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Towards a systemic understanding of innovation-based regional industrial path transformations

Simon Baumgartinger-Seiringer

Dissertation

University of Vienna, Vienna, Austria

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Now, after having written a good part of this thesis in times of a global pandemic, I cannot wait for the next chapter to begin.

Vienna, February 2022
Simon Baumgartinger-Seiringer

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List of acronyms

AAT	Austrian Automotive Triangle (Styria, Upper Austria, Vienna)
C/AV(s)	Connected and Automated Vehicle(s)
EEG	Evolutionary Economic Geography
EU	European Union
FDI	Foreign Direct Investment
GPN(s)	Global Production Network(s)
ICT	Information and Communications Technology
IIS	Institutional Infrastructure
IS(s)	Innovation System(s)
MLP	Multi-Level Perspective
NIS(s)	National Innovation System(s)
NPD	New Path Development
OECD	Organisation for Economic Co-operation and Development
PD	Path Development
R&D	Research & Development
RIS(s)	Regional Innovation System(s)
RG(s)	Research Gap(s)
RQ(s)	Research Question(s)
SDG(s)	Sustainable Development Goal(s)
SoE	Sociology of Expectations
TIM(s)	Territorial Innovation Model(s)
TIS(s)	Technological Innovation System(s)

List of articles

This cumulative dissertation consists of the following four research articles (listed chronologically by publication date):

Article 1: Baumgartinger-Seiringer, Simon; Miörner, Johan & Trippl, Michaela (2021): 'Towards a stage model of regional industrial path transformation', In: *Industry and Innovation 28*(2): 160-181. doi: 10.1080/13662716.2020.1789452.

Article 2: Trippl, Michaela; Baumgartinger-Seiringer, Simon; Goracinova, Elena & Wolf, David (2021): 'Automotive regions in transition: Preparing for connected and automated vehicles', In: *Environment and Planning A: Economy and Space 53*(5): 1158-1179. doi: 0.1177/0308518X20987233.

Article 3: Baumgartinger-Seiringer, Simon; Fuenfschilling, Lea; Miörner, Johan & Trippl, Michaela (2021): 'Reconsidering structural conditions for industrial renewal', In: *Regional Studies* (Advance online publication). doi: 10.1080/00343404.2021.1984419.

Article 4: Baumgartinger-Seiringer, Simon (2021): 'The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency'. Submitted to an international peer-reviewed journal. Currently '*under review*' in second round after receiving '*minor revisions*' in the first. Working paper version published in the PEGIS working paper series: http://www-sre.wu.ac.at/sre-disc/geo-disc-2021_07.pdf

Extended abstract

Since the ‘evolutionary turn’, much attention in Economic Geography has been devoted to the evolution of regional economies and industries. While earlier work focused on path dependence, inertia and lock-ins, the past decade has seen a shift of attention to the analysis of ‘new regional industrial path development’, that is, the emergence of new sectors and innovation-based renewal processes of mature industries. Over the recent years, scholars have developed an impressive body of work consisting of both, narrow and more comprehensive perspectives on the topic.

However, reflecting a broader interest into how novelty is created, much of this literature is preoccupied with the rise of entirely new industrial paths, leaving transformation processes in existing paths under-studied. This thesis contrasts the recent trend and investigates, both conceptually and empirically, radical innovation-based changes in well-established industries (referred here to as ‘path transformations’). To this end, it utilises and further contributes to a burgeoning literature that has enriched Evolutionary Economic Geography with the Regional Innovation Systems (RIS) approach. This body of work essentially highlights that the capacity of regions to generate processes of new path development is determined by a wide set of regional factors and elements, their enabling and constraining influence and how they interact and work in concert.

Informed by this systemic understanding of regional industrial change, this cumulative thesis unravels path transformations by identifying and casting light on four fundamental dimensions through four different research articles: (i) the structures that condition path transformation, (ii) the actors who drive it, (iii) the iterative process between structures and agency underlying it and, finally, (iv) the outcomes of this process. This dissertation projects contributes to the debate by identifying and addressing research gaps in the extant literature associated with each of these key dimensions.

First, the thesis argues that it is necessary to move beyond simplistic conceptualisations of influences of (i) regional structural conditions. Arguably, many established perspectives portray structures as either per se enabling or constraining for certain forms of industrial development, thereby neglecting the greyscales. Inspired by complementary literature in Institutional Theory, this dissertation develops a conceptual lens that appreciates the nuances and distinct positive and negative dimensions inherited in different regional structural configurations.

Second, this thesis argues for reconsidering (ii) the circle of relevant actors and types of agency in path transformations. In particular, it casts light on an actor group that has received very limited attention in the recent debate on new path development: powerful incumbent firms. Drawing on insights from Management and Transition Studies, it is shown how they steer the

direction and pace of path transformation through their engagement that both can be oriented towards either change or maintenance.

Third, this dissertation unravels (iii) the iterative process between structures and agency underlying path transformations. The extant literature tells us little about how this process unfolds. This thesis offers a dynamic perspective, develops a stage model and shows how path transformation requires not only initiation but also acceleration and consolidation.

Fourth, this thesis explores (iv) the outcome of path transformation processes. It explicitly incorporates development outcomes in the wider RIS accompanying successful processes of path transformation. In doing so, it contrasts how this process has ultimately resulted in the upgrading of a regional industrial system in one spatiotemporal context, and to the reorientation in another. Hence, the thesis investigates where – based on varying structural preconditions, different types of agency and underlying mechanisms – path transformations might lead.

Empirically, this cumulative dissertation explores path transformation processes in different mature automotive regions in Austria, Sweden and Canada. The four research articles offer different angles and perspectives on current transformations towards more digitalised and sustainable regional industries. Thereby, this thesis seeks to deepen our understanding of the ways in which these changes take place and why they differ across different automotive regions based on a qualitative research design.

All in all, this cumulative dissertation contributes to a more comprehensive understanding of *how*, *where*, *why* and *when* path transformations unfold, offering nuanced perspectives on the structures, actors, the process itself and its outcome. Based on these insights, the thesis finally elucidates possible avenues for future research and the design and implementation of regional innovation policy, such as smart specialisation.

