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To cite this article: Nikolaus Steinböck & Michaela Tripl (2023) The thorny road towards green path development: the case of bioplastics in Lower Austria, *Regional Studies, Regional Science*, 10:1, 735-749, DOI: [10.1080/21681376.2023.2244572](https://doi.org/10.1080/21681376.2023.2244572)

To link to this article: <https://doi.org/10.1080/21681376.2023.2244572>



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Published online: 29 Aug 2023.



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Nikolaus Steinböck and Michaela Tripl 

ABSTRACT

This article contributes to a better understanding of how heterogeneous innovation system actors shape green industrial path development. Previous research has identified various forces of stability that reside within place-specific and non-local innovation system structures and advanced our understanding of the role of change agency in rearranging these structures to facilitate green transitions. Failures to reconfigure innovation systems have received limited attention so far. Drawing on recent insights into the role of maintenance agency, we cast light on how powerful actors undertake strategic interventions to prevent rearrangements of innovation systems from happening. Our empirical analysis of the emerging bioplastics path in the region of Lower Austria reveals how resistive incumbents from the fossil-based plastics industry, academia and support organisations preserve historically grown system configurations that favour the old unsustainable industry and create barriers to the consolidation of the bioplastics path.

ARTICLE HISTORY

Received 9 February 2023; Accepted 1 August 2023

KEYWORDS

green path development; innovation system reconfiguration; bioplastics; maintenance agency


JEL CLASSIFICATIONS

O33; R11; R58

1. INTRODUCTION

As societal challenges related to climate change and resource depletion are intensifying, green industrial transitions have become a pressing issue. Different perspectives have been used to scrutinise the rise and evolution of green (industrial) paths,¹ ranging from narrower evolutionary economic geography (EEG) models to broader conceptualisations that draw inspiration from innovation system concepts, sustainability transitions approaches, global production network frameworks and the just transitions literature (Binz et al., 2016; Boschma et al., 2017; Chlebna & Mattes, 2020; Eadson & van Veelen, 2023; MacKinnon et al., 2019; Morales & Atziena, 2022).

In this article, we build on conceptual advances at the intersection of EEG and regional innovation system (RIS) studies. An RIS is made up of multiple actors, that is, firms and industries located in the region as well as support organisations (such as research and educational bodies, intermediaries, financial organisations, and policy actors). Key actors and the networks

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connecting them are considered to be influenced by the institutional configurations in regions. Importantly, RIS are not seen as closed systems. They are often embedded in global innovation and production networks and influenced by national and supranational policies and institutional set-ups (Asheim et al., 2019). Regions show different endowments of the above mentioned RIS elements. Employing an RIS approach has led to a better understanding of how place-based industrial, organisational support and institutional structures and their embeddedness in national and supranational environments may facilitate or impede green path development (e.g., Tripl et al., 2020). Inspired by sustainability transitions research, recent contributions on challenge-oriented RIS (CORIS) have begun to offer a more critical and dynamic perspective. They emphasise the importance of considering previously overlooked innovation actors, such as civil society organisations, users or labour unions, in innovation-based path development, and illuminate the ways in which innovation system structures (need to) change in order to stimulate green industrial restructuring (Isaksen et al., 2022; Tripl et al., 2023). What remains less clear is why RIS reconfiguration may fail. In order to capture better the sources of such failures, we move beyond the exclusive focus on change agency and take account of maintenance agency (Bækkelund, 2021; Henderson, 2020; Jolly et al., 2020). This serves as a stepping stone for grasping how the acceleration of green path development and the rearrangement of innovation systems could be actively prevented or delayed by powerful incumbents (Baumgartinger-Seiringer, 2022). That way, the paper also ties in with recent work that highlights the need to accord more attention to power struggles and the politics of path development (Eadson & van Veelen, 2023).

Our empirical analysis covers the nascent bioplastics² path in Lower Austria. This new path has its origins in the 2000s. Despite its long history, it has thus far not taken off but is still in an emerging phase. Based on an analysis of policy and other documents and 13 qualitative in-depth interviews with firm and non-firm actors, we investigate how the bioplastics path is affected by different forms of agency exercised by innovation system actors operating on various spatial scales. We demonstrate how powerful firm incumbents from the fossil-based plastics industry, universities and support organisations (intermediaries) work against a reconfiguration of the innovation system, thereby conserving the status quo.

The remainder of this article is organised as follows. Section 2 carves out the complex relations between (regional) innovation systems, agency and green path development. This is followed by a brief characterisation of Lower Austria's traditional plastics industry and its embryonic bioplastics path in section 3. Section 4 discusses the results of our empirical analysis. Finally, section 5 concludes.

