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## Grasping transformative regional development from a co-evolutionary perspective – a research agenda

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# Grasping transformative regional development from a co-evolutionary perspective – a research agenda

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## **Abstract**

A comprehensive perspective of regional transformative development is pertinent in light of recurring crises and grand societal challenges. We propose an integrative research agenda for transformative regional development, based on a co-evolutionary perspective on industry-focused regional path development and transitions. Combining existing knowledge from the debates on evolutionary economic geography and transition studies we define three key dimensions of co-evolution: the interrelations between different paths and their impact, interregional and multiscalar development dynamics, and the interdependence between industries and society. We address each dimension separately and suggest concrete avenues for further research.

## **Key words**

Evolutionary economic geography, regional industrial path development, socio-technical transitions, co-evolution, research agenda.

# 1 Introduction

Much of economic geography highlights the role of regions and regional conditions in favouring or hindering innovation and associated economic growth. Studies of regional industrial path development focus on technological development as the central driver of regional economic evolution while other influential factors such as social, institutional, and ecological considerations are less in focus. Yet, forced by recurring global crises such as the global financial crisis or the recent global pandemic situation and their impact on regions, scholars increasingly recognize a need to rethink priorities and have identified regions as core to the undertaking (Donald & Gray, 2019; Toedtling & Trippl, 2018).

This has implications for concepts and derived policies in regional development. Established modes of thinking and paradigms are questioned (Hassink & Gong, 2017; Schulz & Bailey, 2014). Numerous recent contributions have offered approaches to expand existing concepts and to demand updated views on regional development and transformation (Coenen & Morgan, 2019; Hassink et al., 2019; Njøs et al., 2020; Weber & Truffer, 2017). Whilst many of these make important contributions to our understanding, we do not yet have a consolidated research agenda for transformative regional development.

The objective of this paper is to contribute such a research agenda on transformative development of regions. Core to our undertaking is a co-evolutionary understanding of industrial pathways, often anchored in regions, and (regional) transition processes at large. We thereby combine insights from the regional path development literature (as an industry focused approach) and the transition literature (viewing technological development as part of wider socio-technical system transformation). While the combination between the debates on regional industrial paths and socio-technical transitions is not completely new, the interdependency of the two complementary concepts is not yet fully understood. By combining both perspectives, we are able to view transformative regional development as shaped by a broader interplay of technological, social, economic, ecological, and institutional factors (Loorbach et al., 2017). For the consideration of regional industrial development, we therefore define three core dimensions of co-evolution with transition at large: 1. industries interact with each other and alter the directionality of regional pathways; 2. Industries are embedded in space, there are important interrelations both between different regions and

between different scales; 3. Industries interdepend with societal dynamics. Within each, we lay out core research avenues aiming towards the identification of the concrete mechanisms that determine the dimension.

The paper is structured as follows. In section 2, we re-visit the two largely separate debates on regional industrial paths and socio-technical transitions and clarify each of their contributions to understanding regional industrial transformation. We summarise this section with a brief review of existing efforts to integrate both debates. Building upon these insights, section 3 identifies and explains the dimensions as introduced above and section 4 specifies relevant research questions to shape a research agenda for grasping regional transformation from a co-evolutionary perspective.

## **2 Towards an integrative agenda: Core aspects of regional path development and socio-technical transitions**

We dedicate this section toward two important debates that have tended to be led largely separately but recently are increasingly recognised in their complementarity: that on regional path development and that on socio-technical transitions. Our contribution is based on a co-evolutionary understanding of regional industrial path development and ongoing transition processes. Such a perspective particularly highlights the multi-scalar nature of a development and points at the importance of non-economic factors (Gong & Hassink, 2019). While this is well accepted on a general level, we agree with Dijk and Kemp (2010) when they stress that “without explicating the processes or mechanisms that constitute co-evolution [...] the term becomes merely a synonym for interaction or co-dynamics” (p. 60) and, with our contribution, seek to encourage research to better understand the concrete mechanisms of co-evolution of regional industrial path development and transitions. In the following we introduce both debates and identify key aspects.

