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Reconsidering structural conditions: Institutional infrastructure for innovation-based industrial path renewal

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Abstract

This paper aims to develop a more elaborated understanding of innovation-based renewal of industries from a structural perspective. Current perspectives offer rather simplistic views on the role of structural conditions in regional industrial renewal process. In order to overcome this limitation, we draw on the concept of 'institutional infrastructure' to examine the ensemble of structural elements for industrial path development in regional contexts. The institutional infrastructure and its conditions, i.e. its elaboration and coherence, are seen as important factors for industrial change. To illustrate this approach, we investigate renewal processes in two traditional automotive regions in Austria and Sweden.

Keywords

Path renewal, institutional infrastructure, structures, elaboration, coherence

JEL codes

O33, R11, R58

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Introduction

In light of 'grand challenges' such as digitalization or sustainability, the question of how established industries can adapt and renew themselves in order to maintain their economic strength has increasingly gained in importance in academic and policy debates alike (Isaksen & Trippl, 2016; Markard, Raven, & Truffer, 2012; OECD, 2015). It is widely acknowledged that the renewal capacity of an industry is inextricably linked to its ability to innovate. A key research focus thus concerns the identification of favorable structures for the generation and diffusion of innovations that will sustain the success of an industry in the long run.

How innovation-based industry renewal unfolds is a core topic in economic geography and innovation studies. Especially work in Evolutionary Economic Geography (EEG) has been devoted to the idea that regional industries face a constant need to adapt to changing circumstances in order to stay competitive. EEG has helped to specify what structural preconditions matter for regional industrial change, placing explicit emphasis on assets, skills, connections and competencies inherited from past rounds of development, which are said to shape present and future activities (Martin & Sunley, 2010). Regional industrial change is thus conceived as a 'path-dependent' process (Martin, 2010). Since assets, competencies and skills acquired in the past are often regionally bound, innovation-driven industrial dynamics are seen as highly localized phenomena (Martin, 2010). Further, EEG places much emphasis on technological and knowledge-related assets within regions (Boschma & Frenken, 2011; Schamp, 2017). This view has attracted criticism for being too narrow, neglecting other important factors for changes of regional industries like formal and informal institutional endowments or organizational support structures like universities, intermediaries and so on (Carvalho & Vale, 2018; Dawley, 2014; Hassink, Isaksen, & Trippl, 2019; Tanner, 2014).

Adopting a broader view and seeking to capture the wider structures that influence the rate and direction of regional industrial change, scholars have begun to invoke insights from the literature on Regional Innovation Systems (RIS) (Isaksen & Trippl, 2016; Trippl, Baumgartinger-Seiringer, Frangenheim, Isaksen, & Rypestøl, 2019) and institutional thickness (Amin & Thrift, 1994; Zukauskaite, Trippl, & Plechero, 2017). This has enriched our understanding of the pivotal role played by different actors, network constellations and institutional fabrics at different spatial scales in regional industrial dynamics.

However, this work still suggests a rather simplistic perspective on structures as being either constraining or enabling, leaving little room for discussing the manifold effects regional structural circumstances might have on the development of an industry. Therefore, the aim of this paper is to advance a comprehensive understanding of the role of structural conditions for the transformation of industries in regional contexts. We move beyond the simplistic dichotomy between enabling and constraining influences of structures. We advocate a more nuanced understanding of the impact that (different) structural configurations might have on regional industrial change. They are – as will be argued in this paper – not enabling or constraining per se, but rather hold various potential for reconfiguration.

We believe that recent work in sociology on 'institutional infrastructures' serves as a stepping stone for conceptualizing the transformative capacity of regional industries. The term

'institutional infrastructure' has recently been introduced in the literature on organizational institutionalism. It draws attention to different formal and informal structures (made up of collective interest organizations, regulators and regulations, standards, informal norms, etc.) that govern industrial dynamics, contributing to either stability or transformation (Greenwood, Raynard, Kodeih, Micelotta, & Lounsbury, 2011; Hinings, Logue, & Zietsma, 2017). Besides identifying structures that are particularly relevant for change processes in a particular industry, studies have tried to conceptualize the degree of elaboration of the infrastructure in an industry as well as its coherence and alignment. While certain industries seem to have a highly institutionalized infrastructure that is well aligned, others can be characterized by a conflicting infrastructure or a poorly developed one, which has implications for the change of structures themselves and thus for industrial dynamics. The hypothesis is that the elaboration and coherence of this infrastructure will have important implications for the initiation and unfolding of transformation processes of industries in regions.