2. INNOVATION SYSTEMS, GREEN PATH DEVELOPMENT AND SYSTEM-LEVEL AGENCY

Much progress has been made to understand how green economic activities emerge in regions. Many studies draw on insights offered by EEG. EEG models explicate how previous rounds of industrial development shape the rise of new paths (Martin, 2010). Research on regional diversification (Boschma, 2017) claims that new paths are built on technologically or skill-related industrial structures. This body of scholarship emphasises that firms are the key drivers of regional structural change and highlights the ways in which they (re-)combine regional capabilities to move into related (and more seldom, unrelated) fields (Boschma, 2017). While this has helped to pinpoint the role of firms, industry structures and regional knowledge dynamics in path development, little attention has been given to non-firm actors, extra-regional influences, power issues and territorial institutions (e.g., Eadson & van Veelen, 2023; Hassink et al., 2019; MacKinnon et al., 2019).

Other scholars advocate broader conceptualisations of green path development, extending EEG models by integrating findings from the literature on technological innovation systems, socio-technical transitions, global production networks and just transitions (Binz et al., 2016; Boschma et al., 2017; MacKinnon et al., 2019; Morales & Atziena, 2022). These approaches go beyond a mere focus on knowledge assets and accentuate the significance of other resources and processes, paying attention to market formation, financial investments and legitimacy (Binz et al., 2016). They acknowledge that these processes are influenced by heterogeneous actor groups. Such a multi-actor perspective recognises the roles played (or not played) by firm and non-firm actors such as research institutes, policymakers and support organisations in green industrial transitions. Recent work goes a step further and underscores the significance of posing critical questions about who is included or excluded from path development, who is deprived of agency and who benefits from it, highlighting the need to give greater consideration to politics and power relations (Breul et al., 2021; Eadson & van Veelen, 2023; Morales & Atziena, 2022).

2.1. RIS and green path development

In this article, we build on work that combines the EEG approach with the literature on RIS. This work elucidates how place-specific systemic conditions – encompassing not only industrial structures (as emphasised by EEG frameworks) but also organisational support structures and institutional configurations – enable or constrain the development of new green economic activities in regions (Tripl et al., 2020).

Extant research has revealed that pre-existing regional industrial structures can facilitate green path development. Green industries may grow out from mature ones, drawing on existing knowledge and skills (Boschma, 2017). Focusing on organisational support structures and institutional set-ups, various studies have accentuated the presence of support actors with capabilities to nurture green transitions (Capasso et al., 2019), environmental laws and regulations, collective visions and a widespread acceptance of sustainability values (Hansen & Coenen, 2015). However, RIS could also impede green shifts. Adverse effects of pre-existing industrial structures might be the outcome of lock-ins of mature sectors and a poor endowment of skills, knowledge and other assets (Boschma et al., 2017; Hansen & Coenen, 2015; Hassink et al., 2019). Further, various barriers residing within the organisational support structures and the institutional set-ups have been identified, including the lack of capabilities within support organisations, institutional rigidities, policy path dependencies, as well as unsustainable social practices and consumption patterns (Capasso et al., 2019). RIS are embedded in multiscalar environments marked by global knowledge and investment flows, market dynamics and supra-regional institutional contexts (Hassink et al., 2019). They can be drivers of green industries but may also be a source of fragility of green path development (Chlebna & Mattes, 2020).

2.2. RIS reconfiguration and system-level agency

Elaborating on the potentially constraining effects of RIS on green path development, scholarly work emphasises that the organisational support configurations and institutional set-ups of RIS co-evolve with and tend to be firmly adapted to the region's long-established economic structures. 'In other words, past rounds of industrial development are reflected in the region's research and education programmes, its skill base, dominant policies and institutional setups' (Tripl et al., 2020, p. 192). Through their strong alignment with established industries, support structures strengthen old paths but may be poorly equipped to facilitate the development of new ones. This is corroborated by contributions on CORIS (Isaksen et al., 2022; Tödting et al., 2022). This work suggests that historically grown (regional) innovation systems are often unfit for addressing environmental and social challenges as they hardly back sustainability innovation and green path development (Tripl et al., 2023). Established actor constellations, network

practices and institutional configurations are perceived to reinforce unsustainable pathways, calling for a reconfiguration of innovation systems (Tödting et al., 2022).

The CORIS approach expands upon the conventional RIS concept by adopting a broader perspective on the purpose of innovation-based path development. It complements the traditional emphasis on economic growth and international competitiveness by focusing on societal problems. It emphasises the need to include not only traditional innovation actors (firms, universities, policy organisations) but also hitherto neglected actors such as civil society organisations, users or labour unions into path development processes, since they can play (or should play) a significant role in developing, implementing, and scaling innovative solutions for pressing societal challenges (Tripl et al., 2023). Whether these actors are actually afforded the opportunity to engage in and co-shape innovation-based path development and the reorientation of RIS (see below), or if they are being excluded, is an important topic of debate in the emerging literature on the politics of path development (Eadson & van Veelen, 2023). The CORIS approach builds on core concepts of transition studies like conflicts between actors on the regime and niche levels. By mapping and analysing the place-based structures and agencies of multiple actors at various spatial scales, it adds to the multilevel perspective (Geels, 2019) by unravelling the multiscale configurations and spatial dynamics of transitions.