Keywords: Economic Geography, Evolutionary Economic Geography, Regional Innovation Systems, regional restructuring, path transformation, new path development, structure, agency, automotive industry, Austria, Ontario, West Sweden

JEL Codes: O31; O33; R11; R58

Kurzfassung

Seit der "evolutionären Wende" in der Wirtschaftsgeographie wurde der Entwicklung regionaler Wirtschaftssysteme viel Aufmerksamkeit gewidmet. Während sich frühere Arbeiten der Evolutionären Wirtschaftsgeographie auf Pfadabhängigkeiten und Lock-in-Phänomene konzentrierten, hat sich im vergangenen Jahrzehnt der Fokus auf die Analyse der "neuen regionalen industriellen Pfadentwicklung" verlagert, d. h. auf das Entstehen neuer und innovationsbasierter Erneuerungsprozesse etablierter Branchen. In den letzten Jahren hat sich so eine umfassende Literatur entwickelt, die sich sowohl aus engerer als auch aus ganzheitlicherer Perspektive mit diesem Thema beschäftigt.

Ein Großteil dieser Arbeiten befasst sich jedoch überwiegend mit der Entstehung völlig neuer Industriezweige und lässt Transformationsprozesse in bestehenden Branchen häufig unberücksichtigt. Die vorliegende Doktorarbeit positioniert sich gegen diesen Trend und untersucht sowohl konzeptionell als auch empirisch radikale innovationsbasierte Veränderungen in etablierten regionalen Industriepfaden (hier als "Pfadtransformationen" bezeichnet). Zu diesem Zweck baut diese Arbeit auf einem Ansatz auf, der die Evolutionäre Wirtschaftsgeographie mit dem Konzept der Regionalen Innovationssysteme (RIS) kombiniert hat. So wird im Wesentlichen hervorgehoben, dass das Potential von Regionen, Pfadtransformationsprozesse in Gang zu setzen, von einer Vielzahl regionaler Faktoren und Elemente abhängig ist, deren Zusammenspiel sowohl einen förderlichen als auch hinderlichen Einfluss haben kann.

Auf der Grundlage dieses systemischen Verständnisses des regionalen industriellen Wandels werden in dieser kumulativen Dissertation Pfadtransformationen erforscht indem vier grundlegende Dimensionen identifiziert und durch vier verschiedene Forschungsartikel beleuchtet werden: (i) die Strukturen, die Pfadtransformationen bedingen, (ii) die Akteur*innen, die sie vorantreiben, (iii) der ihnen zugrunde liegende iterative Prozess zwischen Strukturen und Handeln („structure and agency“) und schließlich (iv) die Ergebnisse dieser Prozesse. Dieses Dissertationsprojekt leistet einen Beitrag zur wissenschaftlichen Debatte, indem es Forschungslücken in der vorhandenen Literatur zu jeder dieser Schlüsseldimensionen identifiziert und adressiert.

In der vorliegenden Arbeit wird argumentiert, dass es zunächst notwendig ist, über eine vereinfachte Konzeptualisierung der Einflüsse (i) regionaler struktureller Bedingungen hinauszugehen. Viele etablierte Sichtweisen stellen regionale Strukturen als entweder per se förderlich oder hinderlich für bestimmte Formen der industriellen Entwicklung dar und vernachlässigen dabei die den strukturellen Bedingungen inhärente Komplexität. In Anlehnung an die Erkenntnisse der „institutional theory“ wird in dieser Dissertation ein konzeptioneller Ansatz entwickelt, der die Nuancen und unterschiedlichen positiven sowie negativen Dimensionen verschiedener regionaler Strukturkonfigurationen hervorhebt.

Zweitens plädiert diese Arbeit dafür (ii) den Kreis der relevanten Akteur*innen und Arten von Handlungsfeldern („types of agency“) bei Pfadtransformationen zu überdenken. Insbesondere wird eine Akteursgruppe beleuchtet, die in der jüngeren Debatte nur wenig Beachtung gefunden hat: mächtige, etablierte Unternehmen. Auf der Grundlage von Erkenntnissen aus der Management- und Transitionsforschung wird gezeigt, wie diese Akteursgruppe die Richtung und Geschwindigkeit von Pfadtransformationen durch ihre Aktivitäten, die sowohl auf Veränderung als auch auf Erhaltung ausgerichtet sein können, beeinflussen.

Drittens wird in dieser Dissertation (iii) der iterative Prozess zwischen den Strukturen und dem menschlichen Handeln, der den Pfadveränderungen zugrunde liegt, untersucht. Die vorhandene Literatur sagt wenig darüber aus, wie dieser Prozess abläuft. Diese Arbeit bietet eine dynamische Perspektive, entwickelt ein Phasenmodell und zeigt, wie Pfadtransformationen nicht nur initiiert, sondern auch beschleunigt und konsolidiert werden müssen.

Viertens untersucht diese Arbeit (iv) die Ergebnisse von Pfadtransformationsprozessen. Dabei werden explizit Entwicklungen im breiteren RIS einbezogen, die erfolgreiche Prozesse der Pfadtransformation häufig begleiten. So wird analysiert, wie dieser Prozess letztlich zur Aufwertung eines regionalen Industriesystems in einem raumzeitlichen Kontext und zur Neuorientierung in einem anderen geführt hat. Die Arbeit untersucht daher, wohin Pfadtransformationen unter verschiedenen strukturellen Voraussetzungen, unterschiedlichen Akteurs- und Handlungstypen und zugrunde liegenden Mechanismen führen können.

Empirisch werden in dieser kumulativen Dissertation Pfadtransformationsprozesse in verschiedenen Automobilregionen in Österreich, Schweden und Kanada untersucht. Die vier Forschungsartikel eröffnen unterschiedliche Blickwinkel auf aktuelle Transformationen hin zu digitalisierten und nachhaltigeren regionalen Industrien. Auf der Grundlage eines qualitativen Forschungsdesigns erweitert diese Arbeit somit das Verständnis darüber, wie solche Veränderungen stattfinden und warum sie sich in verschiedenen Automobilregionen unterscheiden.

Alles in allem trägt diese kumulative Dissertation zu einem umfassenderen Bild darüber bei, *wie*, *wo*, *warum* und *wann* sich Pfadtransformationen entfalten, und bietet nuancierte Perspektiven auf die Strukturen, Akteur*innen, den Prozess selbst und seine Ergebnisse. Auf der Grundlage dieser Erkenntnisse zeigt die Dissertation schließlich einerseits mögliche aufbauende Ansätze für künftige Forschung und andererseits Implikationen für die Gestaltung und Umsetzung regionaler Innovationspolitik auf.