The remainder of the paper is structured as follows. In chapter two, we discuss why it is necessary to take on a more holistic approach to structures in order to understand industrial renewal. We then provide a literature review of some of the most important work in institutional theory, focusing on the notion of institutional infrastructure. In chapter four we develop a framework that explains how elaboration and coherence of broadly defined structural conditions might affect innovation-based industrial renewal. In chapter five, we apply the framework to two automotive regions in transition. Chapter six concludes.

Role of structures in regional industrial change: Evolutionary Economic Geography and regional innovation systems perspectives

EEG seeks to unravel '*the processes by which the economic landscape […] is transformed over time*' (Boschma & Martin, 2007, p. 539). EEG explains industrial change through diversification processes stimulated by re-combinations of complementary and related capabilities on the firm-level (Boschma & Frenken, 2011). Knowledge dynamics, technological competences and skills are thus perceived as essential for the transformation capacity of whole regions or industries.

In essence, this literature puts emphasis on the diversity and relatedness of economic structures, highlighting the positive impact of sectoral related variety for industrial diversification (Boschma, 2017; Neffke, Henning, & Boschma, 2011). Accordingly, related diversification, that is, the development of new growth paths based on pre-existing capabilities is considered the main driver of regional economic evolution. In contrast, unrelated diversification is seen as a more exceptional event. It comes with higher costs and fundamental uncertainty but might prove beneficial for regional competitiveness in the longer run (Boschma, 2017). From an EEG perspective, diversity in regional knowledge capabilities is the key factor that determines the scope for innovation. Other structural factors have thus far received little attention. One exception is Boschma and Capone's (2015) assessment of the impact of overarching macro-institutional frameworks on diversification patterns. Using the 'Varieties of Capitalism' approach, they find that liberal market economies are more likely to diversify into more

unrelated industries, while coordinated market economies tend to favor related diversification. Such accounts of broadly defined national institutional contexts can however hardly capture the local, place-specific nature of institutional settings (Rodríguez-Pose, 2013).

Most EEG work still focuses on explaining the evolution of regional economies through knowledge dynamics and lacks integration of a broad structural understanding (Hassink et al., 2019). Advocates of technological and regional innovation system approaches propagate a more holistic approach (Binz, Truffer, & Coenen, 2016). In this paper, we focus on RIS and its potential to enrich perspectives on regional industrial change (Isaksen & Trippl, 2016; Trippl et al., 2019).

A regional innovation system (RIS) consist not only of the firms within a region, but also the wider organizational support structures (universities, intermediaries, policy actors, etc.) and institutional arrangements, including both formal (regulations, laws) and informal institutions (culture, norms, values) (Asheim & Gertler, 2005; Asheim, Isaksen, & Trippl, 2019). Despite its focus on regional structures, the concept does not neglect the openness of innovation systems. Regions are influenced by extra-regional linkages and embedded in institutional setups at higher spatial scales. This broader perspective on structural preconditions helps to move beyond firm and knowledge-centered views prevailing in EEG.

Using RIS as conceptual lens, research has sought to unravel the link between (regional) structural conditions and regional industrial change. A common view is that regions, which already host highly successful firms, well-functioning research organizations, networks and institutional setups, offer a favorable environment for the rise of new economic activities (Tödtling & Trippl, 2013). Isaksen and Trippl (2016) distinguish between three ideal-type regional configurations focusing on the density of industrial as well as organizational and institutional support structures and degree of industrial specialization, and assess the impact of such structural conditions on innovation patterns and new path development within regional economies. Organizationally thick and diversified RISs (often found in core regions) host a wide array of different industries, well-elaborated support structures and outward-looking networks. Such structural conditions are said to facilitate new path development and path renewal activities. Organizationally thick and specialized RISs (old industrial areas) are dominated by one or few industries only, support structures are highly specialized and aligned, and networks tend to be inward-looking. Such structures are believed to exhibit a weak capacity for endogenous change and favor continuity (i.e. path extension) rather than change. The risk for 'spatial myopia', negative lock-ins, and economic turndown is high (Grabher, 1993; Hassink, 2010; Maskell & Malmberg, 2007). Organizationally thin RISs (peripheral regions) are characterized by poorly developed industrial and support structures, external ownership (branch plants), homogeneity and weak innovative capacities. Under such conditions, continuity (path extension) is said to be the likely outcome.

More recently, scholars have adopted more dynamic perspectives on regional structures to better understand the relationship between the development of regional industries and changes in the structure they are embedded in (Baumgartinger-Seiringer, Miörner, & Trippl, 2019; Tödtling & Trippl, 2013).

While all these contributions offer interesting insights, they generally focus on structural conditions that form an enabling or constraining environment for innovation-based path development. They imply that once a region provides certain structures, particular types of development are likely to occur (e.g. thick and diversified RISs will favour new path development; thick and specialized RISs will likely lead to path extension, etc.).