As noted above, green industrial transitions often require a reconfiguration of innovation systems. Recent work casts light on how such processes unfold, unravelling how existing structures are reoriented and new ones established (Isaksen et al., 2022; Tripl et al., 2023). Yet, in this literature little is said about why a rearrangement of RIS may not succeed. Inherited RIS structures can be extraordinarily stable and therefore hard to change. However, explanations that centre on inertia, path dependencies and lock-ins may not suffice. Failures to rearrange RIS structures can also be the outcome of strategic interventions undertaken by actors who seek to preserve existing system configurations and purposefully impede or delay their rearrangement (Baumgartinger-Seiringer, 2022). This necessitates a close examination of the role of agency in such processes.

Agency perspectives have gained foothold in scholarly debates on (green) path development (Isaksen et al., 2019; Jolly et al., 2020). Much attention has been devoted to system-level agency, which can be defined as ‘collective and distributed activities enacted by firms, non-firm actors and intermediaries in developing and adapting the relevant supportive innovation system structures’ (Gong et al., 2022, p. 527). System-level agency can be undertaken by different actors, who may influence (regional) innovation systems and green paths through collective vision building, networking, resource mobilisation, institutional change, or policy design and implementation (Isaksen et al., 2019; Sotarauta et al., 2021).

Considerable focus has been given to ‘change agency’ (Gong et al., 2022; Sotarauta et al., 2021). Lately, there has also been a growing interest in what is called ‘maintenance agency’, that is, agency seeking to secure the persistence of existing structures, thereby countering pressures for change (Bækkelund, 2021; Baumgartinger-Seiringer, 2022; Henderson, 2020; Jolly et al., 2020). Jolly et al. (2020, p. 179) point to a variety of actions that contribute to reproducing the status quo, such as ‘introducing new practices to create deterrence for change, supporting the persistence of existing institutional routines, and using narratives to support the routinisation of existing practices and adherence to rules’. Building on insights from transition studies (Geels, 2014; Turnheim & Sovacool, 2020), Baumgartinger-Seiringer (2022) further advances understanding of the role of maintenance agency, uncovering how incumbents employ various channels of power to stabilise existing RIS structures that support their interests.

The findings from the recent literature synthesised above provide a useful analytical basis for our examination of bioplastics in Lower Austria in section 4. We adopt the (regional) innovation system approach (e.g., Tripl et al., 2020) to unveil the place-based and non-local structural conditions (pre-existing industries, organisational support configurations, institutional set-

ups) for the development of the bioplastics path in Lower Austria. We analyse and discuss three dimensions in more detail, including (1) the plastics industry in the region; (2) the research and intermediary sectors; and (3) the policy landscape and legislative–regulatory context. In order to identify forces of stability and impulses of change in these system components and the ways in which they are reconfigured (or not), we draw on emerging agency perspectives (Isaksen et al., 2019). Building on Baumgartinger-Seiringer (2022), we pay close attention to system-level maintenance agency and examine how heterogeneous actors operating at various spatial scales seek to manipulate innovation system configurations to their favour.

3. THE PLASTICS INDUSTRY AND THE EMERGING BIOPLASTICS PATH IN LOWER AUSTRIA

3.1. The plastics industry in Lower Austria

Lower Austria is the largest of Austria's nine federal states (provinces) in terms of surface area, and with 1.7 million inhabitants it is the second largest in terms of population (Statistics Austria, 2022). With companies of global significance in the region, the plastics industry is among the most important sectors in Lower Austria. According to Statistics Austria (2022), around 130 plastics-processing companies are located in Lower Austria, employing 5000 workers and generating revenues of €1290 million (as of 2019). In the period 2015–2019, the number of enterprises has remained fairly stable, while the number of employees, salaries and revenues have shown a modest growth (Statistics Austria, 2022, authors' own calculations). The plastics industry in Lower Austria is dominated by powerful incumbents. Global market leaders in the production of food packaging, water and construction pipes, and medical equipment run manufacturing plants in the region. Further, several firms produce components for the global aviation and automotive industries. For the Austrian market, the industry provides a range of generic products such as packaging, plastic bottles and foam mattresses.

Over the past years, the plastics industry in Lower Austria has come under increasing societal pressure. Like in many other countries and regions (Dijkstra et al., 2020; Kishna et al., 2017), the industry has been facing growing concerns over greenhouse gas emissions of plastics production and the leakage of plastic waste into the environment. Yet, production and sales have been remaining at high levels (see above). This also reflects specific features of the market. While citizens call for more sustainability, this does not translate into a demand push for innovation (Siltaloppi & Jähi, 2021).