Stichworte: Wirtschaftsgeographie, Evolutionäre Wirtschaftsgeographie, Regionale Innovationssysteme, regionale Umstrukturierung, Pfadtransformation, neue Pfad-Entwicklung, Struktur, Agency, Automobilindustrie, Österreich, Ontario, Westschweden

JEL-Codes: O31; O33; R11; R58

1 Introduction

We find ourselves in an era of transformational change (Kumaraswamy et al., 2018). On the one hand, grand societal challenges such as the climate crisis, population dynamics, territorial inequalities or resource depletion – often but not always connected to adverse impacts of economic development – drive efforts of industrial restructuring in regions and countries (Trippl et al., 2020). On the other hand, digitalisation, inter-penetrating platforms, big data, increasing computing power and other developments lead to an accelerated pace of change and shorter development cycles (Weber & Truffer, 2017; Kumaraswamy et al., 2018).

Fuelled by these circumstances, economies across the world are confronted with the constant pressure to rebuild their industrial fabric and to develop new, sustainable and digitalised economic activities to offset the decline of old, unsustainable and outdated sectors. Consequently, the creation of new industries and the renewal of mature ones are ranking high on both academic and policy agendas.

It is thus hardly surprising that *innovation* is considered to play a key role, not only to contribute to economic success in a more traditional sense by providing increased productivity, jobs and growth, but also to tackle the grand challenges of our time and sustain long-term well-being (OECD, 2015). Hence, innovation is increasingly understood broadly (Schot & Steinmueller, 2018; Coenen & Morgan, 2020; Tödtling et al., 2021), more and more attention is placed on the direction of innovation and change to achieve more sustainable forms of development from a socio-ecological perspective (Tödtling & Trippl, 2018).

There is a widespread agreement in the literature that the capacity to break path dependencies, to generate novelty, to rejuvenate existing industries and to nourish new ones varies significantly across nations and regions (Martin, 2010; Schamp, 2017; Feldman, 2019). Such processes show distinct spatial patterns. Accordingly, the questions of where new economic activities come into being, why certain regions are better suited to attract and create such activities than others and why some regions succeed in modernizing their mature industries while others fail are at the heart of Economic Geography.

Scientific efforts to tackle these questions date back to Alfred Marshall's work on the 'Principles of Economics' first published in the late 19th century (Feldman, 2019). Since then, many different approaches have been presented. Particularly the various academic currents starting around the 1980s summarised under the umbrella term of 'Territorial Innovation Models' (TIMs) (Moulaert & Sekia, 2003) – that rediscovered Marshall's work – provided important insights into the uneven geography of innovation by casting light on place-specific socio-economic and institutional factors (Asheim et al., 2019). Among them are, for instance, the literatures on Innovative Milieus (Maillat & Lecoq, 1992), Industrial Districts (Bagnasco,

1977), New Industrial Spaces (Scott, 1988; Storper & Scott, 1989) and Clusters of Innovation (Saxenian, 1994).

Innovation and its spatiality are also at the heart of an evolutionary approach to Economic Geography (Boschma & Martin, 2007). Indeed, inspired by Evolutionary Economics, a new paradigm has risen over the past two decades that is intrinsically concerned with processes of change in regional economies and geographical patterns of economic novelty (Martin & Sunley, 2006; Boschma & Martin, 2010). The core argument of this paradigm labelled 'Evolutionary Economic Geography' (EEG) is that regional economies or industries evolve in a quasi-evolutionary way. That is, regional industrial change – brought about by innovation as the main driver of the emergence and creation of novelty (Schamp, 2017) – is seen as a place and path dependent process contingent on structures inherited from past rounds of regional economic development (Frenken & Boschma, 2007; Martin & Sunley, 2006, 2010). Thereby, scholars have brought forward powerful tools to explain the geographical variation of the evolution of the economic landscape (Martin & Sunley, 2006; Martin, 2010; Schamp, 2017).

Based on this fundamental assumption that '*in a nontrivial sense, history matters*' (Martin, 2010, p. 2), earlier accounts within the framework of EEG have placed much attention on the concept of 'lock-in' (Martin & Sunley, 2006). Thereby, they mainly focused on explaining why regional industries evolve in a path dependent manner, putting emphasis on self-reinforcing and self-reproducing effects that steer a regional economy or industry along one development path, lead to increasing rigidification and ultimately to a state where it is locked-in in its (often successful) history. In this sense, the past was long portrayed as a potential source of inflexibility and a constraint for dynamic regional development in the present (Arthur, 1989; Martin & Sunley, 2006).

Over the years, however, scholars have started to re-evaluate the role of a region's past and focused (also) on its enabling influence on the generation of economic novelty and the creation of new development paths[1] (Garud et al., 2010; Martin, 2010). That is, mechanisms of change rather than continuity have received increasing attention. The principal idea is that new industrial paths are latent in old ones, implying that they have little freedom in choosing their location but rather depend on pre-existing structures in regions. This view contrasts earlier contributions that have drawn on the concepts of windows of locational opportunity and new industrial spaces and assumed a relative locational freedom in the early phases of industry emergence (Storper & Walker, 1989; Boschma, 1997).

Since the late 2000s, the so-called 'Utrecht school of EEG' has been particularly influential in explaining the geographical patterns of new path development through the principle of regional diversification based on historically inherited related regional industrial capabilities (Boschma, 2017). Accordingly, the main argument is that new industrial development paths 'branch out' of existing and technologically related ones (Neffke et al., 2011). While this body of literature

[1] A new development path can be defined '*as a set of functionally related firms and supportive actors and institutions that are established and legitimized beyond emergence, and are facing early stages of growth and developing new processes and products …*' (Steen & Hansen, 2018, p. 191).

has been highly influential, scholars have identified a number of shortcomings over the years, in particular related to its endogenous, industry-centred and firm-driven views (Schamp, 2017; Trippl et al., 2018; Hassink et al., 2019).

More recent contributions contest the narrow perspectives proposed by the Utrecht school. Under the umbrella terms 'new path development' (e.g. Isaksen & Trippl, 2016; Trippl et al., 2018) and 'path creation' (e.g. Binz et al., 2016; Steen & Hansen, 2018; MacKinnon et al., 2019a), a new body of literature has formed that seeks to develop a more comprehensive understanding of how industrial dynamics unfold in space and over time. Following Hassink et al. (2019, p. 1637) and others, this dissertation will use the term '*new regional industrial path development*', referring to '*various forms of the rise of new economic activities in regions*', including the emergence of entirely new paths as well as substantial adaptations in existing ones.