In this paper, however, we argue that certain structural characteristics should not be seen as enabling or constraining per se. A more promising approach is to unravel the complex implications they hold for a particular industry. Accordingly, while it might be the case that thick and diversified structures offer great potential for industrial change, they also come with specific barriers hampering innovation. Similarly, thin or highly specialized structures might entail more positive features for regional economic development than commonly thought. Much depends on the context, the configuration of structural elements and the relations between those elements. We believe that new work in organizational institutionalism offers highly relevant insights in this regard.

Organizational institutionalism

In the last decades, institutional theory has been highly influential in organization and management studies to explain organizational behavior and change (Greenwood, Oliver, Lawrence, & Meyer, 2017). Studies have shown that actors are embedded in an institutional environment that affects their cognition and behavior and that legitimacy, i.e. conforming to that environment, is essential for organizational survival. Many disciplines have since used institutional theory to describe the environment of actors by using Scott's seminal typology of institutions, characterizing them as either regulative (e.g. laws, regulations), normative (e.g. standards, values) or cultural-cognitive constructs (e.g. categories, typifications), each with its own way of shaping organizations and their behavior (Scott, 1995).

However, institutional theory has more to offer than the mere conceptualization of institutions. There is also a long tradition to study field-level change. The organizational field is the concept that depicts the relevant institutional environment for a given set of actors. Fields have been defined in various ways (for an overview see Wooten & Hoffman, 2008; Zietsma, Groenewegen, Logue, & Hinings, 2017), but in general they refer to "a recognized area of institutional life" (DiMaggio & Powell, 1983, p. 148) or "a common meaning system" (Scott 2014, p. 106). Fields typically exhibit a specific actor network that is based on an increased frequency of interaction among its actors; particular power relations and status hierarchies among actors; shared meanings and practices as well as a shared identity, i.e. a mutual awareness of each other and the dominant rules of the games (DiMaggio & Powell, 1983; Zietsma et al., 2017). Industries, such as forestry, accounting, building, textiles, art, etc. are prime examples of organizational fields where such dominant rules of the game develop. These rules of the game have also been referred to as institutional logics, defined as "the set of material practices and symbolic systems including assumptions, values, and beliefs by which individuals

and organizations provide meaning to their daily activity, organize time and space, and reproduce their lives and experience" (Thornton, Ocasio, & Lounsbury, 2012).

Research has furthermore shown that fields differ in their capacity to change and innovate. This has primarily been tied to the presence of a specific institutional infrastructure, and in particular its degree of elaboration and coherence. The notion of institutional infrastructure is suggested as a way to "define and typologize field conditions" (Hinings et al., 2017, p. 167). In its essence, institutional infrastructure refers to the formal and informal mechanisms in a field that reproduce or change the dominant rules of the game. It can be regarded as "the cultural, structural and relational elements that generate the normative, cognitive and regulative forces that reinforce field governance, and render field logics material and field governance performable" (Hinings et al., 2017, pp. 163–164).

Hinings et al. (2017) reviewed a range of studies that implicitly or explicitly deal with some aspects of institutional infrastructure and developed a list of cultural, structural and relational elements to be considered institutional infrastructure (see table A-1 in the Appendix, and elaborated in more detail below). Briefly summarized, they refer to a specific type of structure that is particularly important for the maintenance and/or change of the dominant rules of the game and as a consequence crucial for field-level change.

Structures of all sorts can be institutionalized to different degrees and thus be more or less powerful in shaping field activities (Barley & Tolbert, 1997; Berger & Luckmann, 1966; Zucker, 1977). Degree of institutionalization generally increases with the scale and scope of diffusion of a structure, duration of existence, invulnerability to intervention, starkness or overall coherence. A structure that is old, widely diffused and accepted and has materialized into a range of routines and practices can thus be considered an institution (Hajer, 1995). This also implies that institutionalization is a time and effort consuming process of social construction (Berger & Luckmann, 1966). Actors are constantly busy with reproducing or changing their institutional environment.

The idea of institutional infrastructure is to describe the condition of a field in order to say something about its transformative capacity. Field condition can be assessed in three ways: 1) presence of specific infrastructure elements, 2) their degree of elaboration and 3) their degree of coherence.