3.2. The development of bioplastics in Lower Austria

Experimentation with bioplastics in Lower Austria started in the mid-2000s. Pioneering activities by firms were supported by the regional policy level and stimulated by participating in European research projects (Amlinger & Fritz, 2008). Early-use cases included biodegradable plastic bags for supermarkets and bio-based glue produced by a company operating in the agro-industrial complex. A key step for the further development was the foundation of a so-called 'Biopolymer Team' by the intermediary organisation Ecoplus (Lower Austria's business agency) in 2009. The goal of this initiative was – and still is – to ultimately set up an entire production network for bioplastics from the agrarian raw materials to finished products. Starting with five members in 2009, the Biopolymer Team now counts 24 members, including firms, research organisations and public actors.

Lower Austria's bioplastics path is 'populated' by heterogeneous firm actors. More precisely, the firms involved differ strongly in terms of size and dedication towards the commercialisation and diffusion of bioplastics. The most dedicated actors are small, specialised bioplastics firms. Bigger companies show a more conservative attitude. They experiment with bioplastics while

at the same time maintaining their established business models which are based on conventional, fossil-based products (see also section 4.2).

4. THE BIOPLASTICS PATH IN LOWER AUSTRIA: IMPULSES FOR CHANGE AND FORCES OF STABILITY

4.1. Data and methods

Our analysis is based on a qualitative case study approach (Yin, 2018) and draws on 13 in-depth interviews carried out between May 2021 and March 2022 and a document analysis. Five interviews were conducted with conventional plastics and pioneering bioplastics firms operating in the region (C1–C5), five with representatives of the research sector in Lower Austria and its neighbouring regions (R1–R5), and another three with intermediaries operating at the regional and supranational level (I1–I3). A limitation of our study is the absence of interviews with actors who have not been involved in the development of either the old fossil-based plastics path or the bioplastics path, namely actors such as civil society organisations, users, trade unions, etc. While all interviews were open-ended and the guideline tailored to the interviewee's background, every interview followed a similar structure. Interviews focused not only on organisational strategies but also on capturing the wider innovation system dynamics and the ways in which various actors from different fields have been influencing these dynamics. Despite their different organisational background, all interview partners had a deep knowledge of past and ongoing developments in both the plastics industry and the bioplastics path, and they showed a strong capacity to provide insights into and reflect upon the strategies and interventions undertaken by powerful actors in manipulating innovation system structures. Interviews lasted between 50 and 70 min. The interview participants have provided oral consent for the recording of the interviews and have given their permission for the information gathered to be used for our study and any subsequent publications. Interviews were transcribed, coded and analysed. We used a qualitative content analysis based on themes that emerged from the literature review (section 2). Furthermore, interviews have been complemented by a document analysis covering a variety of regional, national and supranational policy documents, papers and reports. Finally, in May 2022, the preliminary findings from our empirical analysis were presented to three representatives of Ecoplus to identify and discuss issues that might have been overlooked during the interviews. This discussion however did not yield further insights but largely confirmed our findings.

In the following subsections, we zoom in on three innovation system components (including industrial structures with a focus on the old plastics industry, the organisational support configurations, and institutional set-ups). We examine the effects of these components on the nascent bioplastics path and analyse how various actors are seeking to shape the innovation system structures inherited from the past.

4.2. Industrial structures: the role of the plastics industry

The plastics industry forms an essential component of the industrial structures of Lower Austria's innovation system. Examining the effects of the traditional plastics sector on the new bioplastics path, we found little evidence for positive impacts. This is not to ignore that some plastics firms have begun to diversify into bioplastics. This includes the provision of raw materials that were previously used in other sectors (such as agriculture) for new applications in biomaterials, and in rare cases the replacement of conventional plastics products by bioplastics, where deemed economically feasible. Other examples are so-called 'bioplastic covers' for strawberry fields and protective covers for trees against damage from wildlife. These activities are, however, limited to small niches. Importantly, insights from our interviews suggest that

limiting bioplastics to these niches is deemed desirable by major plastic producers in the region (C2, I2, I3, R4).

One could also observe various partnerships between plastics firms and new companies specialised in bioplastics (C1, C4). These often take the form of temporary cooperation projects in areas such as the design, production, and market positioning of bioplastics. Some incumbents are also taking part in longer term institutionalised networks such as the 'Biopolymer Team' (see section 3).

While positive influences are clearly limited in scope, we found ample evidence for vast negative effects of the old path on the new one. Lower Austria's traditional plastics industry is extraordinarily stable. This stability is not only the outcome of lock-in, path dependence and inertia but is cultivated and preserved through maintenance agency. The majority of plastics firms are actively resisting change. This seems to hold true even for those firms that take part in the networking activities organised in the context of the Biopolymer Team (see above). Incumbents engage in these activities (I3), while at the same time defending and stabilising the old path and creating barriers to the (further) development of bioplastics (C3–C5).