### **Regional industrial path development**

The regional context provides a common setting for studies of industrial development and innovation. Regions hold varying actors, resources, and networks, as well as (historical)

preconditions that are more advantageous for some industries than for others (Hayter, 2004). We here define regions as subnational entities that often have their own jurisdiction and are determined in their development by the present resources, institutions, actors and networks but are also embedded in and influenced by multiscalar and geopolitical dynamics (Chlebna & Mattes, 2020; Faller, 2014; Jehling et al., 2019; Pierce et al., 2011)<sup>1</sup>. Central for our contribution, to begin with, is therefore the research field on regional path development in economic geography. In this perspective, regional development is strongly associated with the development and specialization of industries (and their growth and decline). Regional development paths depict how firms and industries compete on their technological routines, pointing at a strong relationship between technological innovation and industry development (Boschma & Martin, 2010; Schumpeter, 1942 [2008]). The initial interest in industrial path development can be ascribed to the incorporation of ideas from evolutionary economics into the discipline (Frenken & Boschma, 2007). Core to this literature is the idea that (co-located) firms tend to develop alongside related technological foci based on existing complementary infrastructure and shared knowledge bases<sup>2</sup>.

Inspired by evolutionary approaches, contributions from political and institutional economic geography also shed light on the role and scope of policy, institutions and agency, for regional industrial change (Dawley et al., 2015; Grillitsch & Sotarauta, 2019; Isaksen & Trippel, 2016; MacKinnon et al., 2019; Morgan, 2013). These works stress that not only firms, but also other actors involved in regional innovation, such as providers of innovation infrastructure and research, contribute to shaping regional industrial dynamics (Zukauskaite, 2018). Also firms and entrepreneurs from outside the region are acknowledged to have an effect on new path development (Trippel et al., 2018).

Building on different de-locking scenarios by Martin and Sunley (2006), scholars have developed typologies of path development that regional industries can undergo (Grillitsch et

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<sup>1</sup> For a comprehensive collection of contributions discussing the term from various perspectives and illustrating its complexity, please refer to Paasi et al. (2018).

<sup>2</sup> For an in-depth discussion including several existing definitions of the 'path' concept, refer to Miörner (2019, pp. 24–28).

al., 2018). The diversification of regional industries into related technological fields tends to be considered the rule (Frenken et al., 2007) while unrelated diversification, i.e. the growth of industries based on entirely new technological or organizational knowledge tends to be seen as an exception (Aarstad et al., 2016; Boschma, 2017). Technological innovation as well as knowledge creation and re-combination between firms and knowledge infrastructure organizations are considered main drivers for path development (Martin, 2020).

Recent contributions emphasize the role of agency and the question how actors shape and alter regional industrial development paths (Grillitsch & Sotarauta, 2019; Isaksen et al., 2019; Jolly et al., 2020; Simmie, 2020). In order to achieve change, actors need to break from existing social rules and technological paradigms, which presumes capacities of regional actors to induce and uphold change dynamics (Simmie, 2012). In other words, pioneering actors (including universities, companies and/or governments) are able to change regional economic development by purposive action. At the same time, they are understood to be influenced by local and regional institutional structures (Rekers & Stihl, 2021). The literature on regional development paths thus emphasizes a multiplicity of involved actors (Steen & Hansen, 2018).

Because of its industry-centred view, contributions on regional path development tend to lack a broader perspective on societal change processes and, consequently, struggle to fully grasp transformative change. In other words, these approaches on their own do not explain how the transformation of single industries sums up to transition processes at large, and how more overall, systemic changes can come about. If, however, understood as contingent upon and in a co-evolutionary relationship with socio-technical transitions, industrial paths are crucial components that carry explanatory weight.