First, institutional infrastructure specifies those cultural, relational and structural elements that research has shown to be crucial for the reproduction and/or change of the dominant rules of the game in a field because they are instrumental in creating, maintaining and disrupting institutions and in materializing and solidifying them into field level practices. Collective interest organizations, for instance, have been vital in all forms of lobbying processes for regulations, standards, resource mobilization or policies. A high density of interest organizations in a field will arguably have an effect on how the field is organized, what can be done and what not and who has power and authority. A similar point can be made regarding the presence of regulatory actors in a field. Regulations enable and constrain action, so having regulatory bodies will have an effect on what gets institutionalized or de-institutionalized. The presence of an environmental protection agency or a ministry for innovation not only shows the relevance of these issues for the field, but it can also be assumed that institutions around

environmental protection or innovation will develop, e.g. funding schemes, tax incentives, patent laws, industrial policies, and societal values and visions. This, in turn, will affect which types of knowledge gets generated and which types of technologies will be developed and diffused. The same can be said for fields with a lot of informal governance bodies. This usually is an indication that the field is highly organized and many beliefs, values and ideas have solidified into specific standards and norms that affect the future development of the industry. In addition, educational programs, professional associations or normative networks can all be considered infrastructure elements with a high definitional authority. Their function regarding the definition of legitimacy is very crucial and many institutions get build up or torn down through processes within these types of infrastructures.

Second, the degree of elaboration of the institutional infrastructure in a field varies and has consequences for field activity. The different elements of the infrastructure can be institutionalized to different degrees (or be lacking altogether). It is the difference between highly established, mature fields where a highly elaborated institutional infrastructure has developed over a long period of time that almost automatically reproduces the rules of the game, and the emerging field, where the dominant designs, values, practices and meanings still have to be negotiated and the infrastructure is currently under construction. Research indicates that the power of structures increases with their degree of institutionalization and that therefore fields with a highly elaborated institutional infrastructure are more stable (Barley & Tolbert, 1997; Berger & Luckmann, 1966; Zucker, 1977).

There are good reasons to assume that a high elaboration of institutional infrastructure may not only hamper but could also benefit processes of change. Considering the fact that institutional infrastructure is important not only for the maintenance of the rules of the game, but also its (de-)institutionalization, it could also be hypothesized that having a strong infrastructure is necessary to incorporate change. Examples may include the development of new standards, new training programs, new regulations, new awards, new events, etc. The question thus not only becomes whether or not infrastructure is there, but rather how flexible the different elements are and how open for a change of direction.

Third, the condition of a field is influenced by the degree of coherence of its infrastructure. This refers to the question of whether the infrastructure elements are reinforcing each other and are aligned around a unitary institutional logic, i.e. a coherent rationality in the dominant rules of the game, or whether they are mirroring different rationalities that can be competing or in conflict with each other.

Overall, it can be said that institutional infrastructure defines the condition of a field. It is a way to assess the degree of elaboration/institutionalization of a field as well as its alignment/coherence (Hinings et al., 2017; Zietsma et al., 2017).

Implications for studying innovation-based regional industrial renewal

The notion of institutional infrastructure helps to define structural conditions of fields and allows to capture mechanisms through which fields get maintained or altered. We argue that

the concept offers valuable insights for developing a more comprehensive perspective on the role of regional structural conditions in industry renewal. It helps to assess and compare specific structures that enable or hinder processes of innovation-based change and path development in particular industries. Therefore, investigating the role of institutional infrastructure of a regional industry as well as paying attention to its degree of elaboration and coherence is a way to improve our understanding of industrial change from an institutional perspective.

In this chapter, we seek to systematize the implications of different configurations of the institutional infrastructure, and discuss the potentials and barriers entailed in different degrees of elaboration and coherence of regional structures. Hinings et al. (2017) present three cases of field level change to illustrate the impact of structural configurations on the pace and scope of alterations. We use these cases exemplarily as starting points for the discussion.

Their first case, the professional service field, was a historically stable field (Empson, Muzio, Broschak, & Hinings, 2015). Many elements like collective interest organizations, formal regulators, and professional associations were strongly reinforcing each other. These structural conditions led to a period of reproduction and continuity in a setting of both high elaboration and coherence. The increasing globalization of the industry brought new elements (like regulations, standardization organizations, and agreements) that further increased the elaboration, but, at the same time, led to fragmentation and a weakening of coherence. While this has enabled change and a shift towards a more international industry, the historically high elaboration on the national level has been used to absorb the pressures of globalization, leading to incremental, relatively smooth processes of change that were largely consistent with the existing institutional infrastructure.

Similarly, the forestry field in British Columbia, Canada was characterized by a highly elaborated structure with a variety of elements like interest organizations, organizing bodies, unions, regulations and norms in place (Zietsma & Lawrence, 2010). The fact that the elements were strongly reinforcing each other led to stable conditions. However, concerns over the environment and the emergence of NGOs have started to exert pressure on the industry. The high elaboration and coherence of the field for many years blocked these influences. When ecological concerns became increasingly widespread, they eventually ‘found their way’ into the forestry industry. This led to quite rapid change in the field, unfolding in a very short period.