Bioplastics challenge the economic positions and business models of old path actors. Incumbents protect their vested interests through various forms of maintenance agency. Together with partners from academia and industry associations (see also section 4.3), they have formed an alliance oriented towards conserving the status quo. This alliance has considerable political power, resulting in the slow implementation and continuous postponing of environmental legislation, and a lax execution of regulations. As one interview partner (C1) put it:

we are taking steps backwards, also with things that were already decided ... several regulations and initiatives that were supposed to have been implemented long ago ... are now not being followed through. They [the regulators] say that in the current situation they will surely not force the companies to do things that have to be done. Let me remind you: The ban on plastic bags which was agreed on last year with great turmoil, was followed by an extensive transition phase. And now we even have the situation, that we see fake bags on the market, where non-degradable polyethylene is used. It says 'bio' on it, the people are being ripped off, and nobody checks it, nobody cares.

The reaction of plastics firms in Lower Austria to new national and EU policies (such as the European Green Deal and the Fit for 55 package) is dismissive. Incumbents question the feasibility of many measures such as the plastic tax and condemn the 'ever increasing number of new laws and plethora of environmental legislation that firms have to comply' (C5). This is a common tactic to argue for a weakening of strict policies.

Further, incumbent firms in Lower Austria and their allies downplay environmental and health problems related to plastics production and reframe debates over those concerns as unwarrantable 'plastic bashing' (C5, R2). They keep defending the virtues of conventional plastics. Interestingly, incumbents consider the COVID-19 crisis as a window of opportunity for maintaining the status quo (I2, I3). The pandemic is seen as a chance to defend themselves and demonstrate the importance of the industry. 'The industry has been suffering from plastic bashing for a long time ... suddenly there was an enormous hype around plastic products ...' (I2). Conventional plastics are viewed as a pandemic-fighting solution, with the public sector demanding large quantities of these products, thereby supporting existing business models through emergency measures. Also, incumbents welcome the (temporary) loss in importance of societal debates on sustainability issues and the substantial weakening of green ambitions since the outbreak of COVID-19 (C2).

What is more, incumbents negate the benefits and feasibility of bioplastics. More precisely, they raise concerns about the new path, questioning the sustainability aspects of bioplastics and its economic viability (C1, C3, I1). The emerging path is delegitimised by incumbents in public

discourses. As a representative of a bioplastics firm put it: ‘We have been belittled ... an aberration ... impossible to make it a reality or upscale it. ... The challenge is that there is a very old industry that views us with a great deal of suspicion’ (C4).

Maintenance agency is also expressed in incumbents’ attempts to push for what they call an alternative solution, that is, recycling, thus framing the relation between the two emerging paths (bioplastics and recycling) as competitive. However, such negative inter-path relations do not necessarily exist (C4). By advocating recycling, incumbents seek to strategically weaken the bioplastic path (C2, I1). Recycling is not only backed by conventional plastics producers but also by machine manufacturers, representing an industry that is especially strong in Lower Austria (C1) (Statistics Austria, 2022). Machine manufacturers have more to gain from recycling than from bioplastics. That is because bioplastics require little to no new machines, but can be processed by changing parameters on existing machines (C4). An increase in recycling quotas, however, necessitates an increase in recycling capacity and thus promises higher revenues for companies who manufacture recycling machines. Fighting bioplastics and pushing recycling is problematic, because a sustainable plastics industry requires both; a circular economy fuelled by renewable inputs (BMLFUW, 2015; Ecoplus, 2021; European Commission, 2018).

Firm incumbents undertake a wide array of interventions (ranging from lobbying to prevent or delay environmentally friendly regulations and policies to delegitimising bioplastics and pushing a specific framing of inter-path relations) to preserve system structures that serve their economic interests.

4.3. Support system: the role of the research sector and intermediaries

Next to powerful plastics firms, various actors within the organisational support structures of the innovation system, particularly research organisations and intermediaries, have been found to shape Lower Austria’s bioplastics path.

4.3.1. Research sector

Both Lower Austria’s plastics industry and the emerging bioplastics path sustain manifold knowledge linkages with universities and other research organisations at different spatial scales. Connections to international research partners ensure the constant influx of new knowledge to the region (C2, R3). Of particular interest are however relations between firms and various public and private research organisations situated in Lower Austria and its neighbouring regions.³ The latter play ambivalent roles. Some researchers are driven by normative goals and support the development of bioplastics (R4, R5). They undertake various research projects with small bioplastics firms. In our interviews, they featured the potential of bioplastics for certain applications and referred to it as a ‘partial’ solution in an era of environmental degradation (R1, R3).