### **Socio-technical transitions**

Research on socio-technical transitions stresses that technological development is determined by and reflected in the social, cultural and economic context into which it is embedded (Geels et al., 2008; Markard et al., 2012; Truffer, 2008). Socio-technical transitions have their origin partly in evolutionary economics to explain processes of technological change (Nelson & Winter, 1982). Likewise, they are informed by approaches addressing the social construction of technological systems (Bijker et al., 1987).

Central to this literature is to describe and analyse long-term changes of technological systems in their inter-relationship with social and institutional factors. Socio-technical transitions describe the systemic shift that occurs through radical innovation and its diffusion, which transgresses multiple levels, the niche where radical innovation occurs, the regime which denotes the predominant technology system, and the landscape level which develops exogenously and may put pressure on the regime to open up opportunity spaces for innovation (Geels, 2002; Kemp, 1994). Socio-technical transitions may occur incrementally or through radical innovation and diffusion, as regimes come under pressure and adaptations emerge or are strategically put into place (Smith et al., 2005). Transitions tend to be studied around a focal technology (Bergek et al., 2015) and focus on the production side of technologies on the one hand, and also on their demand, respectively the application side, on the other hand. Conceptual core of transitions are socio-technical systems that fulfil societal functions such as transport, communication, or nutrition (Geels, 2004). Socio-technical systems span a variety of factors such as technology, science, production and supply networks, capital, user practices, cultural meaning, markets and infrastructure. Human actors maintain and refine socio-technical systems but at the same time are restrained, enabled, and guided by formal as well as informal institutions.

Importantly, the transitions perspective facilitates the reflection about normative issues such as the nature of 'growth' or the directionality of change, as well as 'failure' and the wide-ranging intended and unintended consequences of industrial activities, be it in economic, social or environmental terms (Skjølsvold & Coenen, 2021; Turnheim & Sovacool, 2020; Weber & Rohracher, 2012). This is reflected in bodies of literature such as the debate on 'just transitions' (Healy & Barry, 2017; Sovacool et al., 2016). These are issues which have been, to some extent, taken up more recently by scholars in economic geography too (Afewerki & Karlsen, 2021; Sareen & Haarstad, 2018; Toedtling et al., 2021). Blažek et al. (2020) approached the matter analytically and added further 'typologies of decline' to the existing path development typology.

## **Similarities and complementarities of both debates**

The two debates we have shortly introduced above, industrial path development and socio-technical transitions, both shed light onto industrial development and transformation, yet from different perspectives and with different foci.

An important commonality of both debates is their focus on technology development and technological change. Industrial development paths offer an in-depth perspective onto the evolution of industries. They explicitly acknowledge industrial dynamics through a lens of technology development and technological relatedness, whereby they stress the importance of a particular regional context. Industrial branching based on firm-level technological routines is a central field of attention. The transitions concept contributes a more comprehensive perspective on socio-technical change and is less nuanced regarding the underlying industrial dynamics (such as firm-level technological routines and industrial branching processes). Rather, industry development is considered in a broader perspective into which also the demand for and application of technologies incorporates: While the industrial paths community strongly draws on the innovation studies understanding of industries as “set of firms producing similar or substitute products” (Geels, 2004, p. 900; based on Porter 1980), the transitions studies perspective leans more strongly on industries’ roles in contributing to the fulfilment of societal functions (Geels, 2004).

Relatedly, both debates consider a multiplicity of actors and their actions as important to technological and industrial change. Both perspectives conceptualize innovation as a socially embedded process (Granovetter, 1985) that occurs in co-evolution between economic organizations and institutions (Geels, 2014; Gong & Hassink, 2019; van den Bergh & Stagl, 2003), or more broadly defined, between technologies, industrial development and associated structures (Nelson, 1994). In both debates, technological change and industrial development are understood to be an outcome of human agency – contingent upon actors’ perceptions and structured by rules and institutions (Sotarauta & Pulkkinen, 2011; Steen, 2016). Again, the paths literature has contributed with an industry-focused view on how agency can alter technological paradigms that are specific to industries. The transitions debate, however, puts agency in a broader context and considers a larger variety of actors, also including those from the civil society such as grassroots movements, NGOs or consumers (Fastenrath & Braun, 2018). Due to its explicit recognition of directionality for innovation,

normative aspects are addressed more overtly instead of being side-lined or considered contextual (Yang et al., 2021).