Finally, the impact-investing field in Australia, which only developed after the Financial Crisis, was a field with a weakly elaborated infrastructure, yet highly coherent in its emergence (Logue, 2014). Together with preexisting networks of actors connected through previous activities and the strong boom after 2008, this coherence within the emerging field led to a rapidly increasing elaboration of a new institutional infrastructure with high levels of experimentation and very little resistance to change within the field.

These cases offer valuable insights into structural influences for innovation-based regional industrial renewal. Focusing on elaboration, i.e. the number and development of structural elements for a particular industry in a region, and their coherence, that is, the degree to which they are mutually reinforcing each other, provides a toolkit to understand the nexus between structures and change processes. Drawing on the empirical examples outlined above, we argue

that different degrees of elaboration and coherence hold different potentials for innovation based renewal.

Accordingly, **high elaboration** implies that a large number of elements are in place. This resembles the notion of thickness of relevant regional structures for a particular industry (Zukauskaite et al., 2017). On the one side, this variety of elements can be used as a platform to initiate change processes as the case of professional services and its development towards a more globalized industry demonstrates. On the other side, however, the presence of many elements requires alteration of a large number of structural components. In other words, many locks have to be unlocked to trigger change, as the example of the transition of the forestry industry in British Columbia suggests (Hinings et al., 2017). In essence, highly elaborated structures facilitate the change of existing elements.

Low elaboration, that is, poor endowments of infrastructural elements (thinness), as in the case of the impact-investing field in Australia, might be beneficial for change processes, as it offers leeway for the creation of novelty. However, the lack of structural preconditions might also form a strong barrier for change processes, as there is no platform to set alterations in motion; that is, there are no elements in place through which change can be distributed. Consequently, weakly elaborated structures facilitate the creation of new elements.

When structural components are strongly reinforcing each other, i.e. the elements are in a state of **high coherence**, strong alignment is likely. This means that the diffusion of change is facilitated and conflicts can be expected to occur rarely. The case of impact-investment in Australia demonstrates that unity can lead to rapid alterations. However, strong ties and reinforcement between structural elements might also be a source of rigidification, leading to high resistance to change in the first place (Grabher, 1993). Swimming against the stream is often difficult. The example of forestry in British Columbia and its resistance to turn into a more environmentally friendly industry shows that the initiation of change in highly coherent structures is often hampered. Yet, once initiated, it is likely to be diffused rapidly.

In contrast, **low coherence**, on the one hand, might stimulate experimentation and change. Early phases in the process of globalization in the professional service field demonstrate that periods of low coherence might entail an increased capacity to adapt. Additionally, dissent may lead to higher levels of competition between different visions and directions of change. On the other hand, low levels of coherence will often go along with fragmentation and conflict, thereby paralyzing an industry. Furthermore, low levels of exchange and collaboration within a region might weaken path development activities due to weak positive lock-in effects (Martin & Sunley, 2006). Accordingly, in weakly coherent structures, the initiation of change is facilitated. At the same time, conflicts concerning the direction of change are likely.

Table 1 illustrates different combinations of varying degrees of elaboration and coherence and respective implications for innovation-based change in a regional industry.

Table 1: Degrees of elaboration and coherence: implications for change

	Unitary (high coherence)	Competing (low coherence)
High Elaboration	+ structure for change; agreement on objectives - hard to set change in motion	+ structure for change; likelihood for change - conflict is likely
Low Elaboration	+ Leeway and opportunity, change is likely to be agreed on - long way to go	+ extensive room for change - require both, "construction & persuasive work"

Source: own elaboration

Empirical part

Employing a comparative case study analysis, this section applies our conceptual framework to two automotive regions in transition: 1) the Austrian triangle and 2) West Sweden. In both regions, the automotive industry is currently undergoing substantial changes connected to an increasing digitalization and the advent of connected and automated vehicles. The structural preconditions around the 2010s (when transformation processes were initiated in both regions), however, were different.

The empirical analysis is based on an extensive document analysis and 45 in-depth qualitative interviews (25 in Austria in the first half of 2019 and 20 in Sweden between March 2017 and May 2018) with representatives of firms, research organizations, intermediaries and policy makers. Most interviews lasted between one and two hours. The selection of interview partners was based on an initial mapping of relevant actors, followed by a snowballing method. The transcribed interviews were coded and analyzed based on the analytical framework (Saldaña, 2015).

The empirical investigation allows for an evaluation of the configuration of automotive structural elements and the relations between those elements in the Austrian triangle and West Sweden.