Other actors in academia have a long history of successful research and innovation projects with incumbent companies. As the driving forces behind these university–industry partnerships are often established plastics firms, they influence the direction of research, which results in a lot of incremental innovation aimed at optimising existing business models that rest on fossil-based plastics (C5, R1, R3). University researchers with close ties to incumbent firms are however more than mere knowledge providers and innovation partners. Some of them are part of the alliance (see also section 4.2) that defends the old path and propagates conventional plastics as ‘the solution’. Being loyal ‘old path advocates’, they object the benefits of bioplastics and question its usefulness, pointing to limitations in terms of ecological sustainability, application opportunities and societal desirability (R2). At the same time, the widespread use of conventional plastics is legitimised. In the interviews taken with some of those incumbent university researchers, they accented that conventional plastics would be more sustainable than other forms of packaging (paper, bioplastics), and – referring to cheap packaging – also more societally desirable (R2).

Thus, while some researchers support bioplastics and have forged links to pioneering firms in that field, others are loyal companions of conventional plastics firms. They perpetuate established innovation trajectories and delegitimise bioplastics on different grounds.

4.3.2. *Intermediaries*

At the regional level, the business agency Ecoplus has played (and is still playing) a crucial role in supporting the bioplastics path. It has been portrayed as an ‘enabler and catalyst’ (C3). Many of the business agency’s activities are organised within the context of their cluster initiatives (I3).

One representative from Ecoplus describes the role of the organisation as being a ‘technology radar’ (I2) that scans the global market for innovations that could become relevant for Lower Austria’s companies in the future: ‘And we try to use this window of five to ten years, until an innovation becomes relevant on the global market, to generate knowledge in projects with Austrian and international researchers and frontrunner companies’ (I2). This knowledge is then supposed to serve as a basis for further development (I2).

Ecoplus’ overall vision is that Lower Austria will become a technology exporter in bioplastics and a global leader in the field. Achieving this goal will however require more than the initiation of change and an exclusive focus on knowledge generation. Ecoplus restrict themselves to bringing knowledge and technological innovation to the region, while taking a largely neutral stance in sustainability transitions. They seek to find a middle ground between incumbents and newcomers who show strong differences in their visions about the future of the plastics industry.

Put differently, Ecoplus finds itself in the difficult position of having to do a ‘balancing act’ (R3), promoting bioplastics while at the same time serving the interests of the incumbent fossil-based plastics industry. Making bioplastics a key capability of Lower Austria is a goal that intermediaries need to pursue in the context of extraordinarily strong incumbents. In fact, one interview partner stated that the wider diffusion of bioplastics would not merely be a technological or market process that depends on costs, margins, and demand. ‘Transformation [towards bioplastics] is ... a process of negotiation’ (I2). Acting against incumbents in that process is hardly an option for Ecoplus. ‘Policy needs to legitimise itself’ (R5). Through their membership fees, traditional plastics firms contribute a good deal of money to the budget of Ecoplus and the running of its cluster activities. Incumbents stress that weakening the old path may cause socioeconomic frictions in the region. Given its size, the fate of the conventional fossil fuel-based plastics industry is of big concern in Lower Austria with respect to regional income and employment (I2). This helps to explain why Ecoplus shows a focus on the initiation of change by fostering knowledge accumulation and refrains from supporting the consolidation of the bioplastics path and the widespread diffusion of innovation in that field.

Lower Austria’s bioplastics path is also affected by organisations operating at higher spatial scales. At the national level, intermediaries are an active force of stability, seeking to prevent or at least slow down changes towards bioplastics. This holds in particular true for the leading industry association, where officials are closely aligned with conventional plastics firms and sustain strong ties also to incumbents in academia (C5). In one case, the CEO of a company is at the same time the Austrian federal representative of the plastics sector. These double functions and tight networks to incumbent firms and researchers lead intermediaries to strongly support conventional plastics.

Finally, various interview partners pointed to important roles played by intermediaries at the supranational level (C4, I2). Lower Austria’s bioplastics actors benefit from intermediaries such as European Bioplastics, an association that represents the interests of the bioplastics industry in Europe. This body pushes for tougher EU policies and stricter regulations for conventional plastics. Additionally, providing information about the properties and applications of bioplastics is a focus point (I1).

Lower Austria's 'old path actors' alluded to the support from supranational intermediaries such as the trade association Plastics Europe. Unsurprisingly, this body advocates conventional plastics and engages heavily in lobbying for weaker regulations. Further, existing or emerging kinds of fossil-based plastics are presented as advantageous and being 'part of the solution' in combatting environmental problems.

To summarise, there are impulses for change emanating from university researchers, the regional business agency and intermediaries operating at the supranational level. At the same time, there is evidence how other researchers and intermediaries mobilise their long-established connections to the traditional plastics industry to conserve existing innovation system structures.