Both outlined research strands consider industrial development as context-specific. While the paths literature seeks explicit links to specific regional contexts, socio-technical transitions consider industry development against a wider context, including the above mentioned niche-regime interactions but also longer term societal change processes (Schot & Kanger, 2018). Nevertheless, transition dynamics are highly place-dependent, and their specific course differs between regions. This is mirrored in the ongoing debate on the spatiality of socio-technical transitions (Coenen et al., 2012). From a geographical perspective, regional transitions are crucially shaped by place-dependent local and regional dynamics, but also combine to form a national and in the end global transition process (Bauer & Fuenfschilling, 2019; Späth & Rohracher, 2012). This, however, is not just a simple accumulation of regional transitions but they are inter-dependent processes that may reinforce or impede each other through competition, collaboration, and learning (Hassink & Hülz, 2010; Quitzow, 2015).

There has been an increasing awareness that the two theoretical perspectives of industrial paths and socio-technical transitions can potentially complement one another and contribute to a better understanding of transformative industrial change. Several important contributions have been made with the aim of integrating both debates. We will turn to some of these in the following.

### **Integrating regional industrial path development and transition perspectives – a burgeoning field**

Various starting points for an integrative perspective drawing on elements of path development and transition studies have been offered. There seems to be an increasing awareness that the two approaches could benefit from each other. Numerous academic contributions recognize the potential of integrating the bodies of knowledge on economic geography and sustainability transitions, but only few have made concrete proposals on how to understand and analyse transformative regional development in an integrative perspective. Below we expand on some of the contributions in this emerging field.

One differentiated account of the need to integrate between EEG and transition studies is offered by Fastenrath and Braun (2018). The authors argue that both fields share an “understanding of path dependencies, thinking of continuity of change” as well as recognizing the important role of institutional contexts, “actors and actor networks, grassroots movements and policy makers as key drivers behind sustainability transition” (p 2). They define regional economic structures (i.e. paths), political-institutional structures and socio-cultural structures (i.e. agency and structure) and their interplay as the constituting core of regional transformative change. Toedtling and Trippel (2018) advocate going beyond ‘neoliberal’ approaches and acknowledge that more recent approaches are better suited to grasp and tackle the present global challenges due to their greater attention to multiscale, the direction of transformation, barriers to new path development, co-evolutionary processes and the need for policy coordination. They conclude that spatial differentiation is still underdeveloped and that pro-actively disrupting ‘old paths’ might be equally important as introducing new ones.

MacKinnon et al. (2019) also advocate the integration of sociological/institutional approaches, studies of global production networks (GPN), and of transitions into the study of path creation. The authors propose a framework and argue “that it is knowledgeable actors, operating within multiscale institutional environments, who create paths through the strategic coupling of regional and extraregional assets to mechanisms of path creation and associated markets” (p. 117). Along similar lines, Trippel et al. (2020) developed a framework around the creation, maintenance and disruption of assets combined with a distinction in firm and system level agency with an aim of better grasping the rise of new ‘green’ growth paths as well as the ‘greening’ of existing regional industries.

Capasso et al. (2019) define six key themes – skills, technology, physical resources, markets, institutions and policies – the presence/absence and quality of which they see as determinant of drivers and barriers for green growth. They emphasise a need to understand the relations between green technological development and diffusion at the regional scale as well as multiscale relations. They further point to the potential interdependence between green growth and policy rationales. Similarly, Sjøtun and Njøs (2019) suggest to investigate the policy mix in which clusters and respective programs are interwoven to understand the capacity for green reorientation. Furthermore, they integrate the EEG and transition studies

debates in a ‘technology-organisation-discourse’ approach to account for context specificity and complexity of green reorientation processes.