Austrian triangle

Potential within structures

Automotive industry in Austria is one of the country's traditional economic drivers. Not less than 10 percent of the workforce depend on the automotive sector (Kleebinder, Kleissner, Helmenstein, & Semmer, 2019), even though the country does not host any OEMs. Most activities in the industry are concentrated in three provinces (Upper Austria, Styria, Vienna), which together make up the Austrian automotive triangle. Over decades, supplier firms have developed strong ties to German manufacturers. The institutional infrastructure of Austria's automotive triangle is historically established and highly elaborated. A wide array of elements are in place. The industry benefits from a number of (often large) educational and research

organizations, financial support organizations, infrastructural agencies, governance bodies on both the provincial and federal level, industry associations and intermediaries, all of which contribute to the high elaboration of the automotive region (for a more detailed list see table A-2 in the Appendix).

Furthermore, our empirical investigation reveals a historically developed high degree of coherence. First, several interviewees pointed to a "*strong culture of cooperation*" between firms, research institutes, universities and the public domain. This view on strong levels of collaboration was a common theme throughout almost all interviews. One firm representative stated:

> *"Austria is small and Austria's different automotive players are strongly connected indeed, everyone knows everyone, […] this is a huge advantage."*

Further, our analysis suggests that the different structural elements were indeed strongly reinforcing each other. The institutional infrastructure was reflecting the prevalence of a strong engineering culture in Central Europe's automotive industry. Elaborated elements, from educational organizations and governance bodies to certification and regulation, were reinforcing each other, preserving features such as reliability, precision and determinism, which have long been trademarks of the industry.

The recent emission scandal demonstrates the 'dark side' of strongly coherent structures. As one firm representative put it:

> *"They were blind. And the system certainly was in a self-reinforcing state. The authorities said 'that's alright', the engineers said 'we know what we are doing' and the laws supported that. […] It's one of those systems that slowed itself down."*

We argue that these structural conditions and the potentials for change they held are vital to understand the transformation and digitalization of the Austrian automotive industry that started to unfold some years ago. The well aligned set of elaborated elements produced relatively stable conditions in which actors were embedded. Accordingly, the more radical change processes which are currently observable were largely inconsistent with the way the industry in Austria was organized.

Yet, our interviewees have also pointed out that the enabling dimension of strongly elaborated and coherent should not be overlooked. Highly elaborated structures are a big asset for a region and offer reliability, even though they might be hampering in early phases of radical change processes. However, in more advanced stages when the different elements are altered accordingly, the structures in place might function as a platform for upscaling. A representative

from a technical university commented on new agile automotive players in the US in the following way:

> *"At some point maybe, these new players [like Tesla] will be overtaken by their own agility. The power of innovation may be lost again when they move towards mass production. These are completely different dimensions. Sales, maintenance, all these things are big challenges. I wouldn't be surprised if Tesla would be bought by an established manufacturer. And then it falls back into the established structures again."*

Unfolding of change

The increasing digitalization and the advent of CAVs is a major upheaval for the Austrian automotive triangle and (together with concerns over climate crisis) calls for alterations of historically grown structures. However, the initiation of change was slow in the Austrian case that was long in a "*state of self-satisfaction*" (firm representative). As one representative from a research institute put it: "*you face so many barriers when you are right in the middle [of a well-coordinated system]."*

Our analysis reveals that despite an early phase of reluctance, actors have begun to embrace CAVs as a new field of innovation and value creation:

> *"Five years ago it became clear that the classical, mechanical engineering potential for innovation is exhausted; now we have a new hype around CAV" (researcher in 2019)*

However, the fact that a wide set of coherent elements has to change was and still is connected to various efforts of reorientation observable within and in between all relevant structural elements. The ministry of transport and innovation (BMVIT), research organizations and large automotive and microelectronics firms have started to actively approach the current transformation and digitalization. The office for mobility transitions and decabonization ("Stabsstelle für Mobilitätswende und Dekabonisierung") organized a number of large-scale network meetings with 140 stakeholders that resulted in two strategy plans ("Aktionspläne", 2016-2018, 2019-2022), outlining the most important measures jointly carried out by actors from industry, policy and academia for this transformation to unfold[1]. The already high coherence within the elaborated structures strongly facilitates such a collaborative approach, which arguably leads to an even stronger coherence within Austria's structures for CAVs.

[1] Amongst other things, this implies the initiation of projects for real-world testing, newly established endowment professorships, digitalization of existing infrastructure, the stepwise adjustment of the legislative framework, new strategies for enhanced cooperation between different structural elements, reorientation of funding schemes and measures to increase public awareness

One of the biggest 'unsettled' issues concerning the current unfolding of change is the integration of IT knowledge and norms into rather rigid automotive elements that are still dominated by traditional ways of doing things. Intermediaries are thus eager to facilitate and support the inflow of IT competencies into the car sector[2]. However, an analysis of curricula and interviews taken with representatives of technical universities show that these reorientation endeavors are still at an early stage in educational organizations, where the distribution between traditional fields and more digital competencies is still strongly tending towards the former.