Much of this new work on new path development draws on evolutionary ideas but seeks to complement them with insights from other strands of literature in order to compensate for certain shortcomings. In doing so, ties have been forged between EEG and – among others – the literature on Global Production Networks (GPN) (MacKinnon, 2012; MacKinnon et al., 2019a), the Multi-Level Perspective (MLP) (Boschma et al., 2017) or Sociology of Expectations (Steen, 2016). What unites these different approaches is the conviction that in order to better understand the *how, where, why* and *when* of new path development, more comprehensive views are necessary.

Herein lies the starting point of this dissertation project. It aims at contributing to the further development of a more holistic understanding of 'new path development'. To this end, this thesis will draw on a burgeoning and promising body of work that embeds insights from EEG in broader systemic perspectives. In this respect, scholars have previously made use of two different innovation system approaches, namely the concepts of *Technological* Innovation Systems (TIS) (Binz et al., 2016; Steen & Hansen, 2018; Njøs et al., 2020) and *Regional* Innovation Systems (RIS) (Tödtling & Trippl, 2013; Isaksen & Trippl, 2016; Miörner, 2020; Trippl et al., 2020) or both (Miörner & Trippl, 2019; Rohe & Mattes, 2022).

On the one hand, these two approaches share a number of commonalities. Both have their roots in evolutionary economics (Nelson & Winter, 1982) and the broader literature on innovation systems (Weber & Truffer, 2017). Both stress the non-linear, systemic, interactive and evolutionary character of innovation processes (Tödtling & Trippl, 2013; Binz et al., 2016). And both highlight the three core pillars of innovation systems, that is, actors, networks and institutions (Cooke et al., 2004; Markard & Truffer, 2008).

On the other hand, there are a number of differences between the TIS and RIS concept, the main one lying in the definition of the system's boundaries. While the TIS approach focuses on a (emerging) technological field, the RIS approach draws the boundaries along territorial lines. The TIS concept comes with its own merits and shortcomings in the context of research on new path development, which have been discussed elsewhere (see, for instance, Binz et al., 2016;

Weber & Truffer, 2017 or Miörner & Trippl, 2019). This dissertation project seeks to contribute to work at the intersection of EEG and RIS studies.

Comprehensive perspectives based on the RIS approach stress the systemic character of new path development. In essence, they argue that in order to holistically unravel how, where, why and when new regional industrial development paths come into being and existing ones are substantially transformed, it is necessary to incorporate the wider surrounding regional environment in which they are embedded in (Tödtling & Trippl, 2013; Isaksen & Trippl, 2016; Miörner, 2020; Trippl et al., 2020). Thereby, over the course of the past ten years, this literature has brought about several key advancements for our understanding of new path development beyond the rather narrow, firm-oriented and industry-centred explanations of regional structural change found in the Utrecht school (Hassink et al., 2019).

To begin with, work at the intersection of EEG and RIS argues for including a broader set of relevant regional structural conditions, that – together – form the wider regional system in which new path development is embedded. Thereby, this literature casts light on regional support structures (universities, research institutes, intermediaries etc.), on formal (laws, rules, etc.) as well as informal (traditions, norms, values, etc.) institutional set-ups and on other industrial paths located in the region (Frangenheim et al., 2020; Trippl et al., 2020). It has been shown that regions endowed with different innovation system structures come with substantially different potential to generate new development paths or to alter existing ones (Isaksen & Trippl, 2016).

Moreover, while studies in narrow EEG models have extensively focused on change processes on the firm-level in regional restructuring, this body of work highlights dynamics in the wider regional system that – as this literature has shown – are often linked inextricably to new path development (Tödtling & Trippl, 2013; Miörner & Trippl, 2019). Scholars have explored the role of different actors and various types of agency in bringing about these change processes necessary (Miörner & Trippl, 2017; Isaksen et al., 2019; Trippl et al., 2020).

Finally, through this lens, new path development has been conceptualised as being embedded in open systems (Trippl et al., 2018; Asheim et al., 2019) Thereby, scholars have casted light on the interplay between intra-regional and extra-regional influences (e.g. in the form of knowledge flows or interferences of external actors).

This thesis – for its overarching goal to further contribute to advancing our understanding of innovation-based regional restructuring – will utilize this elaborated conceptual ground to investigate new path development through a systemic lens based on the RIS approach. Drawing on these opening remarks, the next chapter will outline the concrete aim and contribution of this dissertation.

1.1 Aims and contributions: Reconsidering new path development

New path development, as per definition, refers to the rise of entirely new paths as well as the substantial alteration of existing ones (Hassink et al., 2019). However, reflecting a broader scholarly interest into how novelty is generated (Morgan, 2017), the research field is clearly characterised by a strong recent focus on the former (MacKinnon et al., 2019a). EEG stresses the constant need of established industries to (incrementally) adapt to changing internal (e.g. new knowledge through R&D, search for new competitive advantages) and external (e.g. extra-regional policies, changes in global production or innovation networks) circumstances to avoid negative path dependencies and lock-ins (Martin & Sunley, 2006; Martin, 2010). However, it has hitherto placed limited attention on radical changes happening *on the path*, which, as a consequence, are arguably understudied (Miörner & Trippl, 2019; Baumgartinger-Seiringer et al., 2021b, paper #1 of this thesis). This is the case even though digitalisation and the need for sustainability transitions will only continue to fundamentally change existing paths in the years to come (Weber & Truffer, 2017; Kumaraswamy et al., 2018).

This dissertation project stands in contrast to the recent trend. For the reasons just outlined, it explores transformation processes in mature industries and, thereby, aims at closing a gap in the broader research field. Such radical *on path* changes are referred here to as '*path transformations*', that is, '*radical, innovation-based forms of path development, where an established path and the regional support structures it is embedded in are undergoing major change*' (Baumgartinger-Seiringer et al., 2021b, p. 161, paper #1). This means that new path development is approached in this thesis with a distinct focus on important, yet recently often overlooked transformation processes in well-established industries and their surrounding RIS in ways that they can be considered as embarking on a new development trajectory without being dissolved (Hassink et al., 2019; Miörner & Trippl, 2019).

Informed by work at the intersection of EEG and RIS, this dissertation investigates path transformations from a distinct systemic perspective. It identifies four key dimensions, which not only are considered fundamental to the transformation of well-established paths, but also constitute the main building blocks of the conceptual framework underlying this thesis and its four research articles (see chapter 4.1).