Building upon these different contributions, we can hence conclude that there is an acknowledged need of a consistent integration between path development and transition studies. Whilst recently contributions transcending the two debates have been offered the actual mechanisms that determine the interrelationship between regional industrial path development and transition processes remain unclear. This research gap results in the following open research question: *How do regional industrial paths interrelate with socio-technical systems and transition processes?*

### **3 Understanding the mechanisms of co-evolution between regional industrial path development and transition processes**

Above we have outlined the core components of transformative regional development dynamics: regional industrial paths and socio-technical transitions. We suggest to base the integration of both on a co-evolutionary perspective, following Schulz and Bailey (2014) who suggest to pay “more attention to the complex co-evolution of social institutions, technologies and production systems” (p. 288).

The central idea is that regional industrial paths form the backbone of transition processes, even though they are in themselves not enough to explain transitions. This means that we need to better understand how several paths interrelate and contribute to or impede sustainability transitions, how regional industrial paths interdepend with spatial dynamics, and how regional industrial paths are embedded in societal change dynamics. In the following, we turn to each of these dimensions separately.

#### **Industry: The interrelatedness between several industrial paths**

Evidently, single industries cannot be considered in isolation. Instead, regional industrial paths are continuously subject to reciprocal dynamics. Contributions on regional industrial development highlight a range of potential interactions, including mutually supportive, but also competitive or simply neutral relationships between technologies and sectors (Breul et al., 2021; Frangenheim et al., 2020; Sandén & Hillman, 2011). Technological relatedness is generally considered a key reason for reciprocal dynamics between industrial paths (Neffke

et al., 2011). Common resources like technologies, knowledge or raw materials are highly relevant in the context of transformative change (Steen & Njø, 2019). For example Steen and Hansen (2014) show how the emergence of the offshore wind energy industry in Norway was favoured by cross-sectorial knowledge transfers from the mature oil & gas sector. Strategic agency can exploit this relation with the help of knowledgeable entrepreneurs that break from mainstream technological paradigms (Grillitsch & Sotarauta, 2019; Isaksen & Jakobsen, 2017). Further important path interrelationships may occur through shared markets, e.g. when demand changes in a socio-technical system simultaneously affect various industries up and down the value stream (Andersen et al., 2019; Andersen & Markard, 2020).

Regional transformations are hence unlikely to be based on single technological solutions and industries. Rather, innovative actors may explore synergies by recombining several existing and/or emerging technologies in order to create the desired outcomes. They are hence loosely coupled to each other and co-evolve. Whilst the relationship between several regional industrial paths has been studied vis-à-vis the aim of regional economic growth, the combined effect of multiple paths on regional sustainable development (i.e. including in ecological and social terms) remains less explored.

### **Industry and space: The interdependence between regions in transition and the multi-scalarity of transition processes**

Industrial paths are rarely constrained to just one region, although they are likely to have a strong influence on the development of the region where they mainly stem from. Rather, they are often linked vertically with global production networks and associated innovation systems (Binz et al., 2014; Yeung, 2015). The build-up of skills and knowledge may occur endogenously within a region (building cumulatively on existing, regional knowledge) or exogenously (based on the incorporation of extra-regional knowledge), or most likely, in a combination of both (Trippel et al., 2018). As experiences are shared and experimentation and learning are encouraged, regionally tried and tested solutions (technologies, business models, regulatory arrangements etc.) may also be taken up in other regions, thus in turn impacting the transition process (Chen & Hassink, 2020; Hassink & Hülz, 2010). Within this process, regions may specialise differently, given that they are equipped differently with natural resources and

other assets, and sites of technological innovation, production and application are unlikely to be co-located, thus commonly reinforcing old and creating new inequalities (Forget et al., 2021; Skjølsvold & Coenen, 2021; Toedtling et al., 2021).