Drawing on the findings outlined above, one can indeed recognize an acceleration of change after a period of reluctance that is conditioned by certain structural configurations. However, two other decisive factors should be emphasized. First, the recent emission scandal has been an important trigger of change. Second, the BMVIT has been identified as an important facilitator and coordinator of current transformation activities, demonstrating the role of key actors in orchestrating change processes.

Automotive industry in West Sweden

Potential within structures

The region of West Sweden is both the cradle and the heart of the Swedish automotive industry. It hosts the headquarters of OEMs such as Volvo Cars and AB Volvo, as well as a range of suppliers, automotive technology firms and consultancies, catering to local as well as global markets. Similar to the Austrian automotive triangle, the institutional infrastructure of West Sweden's automotive industry is highly elaborated. A range of well-developed elements reflect the industry's long and successful history. The region hosts various educational and research organisations, science parks, cluster organisations and incubators, testbeds, innovation support initiatives, governance bodies at the local, regional and national levels, and funding organisations (for a more detailed list see table A-2 in the Appendix). Previous studies suggest strong reinforcing effects between the elements outlined above, pointing to high levels of coherence (James, Vissers, Larsson, & Dahlström, 2016).

Both elaboration and coherence declined in the late 1990s and early 2000s. In that period the regional industry was re-aligning towards more technology-focused safety features as the primary competitive edge (James et al., 2016). However, while the elaboration of the institutional infrastructure quickly increased again after the global financial crisis, it did not regain the strong coherence that had characterized the industry historically. Instead, regional automotive infrastructure elements pointed at different, sometimes contradictory, directions of change, leading to disalignment in West Sweden's automotive structures around 2010. Associated with the thematic shift towards active safety technology in the regional automotive industry, several interviewees pointed at a divide between the traditionally oriented development of 'hardware' versus the development of 'software'. The latter requires more agile ways of working that were somewhat incompatible with established practices. One interviewee from an innovation support organization stated that:

[2] For example with initiatives like „Connected mobility" or „AutoContact"

> *"We can forget the whole old logic. It is no longer possible to talk about vehicle industry, IT industry, and so on. These boundaries have been completely wiped out in the new landscape."*

Second, our interviews revealed that around 2012 when autonomous technology was brought into the spotlight of automotive firms, winds of change were already blowing in the industry, fuelled by a period of decreasing coherence and different change directions. Examples include electric vehicles (including battery technology, hybrid technologies), connected vehicles, and various services (e.g. carsharing). Interview results point at safety technology being the lowest common denominator, while "*everything else goes*" *(Interview with former executive at Volvo Cars).*

Decrease in coherence of the institutional infrastructure is exemplified by the fact that a large number of 'fringe' elements have become part of the institutional infrastructure of the regional automotive industry (see above). From previously being dominated by 'automotive' elements, firms in the automotive industry are now engaging with infrastructure elements being shared with other regional industries, with cross-industry thematic focus areas. The same goes for educational and research programmes; while previously being oriented at 'automotive technology' they are now focusing on broader themes, such as AI and machine learning. Accordingly, in contrast to the Austrian triangle, regional automotive structures in West Sweden were characterized by a lower degree of coherence around 2010; the different elements have reinforced each other to a lesser extent.

In order to understand the shift towards CAVs that started at the beginning of this decade, the particular combination of elaboration and coherence in the institutional infrastructure of the automotive industry has explanatory power. When it comes to potentials for change, interview results indicate that the elaborated institutional infrastructure provided a platform to set in motion change processes. Our empirical analysis shows that the close technological relationship between 'active safety' and 'autonomous technology' meant that many existing infrastructure elements could be used to embrace CAV (e.g. test infrastructure and funding programmes). For example, one technology expert at Chalmers University said with respect to autonomous technology that *"we already know how to do this"*.

Unfolding of change

Initiation of change took place rather quickly. Due to a low degree of coherence, structures were not particularly rigid. It was easy to set change processes in motion. This is illustrated by the rapid development of new infrastructure elements focusing particularly on CAV development, as well as by the reorientation of existing ones. Interviewees expressed that *"everyone wants to get on board"*, if not by completely reorienting towards CAVs then at least by aligning one or a few key activities to the emerging theme.

However, a high degree of elaboration also meant that the initial stage of the change journey became incremental, even though there was a lot of buzz around CAVs. Activities were largely built on the existing ways of doing things of the regional industry. It is possible to argue that firms in the automotive industry went for the 'low hanging fruit', hardly challenging the institutional infrastructure. With the large number of well-developed institutional infrastructure

elements in place, it would not have been a feasible strategy to try to *"change everything at once" (Interview with regional industry expert)*.

