eco-innovative activities in Germany. Chapter 8 by Ole Semrau presents a review of the contribution which the influence of trade and market openness can have on environmental efficiency and the adoption of environmental innovations. On more empirical grounds, Chapter 9 by Barbieri, Consoli and Perruchas presents a new technology life cycle indicator for the different stages of maturity of green technologies and across different European regions. Finally, Chapter 10 by Lanza and Quandt takes the case studies of the Brazilian cities of Cascavel and Tubarão to test their adherence to the Smart City concept in the framework of sustainable development.

Part IV of the Handbook, ‘Innovation and Society’, focuses on the topic of inclusive, economic and community-led eco-innovation. It includes Chapter 11 by Schillo and Puri, presenting a theory of inclusive innovation to take a broader view of socio-technical transitions within the landscape of eco-innovation. After providing more insights on the concept of frugal technologies, Chapter 12 by Le Bas investigates the potential role of frugal eco-innovation towards the sustainability transition in the development process. Chapter 13 by Roberts, Brent, Hinkley and Shedlock investigates the role of culture and local traditions in promoting inclusive, community-embedded innovations in sustainable energy of the island nation of Aotearoa–New Zealand.

Part V, ‘Innovation and the Circular Economy’, presents evidence of the implementation of the circular economy in different parts of the world. Through case study analysis, Chapter 14 by del Río, Kiefer and Carrillo-Hermosilla aims to provide analytical framework to policy mixes to encourage the adoption of a circular economy. Within the product life-cycle approach (Chioatto et al. 2020) to define circular eco-innovation, Chapter 15 by Chioatto and Zecca evaluates firms’ level of engagement using data collected on Italian SMEs. Chapter 16 by Carrillo Gonzalez and Ponce Sanchez employs cluster analysis and text mining to profile the characteristics of the best performers in the circular economy and the bioeconomy in Latin America.

The final part, Part VI, of this Handbook focuses on the topic of ‘Systems of Innovations and Sustainability Transitions’. Chapter 17 by Pallaske, Bassi, Garrido and Guzzetti adopts a systemic and multi-faceted analytical approach (e.g., the green economy model) to better assess the outcomes of mitigation and adaptation investments for sustainable development, with both a national and local perspective.
Chapter 18 by de Kock and Brent outlines a systematic and structured approach to providing the basis for the definition and identification of technology management considerations within the context of sustainability transitions. Coupling empirical analysis and theoretical modelling, Chapter 19 by Marin and Vona investigates the potential role of environmental policy on labour market dynamics and its implications for sustainability transitions. To conclude this Handbook, Chapter 20 by Pierucci, Agostinho, Almeida and Giannetti presents a novel sustainability indicator for municipalities and tests it on a sample of 30 Brazilian cities and towns as a support measure to their sustainability transition.

NOTES

1. A search in the popular search engine Google produces about three billion records for the term ‘innovation’, whereas Microsoft’s Bing search engine generates about 41 million results.

2. In September 2022, Google Scholar reported about 4.8 million results of academic documents including the term ‘innovation’. In comparison, Scopus identified 514,212 scientific documents using the term ‘innovation’ in the title, keywords or in the abstract. EbscoHost for EconLit had over 91,000 records.

3. Eco-innovations is the main reference term. Sustainable innovations and environmental innovations are also used. Given that there is no unique terminology, we refer to the definitions in the literature (Barbieri et al. 2016) and to two EU projects, namely the MEI project Measuring Eco-innovations (www.oecd.org%2Fenv%2Fconsumption-innovation%2F43960830.pdf) and Green.eu H2020, which published the new Maastricht manual on eco-innovation for a green economy by Kemp et al. (2020). https://www.inno4sd.net/uploads/ originals/1/inno4sd-pub-mgd-02-2019-fnl-maastricht-manual-ecoinnovation-isbn.pdf.


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Towards a sustainable, circular, innovative economy


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Towards a sustainable, circular, innovative economy


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Towards a sustainable, circular, innovative economy