Likewise, social dynamics, although crucially influenced by historical regional trajectories, are not usually restrained to a certain territorial unit. Transitions may be expected to manifest themselves in changes in the regional, national and international discourse, in regulatory frameworks and patterns of production and demand (Sjøtun & Njøs, 2019). This is likely to affect regional industries through its impact on actors' mind-sets and on institutional settings, both of which influence (regional) innovation capacity (Chlebna & Simmie, 2018; Laurentis, 2021; Nooteboom, 2000). Such multi-scalar interdependencies are important to consider for a comprehensive perspective of transformative regional development. The regional path evolution and the related socio-technical transition hence interact with paths and socio-technical transition processes elsewhere and across spatial scales (Binz & Truffer, 2011; Heiberg et al., 2021; Miörner & Binz, 2020).

### **Industry and society: The embeddedness of industrial paths in socio-technical systems**

This section looks at mechanisms that connect industrial paths and socio-technical systems. The trajectories of regional industrial paths and the wider social dynamics in a region must be understood to be crucially tied together. Both regional industrial path development and transition processes rely to a great degree on formal and informal institutions. In combination, both provide the regulatory and social infrastructure for the creation and further development of regional industries. Likewise, the proliferation and acceleration of transition relies on an array of different kinds of actors who are empowered and restricted by formal and informal institutions (Wiskerke & Roep, 2007).

The path development literature emphasizes a 'thick' cooperation and innovation culture of regional actors as favourable in general (Isaksen & Trippel, 2016), and for transformative industrial change in particular (Martin, 2020). Thereby, the ability of regional actors to develop and hold on to common long-term goals is essential; in combination with (a certain degree of) political autonomy to decide on their region's economic development (Martin & Martin, 2017). The capacity to develop visions and to adjust the directionality of respective

pathways is vitally important for regional development – transitions can serve as anchors for such visioning exercises (Wiskerke & Roep, 2007). Pro-active local leaders, supportive of sustainability activities, e.g. mayors of small towns, can have a crucial influence in the local and regional context (Gustafsson & Mignon, 2020; Lukesch et al., 2019; Mattes et al., 2015; Rohe & Chlebna, 2021b).

Furthermore, intermediaries play an important role in shaping transition processes, and they are commonly rooted in regional industrial paths. Their regional presence may support industrial path transformation (e.g. climate and energy agencies). Energy clusters and start-up centres may also contribute to a local and regional entrepreneurial climate, provide general support for sustainable development activities or influence policymakers (Kivimaa et al., 2019; Mignon & Kanda, 2018). Given their focus on knowledge exchange and communication their evolution is closely linked to and shaped by societal development (Busch & Hansen, 2021; Kanda et al., 2020; Rohe & Chlebna, 2021a).