- **(i)** Structural conditions
- **(ii)** Local and non-local multi actor constellations
- **(iii)** Structure-agency dynamics
- **(iv)** Outcomes

This dissertation project casts light on each of these building blocks, identifies associated research gaps in the extant literature and proposes advancements in specific aspects in all of these dimensions. In what follows, the gaps addressed and key aims will be briefly outlined (for

a more thorough discussion of the research gaps, research questions and core contributions, see chapter 4.2).

First, when it comes to **(i)** structural conditions, this thesis is in agreement with several recent publications in the wider research field on new path development that argue for moving beyond the almost exclusive focus on knowledge-related assets in narrow EEG models (Binz et al., 2016; MacKinnon et al., 2019a; Trippl et al., 2020). However, this dissertation contends that established concepts – even those featuring broad perspectives on structural conditions like approaches based on the RIS literature – portray structural influences rather simplistically. Therefore, this work argues for a reconsideration of the potentials for and the constraints to path transformation entailed in different regional structural configurations.

Second, in respect to **(ii)** local and non-local actors, this thesis – inspired by recent comprehensive perspectives – adopts a multi-actor approach (Hassink et al., 2019), and understands path transformations not only as a firm-driven process, but places attention on actors in universities, research institutes, intermediaries and the policy domain from inside (that is, actors in the wider RIS) and outside the region and their role in development processes of regional industrial paths (Tanner, 2014; Dawley et al., 2015; Binz et al., 2016; Vallance, 2016). Hassink et al. (2019, p. 1638) have further pointed out that a '*possible starting point for a multi-actor approach to new path development is to zoom in on the role of human agency*'. Indeed, many recent publications have started to incorporate the role of various types of agentic processes originating from different actors in their analyses of (new) path development (Boschma et al., 2017; Isaksen et al., 2019; Grillitsch & Sotarauta, 2020). This thesis is strongly informed by this 'recent turn towards agency'. However, again reflecting a general recent interest in the creation of novelty, much of this literature is preoccupied with change agents and change agency, neglecting the role of other actors and types of agency oriented towards maintenance, reproduction and stability (Jolly et al., 2020; Bækkelund, 2021). This dissertation project addresses this gap and reconsiders the circle of relevant actors and agentic processes necessary to comprehensively unravel (the lack of) path transformations.

Third, this thesis holds the view that it is **(iii)** the iterative process between structures and actors and their agency that drives new path development. As such, this dissertation follows recent contributions arguing that the mere existence of structural conditions cannot explain the emergence of new industries or the transformation of existing ones. Instead, the potential in structures must be identified, harnessed and valorised by actors for new path development to unfold (MacKinnon et al., 2019b; Trippl et al., 2020). Moreover, recent analyses (in particular those based on the RIS approach) have shown that the emergence of new regional paths and substantial changes in existing ones are often inextricably linked to modifications of the wider regional structural environment in order for the demands of a novel or deeply altered industry (e.g. new knowledge or altered institutional framework conditions) to be met (Tödtling & Trippl 2013; Miörner & Trippl, 2019). As mature industries are often (albeit not always) strongly aligned with their surrounding RIS, this interdependence between the development within a path and the wider regional reconfigurations coming with it are arguably of particular importance in cases of path transformations. However, the recent literature tells us little about

how this process underlying the transformation of industries unfolds over time. In this respect, this dissertation argues for more 'temporal wisdom' when analysing path transformations and develops a processual approach.

Fourth, this thesis seeks to make more informed statements about the **(iv)** outcome of the process. While established models argue that the process can result in either successful or failed new path development, thereby placing limited attention on the nuances, this dissertation offers a novel perspective by investigating in more detail the contingent nature of path transformation and the wider adaptations in the surrounding RIS coming with it. It shows how certain structural conditions, different actor constellations and varying types of agency shape routes of change, leading ultimately to different development outcomes.

In order to address the blind-spots elucidated and fill the gaps outlined, this thesis has made use of the explanatory power residing in other, complementary strands of literature beyond the sphere of Economic Geography. Accordingly, this dissertation project has drawn important insights from Relational Sociology (Emirbayer & Mische, 1998), Sociology of Expectations (Borup et al., 2006; Steen, 2016), Transition Studies (Geels, 2002, 2014; Turnheim & Sovacool, 2020), Management Studies (Kumaraswamy et al., 2018; Patala et al., 2019) and Organisational Institutionalism (Hinings et al., 2017; Zietsma et al., 2017). These insights have been instrumental for many advancements proposed in this dissertation project and in the four constituting articles. As such, this thesis pursues a 'synthetic approach' to theoretical combinations in order to produce new perspectives and explanations (Cairney, 2013). As Cairney (2013) points out, however, the combination of multiple theoretical standpoints does not only come with great potential value, but also raises important ontological, epistemological and practical issues. The pros and cons of this approach will be reflected on in the final chapter of this framework text (see chapter 6).

Finally, this dissertation does not only seek to contribute conceptually, but – based on insights from different case studies – also offers empirical insights. Accordingly, this thesis explores and compares three different mature automotive regions in Austria (with a focus on the so-called 'Austrian automotive triangle' (AAT), consisting of the three federal states Styria, Upper Austria and Vienna), Sweden (West Sweden around Gothenburg) and Canada (Ontario). All three regional industries are presently undergoing profound transformation processes based on radical innovations, making them interesting case studies for exploring the contingent nature of regional economic restructuring. This dissertation and the four research articles offer different angles and perspectives on these current transformations towards more digitalised and sustainable regional industries. Thereby, this thesis seeks to deepen our understanding of the ways in which these changes take place and why they differ across different automotive regions based on a qualitative research design.

All in all, it is argued here that these advancements contribute to a better understanding of the *how*, *where*, *why* and *when* of new path development (with a distinct focus on path transformations) and, thereby, add a small piece to the larger mosaic of research on innovation-based regional restructuring.

1.2 Overview of the articles

This dissertation project has been carried out in a cumulative form. It consists of four research articles that have been published in, or submitted to different international peer-reviewed journals. These articles – which have been developed, written, submitted and revised over the period of 2018-2021 – constitute the heart of this thesis. This section briefly introduces the four papers and their link to the research aims. Importantly, each article is particularly concerned (albeit not exclusively) with one of the four key dimensions (structure, actors, process, outcome) and associated research gaps outlined above.