4.4. Institutional configurations: the role of policy landscapes and legislative–regulatory contexts

The bioplastics path is strongly affected by multiscalar policy influences and legislative and regulatory contexts. The supranational level has been found to play a vital role. Interview partners have identified European Union bodies as the key driving force in supporting the development of bioplastics (C1, C4, R2). At the EU level, initiatives and measures range from funding research to setting regulations, providing subsidies, and creating shared market rules. Additionally, attempts to introduce a coherent standardisation and labelling scheme for sustainable bioplastics are undertaken to ensure that the production and use of bioplastics supports the EU's efforts to reduce CO₂ emissions and the environmental impact of plastic waste (Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019). The weakest element in the EU's overall portfolio of measures are EU-wide market regulations supporting bioplastics. In this regard, the national level is supposed to play a significant role.

While other countries such as France and Italy have already created beneficial regulatory environments for bioplastics, in Austria the national level has been identified as a retarding force (see also section 4.2 for the slow implementation of policies and regulations supporting bioplastics). One can spot a strong focus on supporting research (the nation-state as funding body) while activities for market formation tend to be sidelined. Our interviews suggest that national policy actors are hesitant to incentivise changes and refrain from developing a clear vision and from setting common goals (R3). Apart from research funding, little is done at the national level to mobilise different stakeholders and provide direction to spur the (further) development bioplastics (C2).

Notable exceptions are the formulation of a national bioplastics strategy and a national bioeconomy strategy (BMLFUW, 2015; BMNT et al., 2019). However, besides these strategies, little has been done to boost bioplastics. Two representatives from small bioplastics firms explicitly address a lack of market formation policies to bridge the gap between research and diffusion and point to missing regulations as critical for upscaling bioplastics (C1, C4). The wider national regulatory context is clearly insufficient for reducing the fragility of the bioplastics path.

At the regional level, manifold initiatives have been pursued to support bioplastics. The provincial government has been funding research and dissemination activities in the field of bioplastics since 2005. Bioplastics is considered one important area to create jobs in the region and to help protecting the climate (I3). Initiatives like public support of biodegradable plastic bags and more recently the establishment of a bioeconomy platform have been steps to implement this strategy (Ecoplus, 2021). What stands out in terms of the legal framework, though, is the regional legislation on the processing of bioplastics waste. While Lower Austria allows for waste of biodegradable plastics to be collected together with other biological matter, for example food waste, this is not possible in the neighbouring region of Vienna (C4). Lower Austria's approach has the advantage of processing bioplastic waste to its full potential, as it is

not simply burned but decomposed. This shows that there is room for manoeuvre for establishing favourable regulatory framework conditions at the subnational level.

Taken together, Lower Austria's bioplastics path is embedded in a complex and multifaceted policy and legislative–regulatory context. Supranational (and partly regional) ambitions to consolidate the bioplastics path have thus far been counterbalanced by slow-moving or resistant actors at the national level.

4.5. Summary

The case of bioplastics in Lower Austria illustrates how green path development is influenced by innovation system structures and the way in which actors from various domains shape those system conditions. Influential incumbents undertake strategic interventions to block change and work against a rearrangement of the historically grown innovation system that would favour the further development of bioplastics.

Our analysis reveals that powerful plastics firms impede institutional change by opposing environmental regulations and policies. What is more, they delegitimise bioplastics in public discourse and further weaken it by pushing recycling. In fact, with bioplastics and recycling we find two emerging paths that compete over resources, political influence and standing in public discourse. Incumbents from the old industry seek to construct the relationship between the two new paths based on their interests and frame it as being mutually exclusive rather than complementing each other. Furthermore, they influence the direction of academic research and exert pressure to ensure that networking and cluster activities do not threaten their business models. Put differently, they prevent changes in the organisational support structures from taking place.

Importantly, Lower Austria's plastics firms are supported by allies from universities and national and supranational intermediaries to ensure the alignment of innovation system structures with the old fossil-fuel path. Certain university actors are found being reliable partners in research and innovation along established trajectories, leading to innovation outcomes that are incremental in nature and help stabilising the old path. These actors, along with national and supranational intermediaries, also contribute to delegitimising the bioplastics path.

This is not to deny that there are also impulses for change that benefit Lower Austria's small bioplastics firms and their research partners. To begin with, EU policy actors and intermediaries such as European Bioplastics work towards a reconfiguration of supranational support structures, facilitating bioplastics through funding, favourable regulations and policies. These impulses, however, are trickling down very slowly to the national and regional level. Impetus is also found at the regional level, where policy actors and intermediaries like Ecoplus have been initiating change by fostering knowledge accumulation and networking activities in the field of bioplastics. However, little is done to fuel the maturation of the nascent bioplastics path. Its consolidation has thus far been prevented by incumbents' maintenance agency. Bioplastics is strategically kept in a niche (both at the firm and regional levels) even by those incumbents that have begun to experiment with it and take part in longer term networking activities. To summarise, forces of stability clearly trump impulses for change. A powerful alliance made up of incumbents from various domains impedes changes at the system level that would favour resource-weak small newcomers in the bioplastics field.