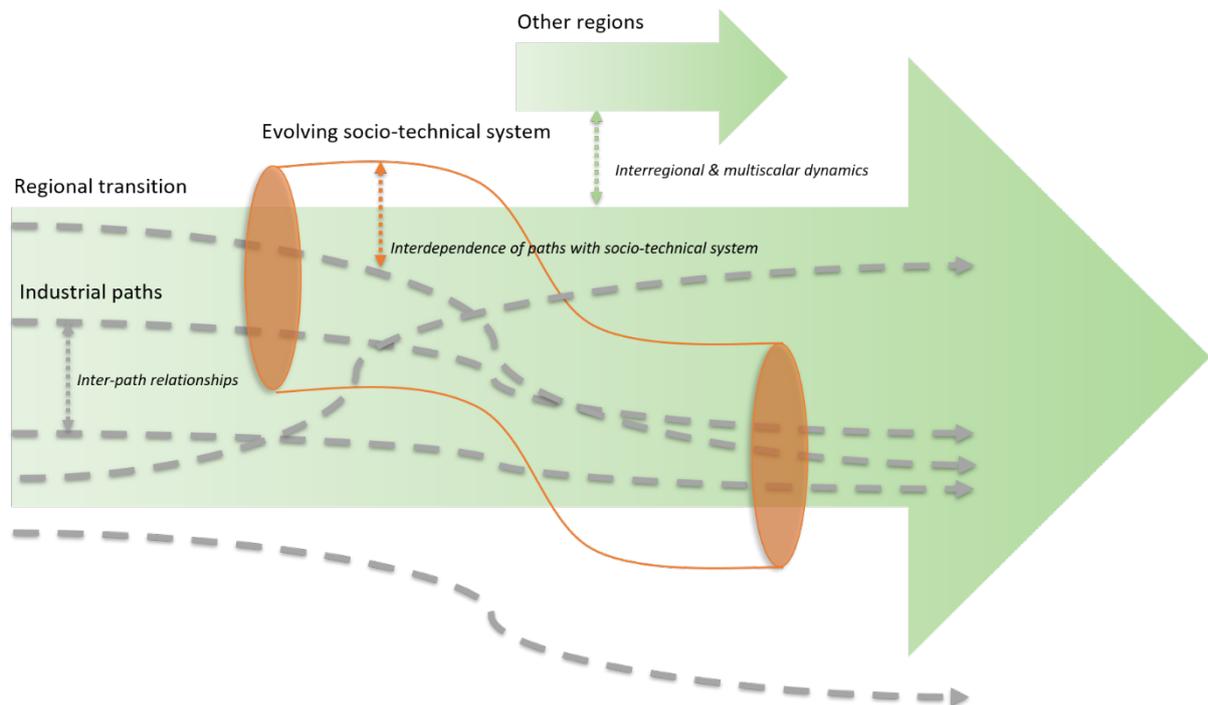
In summary, regional industrial development and longer term societal dynamics are tied together as the social dynamics of a region constrain and enable the development options of regional industries.

### **Co-evolution between industrial path development and transition processes**

Above, we have explained the key dimensions of the co-evolution between regional industrial path development and transition processes. We have described them as a matter of relations between industries, between industry and space, and between industry and society. Thereby we have shown that regional path development has impacts on and is likewise structured by the transition process: combined, regional industrial development paths may have positive, negative, or neutral effects on sustainable regional development. Development processes in different regions are likely to influence each other, and multiple scales interdepend. Institutions, socio-cultural aspects, and social relations influence and condition the behaviour of actors (including innovators, policymakers, and citizens/consumers).

Drawing these insights together, we can conclude that path dependent industrial development is a central constituent of regional transition processes. The outlined interdependencies are summarized in figure 1.

Figure 1: The interrelation between industrial paths and transition processes



#### **4 Applying a co-evolutionary perspective to bridge regional industrial path development and transition studies - A research agenda**

The overarching question for our contribution has been how regional industrial paths co-evolve with transition processes. Above, we have laid out our co-evolutionary approach, which suggests entering the debate via three essential dimensions: the interrelations between regional industries and their combined impact, industries as they evolve in different spatial settings, and the embeddedness of regional industries in society. Below, we now turn to each dimension separately to define the associated research avenues as we see them.

##### **How do multiple paths interact? What is their combined effect?**

Despite a vivid debate, we still do not fully understand how different paths interact, coevolve and hinder each other. To gain a more profound understanding of transformative regional development, we need to consider ranges of relevant technologies and associated industries, their interdependencies as well as innovation that goes beyond technological innovation. By analysing individual processes in-depth, acknowledging the breadth of their mutual impact

and disentangling the coupling mechanisms between them, we should hence explore how multiple paths shape transition processes. What might be beneficial combinations of regional industries for transformative change? Is there any regional industrial mix that might be particularly conducive, or obstructive? Closely related, transformative change necessitates a more conscientious use of resources in industrial production. How can material inputs within and between regional industries be reduced and optimized? What competences and skills are required for transformative regional industrial change, and where shall they be obtained from? (How) does the role of regional actors change in regional innovation, and who are the change agents triggering transformative regional industrial change? What is the role of regional demands and consumer behaviour in impacting technological change and regional industrial pathways?