Article 1, titled *Towards a stage model of regional industrial path transformation*, published in Industry and Innovation (Baumgartinger-Seiringer et al., 2021b) casts light on radical transformation processes occurring within existing paths and the wider RIS they are embedded in from a processual view. The paper highlights the need for a dynamic perspective on such profound alterations and proposes a stage model. In doing so, three phases of transformation are differentiated: an initiation, an acceleration and a consolidation stage. It is argued that each of these stages comes with quite specific characteristics and challenges. The article places particular emphasis on the role of agents and their agency – influenced by both historically-inherited structural conditions and perceived futures in the form of visions and expectations. The framework is applied to the analysis of transformation processes in West Sweden's automotive industry towards the development of self-driving cars. Therefore, this paper is particularly concerned with building block **(iii)** of the conceptual framework, the iterative process between structures and actors underlying path transformations.

Article 2, titled *Automotive regions in transition: Preparing for connected and automated vehicles*, published in Environment and Planning A: Economy and Space (Trippl et al., 2021) investigates conceptually and empirically how automotive regions cope with the fundamental transformation challenges posed by the advent of connected and autonomous cars (C/AVs). Particular emphasis is placed on broadly defined regional structural preconditions. In doing so, the paper focuses not only on the focal automotive path, but also on the role of other regional paths, the automotive region's embeddedness in GPNs, the regional organisational support structure and institutional set-ups. It is shown how these conditions provide the platform for distinct change processes brought about by agency that underpin two different routes of transformation: a reorientation and an upgrading route. Empirically, it is shown that the Austrian automotive triangle transforms towards a reorientation, while the automotive system in the greater Ontario area (Canada) is following along an upgrading route. Therefore, this paper is particularly concerned with building block **(iv)** of the conceptual framework: the outcomes of path transformation.

Article 3, titled *Reconsidering structural conditions for industrial renewal*, published in Regional Studies (Baumgartinger-Seiringer et al., 2021a) problematises that structural conditions are often portrayed in a rather simplistic way in established perspectives. They are usually seen as either per se enabling or constraining for certain forms of development. It is argued that this holds true also for systemic perspectives. The article seeks to provide more

comprehensive perspectives by building a bridge to recent work on 'institutional infrastructures'. Inspired by this concept developed within Organisational Institutionalism, attention is placed on two decisive features of relevant structural conditions: their elaboration and coherence. The paper suggests that this conceptual lens is well-suited to conceptualize the potentials and limitations found in different structural configurations, not least because of important implications for agency. This approach is illustrated by investigating comparatively transformation processes in the AAT and West Sweden's automotive industry. Therefore, this paper is particularly concerned with building block **(i)** of the conceptual framework: the structures conditioning path transformation.

Article 4, titled *The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency* (Baumgartinger-Seiringer, 2021), submitted to an international peer-reviewed journal (currently '*under review*' in the second round after receiving '*minor revisions*' in the first) draws attention to an actor group that – hitherto – has received limited explicit attention in the debate on new path development, namely powerful incumbent firms. Arguably, this lack of attention is due to the fact that incumbents are often portrayed as actors who seek to reproduce the status quo from which the usually benefit, instead of bringing about novelty and change. However, drawing on insights from Transition Studies, this article argues that incumbents play a crucial role in steering path transformation processes through agency oriented towards both, change *and* maintenance. From a systemic perspective, particular emphasis is placed on how they leverage their power to reconfigure or stabilize their surrounding RIS to support their intentions. Empirically, incumbent firms in the AAT and their role in propelling processes of digitalisation while suppressing processes of decarbonisation are investigated. Therefore, this paper is particularly concerned with building block **(ii)** of the conceptual framework: the actors driving path transformation.

1.3 Structure of the thesis

The main contribution of this thesis lies in the four research articles found in the second part. The articles are preceded by a general introductory text that provides the framing for this dissertation. This framework text is structured as follows.

Chapter 1 has offered an introduction to the subjects of the thesis and elucidated the underlying aims and goals of this dissertation.

Chapter 2 outlines the theoretical background on which this thesis is based. It briefly introduces the debate on the uneven geography of innovation. It then traces back the development of EEG from path dependency and lock-in to new path development. This is followed by a discussion of the strengths and weaknesses of the predominant 'Utrecht school of EEG' in explaining new path development. Then, the chapter highlights the need for and the contribution of new and more comprehensive perspectives. In this regard, three key

advancements will be briefly outlined (broader views on structures, multi-scalar view, multi actor approach and the role of agency), all of which play an important role for the research articles.

Chapter 3 moves from these more general descriptions of the broader theoretical background to the concrete branch of literature to which this thesis contributes. As such, it first discusses the Regional Innovation System approach and then introduces in more detail the state of the art of work at the intersection of EEG and RIS. Thereby, chapter 3 lays the groundwork for the four research articles.

Chapter 4 is concerned with the dissertation's conceptual framework. It first elucidates the conceptual underpinnings guiding this thesis. This is followed by an outline of open problems and avenues for developing and further advancing a systemic approach to path transformation based on the RIS approach.

Chapter 5 casts light on the dissertation's research design. It first focuses on the underlying epistemological and ontological perspectives based on which it then outlines the methodology. This is followed by a description of the methods used for data collection and analysis. Lastly, it discusses the concrete empirical cases and their contexts.

C**hapter 6** offers a synthesis of the results of this thesis. The first part is structured along the four articles and discusses their results individually. This is followed by a more general and overarching conclusion, which expounds how insights of this dissertation project can contribute to move towards a more comprehensive systemic framework. Finally, an outline of possible avenues for future research and implications for policy are presented.

2 Theoretical background: New regional industrial path development

This chapter seeks to outline the theoretical background of this dissertation. Thereby, it embeds the overall dissertation project as well as the single research articles in the broader academic field.

The aim of this thesis – broadly defined – is to contribute to the debate on innovation-based regional restructuring. From a geographical perspective, emphasis is placed on the question why underlying processes vary across space and time. To this end, it is useful to first turn to innovation itself, what it is, to its uneven geography, and, last not least, why it plays an important role in the restructuring of regions (see chapter 2.1).

This is followed by a short introduction to Evolutionary Economic Geography (EEG), which has become the dominant paradigm in the debate on innovation-based regional restructuring over the past two decades. Chapter 2.2. outlines the recent development of evolutionary thinking in Economic Geography from path dependency to new path development and, thereby, elucidates essential theoretical underpinnings of the thesis.