On the one hand, a low degree of coherence in terms of technological focus, directions of change, and long-term goals manifested in the institutional infrastructure promote experimentation among a wide range of actors. In combination with a high degree of elaboration, this means that actors are incentivised to engage in the development of solutions related to CAVs defined broadly, and sometimes even defined in contradictory ways. For example, innovation support organisations such as Lindholmen Science Park provided support to actors that developed new products that would enhance the driving experience in privately owned cars, and to actors that rejected a future with privately owned cars altogether, developing mobility solutions for a future with shared vehicles. It is possible to observe contradictions between emerging activities and prevailing logics manifested in the institutional infrastructure.

On the other hand, the existence of a wide range of change directions also enables the participation of different types of private and public actors, working together under the umbrella of CAVs. For example, through a newly established AI research centre in the region, actors with different goals and ideas about change directions are brought together in AI research, aggregating underlying logics to a kind of 'mission-orientated' one.

Comparison and Conclusions

In summary, this paper advocates a more comprehensive understanding of structural conditions for innovation-based regional industrial renewal. Current EEG perspectives portray structures as either enabling or constraining for particular forms of path development, leaving little room for a more in-depth discussion of the implications certain structural configurations hold. Inspired by recent work in organizational institutionalism on 'institutional infrastructures', we propose to focus on the degree of elaboration and coherence as decisive features of regional structural conditions to gain a better understanding of their positive and negative implications for innovation-based regional industrial change. We argue that this conceptual lens allows for a more comprehensive discussion of the varying potentials and limitations entailed in different structural conditions.

The comparison of two empirical cases with different structural preconditions demonstrates the applicability of the framework. The Austrian triangle and West Sweden are both traditional automotive regions undergoing profound transformation processes due to the increasing digitalization of the sector and the advent of CAVs. This current upheaval is global in nature and – because of climate change and new, highly innovative players entering the market – affects an industry currently finding itself in distress. It is thus hardly surprising that we can observe parallels between two cases (most notably concerning the clash between traditional, 'engineering' logics and new, agile, IT-related approaches). Despite similarities, there are a number of differences between the two regions that highlight the place-specific dimension of radical innovation processes. Both regional industries are characterized by historically grown and well elaborated automotive structures that can – in particular in early phases – pose barriers

to change. We found evidence in both cases that the initiation of change was indeed hampered due to its inconsistency with the way the automotive structures were organized. However, West Sweden's structural conditions (featuring a lower degree of coherence as a result of a shift towards active safety technologies in the 2000s) – were allowing for more experimentation compared to the Austrian triangle, where change is now, after a period of reluctance, unfolding quickly. Interestingly, our empirical investigation points to different routes of transformation. In West Sweden, structural elements formerly only connected to the automotive industry are losing their strong focus, supporting now a wider variety of different regional industrial paths. In contrast, structures in the Austrian triangle are arguable even more coherent now. The complexity of change leads to the reorientation of structural elements and to the prioritization of activities related to CAVs. In this sense, the different structural elements in Austria are now more strongly reinforcing each other in order to advance this transformation.

The approach propagated in this paper has its merits but it is not without limitations. While the framework is admittedly putting a strong emphasis on structural influences, the concept should not overstate their importance at the expense of agency (see also Hinings et al., 2017). However, while it is crucial to stress that structures are created, maintained and disrupted by the actors that are influenced by these structures in the first place (i.e. "*the paradox of embedded agency*", Hinings et al., 2017, p. 183), it is still important to understand "*what is being worked on*" (Hinings et al., 2017, p. 183). The aim of this paper was thus to advance perspectives on structural conditions. Yet we consider agency perspectives (see, for instance, Sotarauta & Suvinen, 2018) as equally important.

Further, the paper directs attention to the relation between regional structures and industry renewal. The impact of varying degrees of elaboration and coherence of regional structures will depend on the regional embeddedness of an industry (Binz and Truffer, 2017). In essence, the stronger the regional embeddedness of an industry, the stronger regional structural conditions will affect its development. Future studies could extend the approach advocated here, examining how industrial path development is shaped by nationally and internationally configured structures.

Finally, this paper is mainly concerned with the influences of structural preconditions on regional industrial change. In line with other recent work (Miörner & Trippl, 2019; Tödtling & Trippl, 2013) and based on our empirical findings, we appreciate that the structural conditions themselves are often subject to alterations in regional processes of industrial change. Future work building on the perspectives outlined here should not only focus on the conditions for innovation-based change, but also more systematically examine how structural configurations and the degree of elaboration and coherence are evolving themselves in transformation processes. Future research should further advance the typology of different configurations presented in Table 1 and develop different pathways of change under these conditions (Hinings et al., 2017).

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