### **How do transition processes in different regions interact with each other? What are interscalar relations?**

It is well-established that transition processes as well as regional development paths are place specific. This is down to the socio-cultural context, historically grown institutions like values and norms, as well as the endowment with resources, available infrastructures, markets, and networks. This implies that transformative development occurs in different regions at different times and at different speeds. We only have little knowledge on inter-regional learning in the context of transformative change. What dynamics of interregional competition or even collaboration may give momentum to interregional learning regarding transition processes? What are the underlying preconditions, drivers, respectively hindrances of interregional learning? Relatedly, there is more research required regarding the interdependence between different political levels, including the possibilities of regions to influence supra-regional context conditions. Such studies could also enlighten the mechanisms behind creating inter-regional socio-technical alignments. How can inter-regional learning potentials be identified and strengthened? What is the role of various public actors at different geographical scales? Who can and needs to take agency? Another so-far less addressed issue is the role and contribution of multinational (and often incumbent) companies to transformative regional industrial change and inter-regional learning.

### **How is regional industrial path development linked to societal change?**

We know that both regional industrial path development as well as transitions rely on formal and informal institutions. The role of actors in changing, maintaining, and disrupting these institutions is increasingly explored. Applying such a perspective of institutional work might be particularly useful to better consolidate what the actual activities are that underlie transitions and associated regional industrial path development. Discourses, on the local, regional and supraregional level can be powerful mechanisms to influence informal institutions. How are public and private actors in regions influenced by these, and how do these affect regional industrial transformation? How do changing societal norms and values influence demands for products and technologies, and affect industry development? Furthermore, how local and regional actors in the media or in similar outlets portray the entanglement of regional industrial development with societal change processes may be an entrance point to their rationale for (in)action. Who does or does not get involved and who does and does not benefit from regional industrial development is considered to some extent within regions, but less so from a transregional and transnational perspective. All these questions are particularly pressing in the field of sustainability transitions that are relatively advanced in some regions, while others suffer from unexpected and unintended social and ecological cleavages.

### **Summary: How do industrial paths co-evolve with transitions?**

Paths and transitions develop in a deeply interdependent fashion and shape each other's evolution. Paths constitute transitions, but transitions as an aggregated phenomenon likewise impact the evolution of individual paths. Regional development is a complex phenomenon that can be understood better when considering both perspectives. This observation is not only based on the fruitful combination of insights from two debates, but also rooted in the closely intertwined objects of analysis of the two strands of literature. However, what exactly do these interlinkages look like? Which specific mechanisms couple paths and transitions? Of course, it is relevant to look at industrial paths from a pure path perspective. Likewise, it may make good sense to analyse transition processes purely based on socio-technical systems. Nonetheless, if we want to explore the underlying dynamics which shape the occurring development processes, how these dynamics unfold in space and over time, and which interdependencies exist, adopting a co-evolutionary perspective that draws on insights from

both debates will enrich our understanding and may help to systematise our research. We argue that the research avenues laid out above will offer key starting points for further debate. This is both a theoretical and an empirical task: While regional case studies would certainly shed further light on the specific nature of the three outlined interrelations, case comparisons could help deriving patterns and illustrating regional specificities.

Confronted with grand societal challenges, an integrated perspective drawing on the literature on regional industrial paths on the one hand, and transition research on the other hand, will help us to gain a more nuanced picture of the underlying processes of sustainable regional development. The proposed co-evolutionary perspective on regional industrial path development and transitions deepens our understanding of regional development dynamics: First, understanding regional industrial paths and their interactions and impacts offers more detail on the emergence and modification of industries and technologies as part of transition processes. Second, the spatial dimension encourages to further explore the interrelations between different regions and between different spatial scales. Third, the recognition of interlinkages between industrial development and societal dynamics emphasises the role of formal and informal institutions as part of transition processes.

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