Chapter 2.3 then discusses the most influential stream within EEG, the so-called Utrecht school and its strengths and weaknesses. Its widespread recognition both in academic and policy circles, its explanatory power but also its shortcomings can be seen as the key motivation for the development of emerging comprehensive perspectives on new path development. While systemic perspectives based on the RIS concept – as one comprehensive approach among others – will be reviewed separately in chapter 3, key advancements made in the wider field of regional path development research (and beyond) are an important source of insights that have been consulted throughout this dissertation project and, as such, will be presented in Chapter 2.4

2.1 Innovation, its uneven geography and regional development

Over the past decades, innovation has become a '*global buzzword'* (Coenen & Morgan, 2020, p. 13). It is considered '*imperative'* for the productivity, growth and well-being (OECD, 2015, p. 3) on the micro level of single firms but also on the meso und macro levels of cities, regions and whole nations (Shearmur, 2012; Coenen & Morgan, 2020). Accordingly, it ranks high on academic and policy agendas to understand how and where innovation is occurring and how it can be promoted (OECD, 2015). Despite its significance (or – maybe – just because of it), there is no single definition of innovation that is universally accepted (Baregheh et al., 2009). Hence,

to begin with, this chapter will lay the foundation by casting light on different perceptions of innovation.

In his seminal work on 'The theory of economic development' – that until today is one of the most influential contributions in the history of the field of Economics (Croitoru, 2012) – Schumpeter (1934, p.66) refers to what he later called 'innovation' as '*new combinations'*. The concept of 'new combinations' – as Schumpeter (1934) pointed out – covers five cases: (i) the introduction of a new good or new quality of a good, (ii) the introduction of a new method of production, (iii) the opening of a new market, (iv) the conquest of a new source of supply and (v) the carrying out of the new organisation of an industry. Importantly, Schumpeter considered these innovative actions as engines of economic development through the so-called '*gale of creative destruction*', which describes the '*process of industrial mutation that continuously revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one*' (Schumpeter, 1942, p. 83). He saw the main protagonists of this processes in entrepreneurs (Croitoru, 2012), which – in contemporary debates – are often referred to as 'Schumpeterian entrepreneurs'.

Schumpeter's notions – first published in German in 1911 and hence more than a century old – remain important to this day, particularly in Evolutionary Economics. Driven by the circumstances outlined above, the last decades have witnessed a renewed interest in the concept of innovation and further exploring its nature, types, stages, means and aims has become a multidisciplinary endeavour (Baregheh et al., 2009). Over the years, research has investigated how innovative activities unfold as a multi-stage process, moved beyond a linear and unidirectional perception of innovation and thereby came to terms with a new understanding of innovation as an often incremental, interactive process consisting of feedback loops and potential restarts (Lundvall, 1992; Fagerberg, 2005). Moreover, scholars have highlighted the diverse character of innovation. As Schumpeter has pointed out, it can come in quite different forms and shapes, namely as new/improved products, services or processes that play an important role in the competition with competitors (Fagerberg, 2005; Baregheh et al., 2009). However, these early accounts of innovation are characterised by very economic and technological conceptions. Thus, more recent contributions highlight that innovation is not only concerned with improving productivity or competitiveness but also with the development of better forms *of living* through social innovations (Moulaert et al., 2013; Boslaugh, 2016).

What is more, innovation is increasingly considered as a means by which the grand societal challenges can be tackled (Coenen & Morgan, 2020). Indeed, one can observe a more recent shift in the rationale for innovation, where its importance for addressing and meeting the sustainable development goals (SDGs) is emphasised (Weber & Truffer, 2017; Coenen & Morgan, 2020; Tödtling et al., 2021). In this sense, innovation is considered as a key variable in the process of replacing the established and conventional with a more sustainable alternative[2] (Boslaugh, 2016).

[2] This broad understanding of innovation has been one key motive for a recent investigation of the unfolding of *green* forms of (new) path development (Trippl et al., 2020; co-authored by the author of this thesis).

However, it is important to note that innovation, from this angle, is often put forward as an excuse to keep the status-quo, to delay necessary and profound alterations to our socio-technical systems and as a promise that the solution (i.e. *the* innovation) 'is around the corner' (Baumgartinger-Seiringer, 2021, paper #4). Accordingly, there is a growing interest in destabilisation policies (Kivimaa & Kern, 2016) based on the fundamental conviction that in order to solve the challenges ahead, innovation alone is insufficient and must be complemented by exnovation, referring to '*the purposive termination of existing (infra)structures, technologies, products and practices*' (Heyen et al., 2017, p. 326). In other words, the ways in which the 'destructive part' of Schumpeter's creative destruction can be accelerated are increasingly attracting interest (Kivimaa & Kern, 2016).

All in all, there is no universally agreed understanding of innovation. What is meant by the term is itself subject to ever new ways of thinking and continuous re-evaluation and dependent on the context. As Weber and Truffer (2017) point out, innovation is at the origin of disruptions in society, but it is also often seen as a tool to address problems and to respond to disruptive changes. As such, what we understand by innovation also depends on the problems it is intended to solve.

Thus, the discourse on innovation is characterised by ubiquity (Coenen & Morgan, 2020), fuzziness (Godin, 2002) and changes in perspective (Schot & Steinmueller, 2018). However, in contrast to the lack of a universally-accepted definition and understanding, there is widespread agreement that geography matters. As Feldman (2019, p.1) pointed out:

> *'One of the most striking features of innovation is its pronounced tendency to cluster both spatially and temporally. Throughout human history we observe that creative activity has been concentrated in certain places and at certain times: consider Florence under the Medici, Paris in the 1920s, Britain during the Industrial Revolution and Silicon Valley in more recent times.'*

This spatiality of innovation is what makes it an exciting subject for economic geographers, as the discipline was always intrinsically concerned with uneven space and understanding the underlying factors and determinants (MacKinnon & Cumbers, 2018). Today it is commonly acknowledged that agglomeration and geographical proximity are a crucial explanatory variable of innovation processes[3] (Morgan & Coenen, 2020). Therefore, Geography as a discipline offers an important lens to the study of innovation and – as Feldman (2019, p. 5) has argued – has a certain competitive advantage in this regard, as '*there is often a temptation to analyse firms, institutions and actors individually [when studying innovation, note of the author]; however, the geography of innovation literature considers the larger context. […] once the analysis is open to consider geography there is a need to understand history, building a deep contextualised understanding of a place […]*'.