6. CONCLUSIONS

Scholarly work has begun to unveil the ways in which RIS rearrangement processes take place for green path development to gain momentum (Isaksen et al., 2022; Tripl et al., 2023). In contrast, failures to reconfigure innovation systems have thus far received little attention. Drawing on insights from the growing literature on the role of agency in path development, we claim

that due attention should be paid to maintenance agency, that is, how actors undertake strategic interventions to prevent RIS reconfiguration from happening (Baumgartinger-Seiringer, 2022).

Our empirical analysis of the bioplastics path in Lower Austria has provided several insights into the role of agency in catalysing or preventing changes in structural conditions that would favour green path development. This new path emerged already in the 2000s but has thus far failed to take hold. Our analysis suggests that its fragility (Chlebna & Mattes, 2020) is not due to a lack of technological knowledge or missing competences in the (regional) innovation system. Rather, it is the outcome of active resistance to change. Powerful firm incumbents and their allies from academia and intermediaries constrain the maturation of bioplastics and prevent or delay the reconfiguration of the innovation system through various forms of distributed yet highly orchestrated maintenance agency. The involved actors employ a range of strategies to allocate resources between different paths (plastics, bioplastics and recycling), and to maintain an innovation system that is in their favour. To this end, powerful business actors, intermediaries but also researchers shape the wider, multiscalar context in which innovation-based path development is taking place. This leads us to conclude that the outcomes generated by innovation systems and path development are a highly political matter.

Further research is needed to deepen our understanding of these processes and their variations across different spatial and industrial contexts. Future studies could build upon recent work on ‘green and just transitions’ and the politics of path development (Eadson & van Veelen, 2023), which emphasises the importance of politics and power relations, urging a critical examination of questions about the beneficiaries of (new) path development, the dynamics of actor inclusion and exclusion in decision-making, and the unequal capabilities to exert agency (Eadson & van Veelen, 2023). In conclusion, further exploring these dynamics and critically examining the power dynamics and agency in path development and RIS reconfiguration, should rank high on future research agendas.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICS STATEMENT

This manuscript includes interview data. The interview participants provided oral consent for the recording of the interviews and gave permission for the information gathered to be used for this study and any subsequent publications. Ethical approval of the study by the University of Vienna was not required because our research did not involve any potentially unethical and/or adverse effects for the participants involved. Our research was set up to respect the fundamental values of dignity, liberty and health, and complied with the legal provisions stipulated by the Statutes of the University of Vienna. The research was designed to ensure that it did not threaten the physical or mental integrity, the right to privacy, other subjective rights or prevailing interests of participants. Adequate protection of the rights, safety and welfare of the participants was ensured during the implementation of the research project.

NOTES

¹ A regional industrial path can be defined as ‘a set of functionally related firms and supportive actors and institutions that are established and legitimised beyond emergence and facing early stages of growth, developing new processes and products’ (Binz et al., 2016, p. 177). Following Eadson and van Veelen (2023, p. 218), green path development can be understood as ‘industrial change associated with environmentally beneficial products and services’.

² In contrast to conventional plastics, which are made from fossil fuel-based raw materials, a plastic material is considered a bioplastic if it possesses either biobased, biodegradable properties or both (European Bioplastics, <https://www.european-bioplastics.org/bioplastics/>; see also Shamsuddin, 2017). The term 'biobased' refers to the utilisation of biomass (plants) as a primary source, indicating that the material or product is derived, at least in part, from organic matter. Biodegradation refers to a chemical process facilitated by microorganisms in the environment, leading to the conversion of materials into natural substances (water, compost, CO₂, etc.) (European Bioplastics). Biobased plastics that are not biodegradable are, for example, biobased polyethylene terephthalate (PET) products. Plastics that are both biobased and biodegradable include starch blends or the relatively popular polylactic acid (PLA). Lastly, some materials are fossil based but biodegradable. Compared with fossil-based plastics, bioplastics is said to have several sustainability benefits. Using biobased inputs saves fossil resources and can reduce CO₂ emissions during the production process, and they can help to reduce plastic pollution by being degradable or compostable. It is important to add that the sustainability of bioplastics depends on the precise mode of production and processing as well as on recycling capacities (e.g., Shamsuddin, 2017).

³ A key player is the Institute of Natural Materials Technology situated in Lower Austria. It belongs to the University of Natural Resources and Life Sciences and is well-known for its research on the optimisation of bioplastics for various applications. Other research organisations located in the neighbouring regions of Vienna, Upper Austria and Styria, such as TCKT (Transfer Center for Plastic Techniques), Technical University of Vienna, Johannes Kepler University Linz and Montanuniversitaet Leoben, also play important roles.

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