[3] At the same time, it is also accepted that their implications are not straight-forward or universally enabling, but more complex and multi-layered (Morgan, 2004). In this respect, Boschma (2005) argues that spatial proximity alone is insufficient to explain innovation but has to be seen in relation to other dimensions, namely cognitive, organisational, social and institutional proximity. Geographical proximity can stimulate the other dimensions.

As such, the geography of innovation offers essential answers in the grand scheme of understanding innovation processes. In particular since the 1980s, when Marshall's work has been rediscovered (Asheim et al., 2019), scholars have devoted much time and effort to unravel key questions of the field, such as: 'What spatial conditions enable the rise of new (economic) activity?' and 'what makes a location more or less conducive for such processes?'.

The growing interest in the uneven geography of innovation was amplified by a climate of crisis back in the 1970s, when policymakers were forced to turn away from traditional, national state-led policies on regional development that were mainly concerned with traditional industrial firms and regions. These conventional policies were informed by a linear model of innovation and rested on the assumption that the prosperity in certain growth centres would 'trickle down' to other regions based on multiplier effects. These policies – as the crisis of the 1970s have shown – were flawed (Moulaert & Sekia, 2003; Asheim et al., 2019).

Fuelled by these circumstances and further propelled by increased global competition between nations and regions, a new interest in the potential of endogenous regional development through new technologies and advanced services arose. As such, innovation and learning moved centre stage and were increasingly considered as the key determinates that underpin regional development and the construction of regional economic competitiveness (Asheim et al., 2019). Many different scholars picked up this debate and brought forward different concepts. In particular those different academic currents that were later subsumed under the umbrella term of Territorial Innovation Models (TIMs) (Moulaert & Sekia, 2003) have become highly influential by placing emphasis on the place-specific, socio-economic and institutional factors of innovation (Asheim et al., 2019). Arguably, the most important of these is the RIS concept (Marques & Morgan, 2021), which – as Coenen and Morgen (2020, p. 14) argue – '*can be seen as a synthesis of decades of research on the topic*' and which plays a crucial role for this thesis (see chapter 3). Today, as Marques and Morgan (2021, p. 476) have recently pointed out, '*regional development theories have become dominated by the notion that innovation is the most important factor explaining territorial inequalities*'[4].

2.2 An evolutionary approach to Economic Geography

The fact that endogenous change and innovation are so highly regarded as engines for regional development today is undoubtedly connected to the influx of evolutionary thoughts into the sphere of Economic Geography (Schamp, 2017). This stream has been one of the most influential sources of inspiration in the last decades to unravel questions concerning the spatial dimension of innovation and the creation of economic novelty that underlie the rise of new or deeply altered industries (or the lack thereof). Evolutionary notions have not only played a crucial role for the development of the concepts of National and Regional Innovation Systems

[4] It is crucial to note here that innovation and regional development are not necessarily the same thing (Shearmur, 2016) and that the link between those two is to be questioned, particularly in less-developed regions (Marques & Morgan, 2021).

(Moulaert & Sekia, 2003), but also underpin the rise of what today is arguably the most influential paradigm in the discipline of Economic Geography (Hassink et al., 2019): Evolutionary Economic Geography (EEG) (Boschma & Frenken, 2006; Boschma & Martin, 2007).

EEG is based on fundamental notions in evolutionary economics that have first been formulated at the end of the nineteenth century. This is best exemplified by Boschma and Frenken's (2006) adaptation of Veblen's (1898) question '*why is Economics not an evolutionary science*?' to '*why is Economic Geography not an evolutionary science*?' (Martin & Sunley, 2006).

Evolutionary Economics is intrinsically concerned with processes of change in the economy generated by innovation and (technological) progress. It explains such processes by drawing some basic analogies to translate biological concepts to the sphere of social sciences (Nelson & Winter, 1982). First, the existence of a historically inherited variation among a population serves as a starting point. This is translated to firms and institutions within an industry. Second, it is assumed that individuals possess certain characteristics, that is, routines and technologies. Third, there is a process of selection in place (market selection as the most important mechanism) that determines the ability of units to succeed within their environment (societies, institutions, regulations, and so on). Fourth, the capacity to adapt (innovation and the generation of novelty) to an ever-changing environment is vital for the survival of units (MacKinnon et al., 2009; Schamp, 2017). In other words, from an evolutionary perspective the processes of innovation and economic development are considered to be conditioned by the evolutionary mechanisms of variety, selection, and inheritance (Nelson & Winter, 1982).

This step taken has been the much-acclaimed contribution by Nelson and Winter back in the early 1980s (Schamp, 2017). But what does geography bring to this picture? Indeed, the crucial question is '*how geography matters in determining the nature and trajectory of evolution of the economic system*'? (Boschma & Martin, 2010, p. 6). In what follows, this question will be discussed and the contours of this relatively young paradigm and its development will be briefly outlined.

The 'evolutionary turn' in Economic Geography (Boschma & Frenken, 2006; Martin & Sunley, 2006; Boschma & Martin, 2007) has brought a new influential paradigm to the study of regional industrial development (Martin, 2010; Schamp, 2017). Using Darwin's theory in either a metaphorical or metatheoretical way as a heuristic device has been crucial for the development of an evolutionary approach to Economic Geography (Essletzbichler, 2009; MacKinnon et al., 2009; Essletzbichler & Rigby, 2010; Schamp, 2017). Importantly, EEG emphasises geography in assuming economic development to be contextual (Schamp, 2017; Hassink et al., 2019). The fundamental assumption is that aforementioned quasi-evolutionary dynamics are deeply embedded in regional structures and local contexts inherited from past rounds of regional development (Boschma & Frenken, 2006; Schamp, 2017). In other words, a region's '*industrial history is literally embodied in the present*' (Walker, 2000, p. 126). Therefore, EEG places explicit emphasis on *regional* assets, skills, connections and competencies accumulated in the past (Martin & Sunley, 2006, 2010).

Based on these theoretical foundations, the discussion has long been centred around the phenomenon of 'path dependence', that is, the inability of regional industries or regional economic systems '*to shake free of their history*' (Martin & Sunley, 2006, p. 399). Ultimately, whole regions or regional industries can become 'trapped' in the past (Grabher, 1993; Martin & Sunley, 2006). A process that might result in a state of regional 'lock-in', depicted as a history-dependent equilibrium state from which a region or regional industry can't escape until an exogenous shock moves it onto another development path (Martin, 2010). Hence, EEG – in its earlier days – was mainly concerned with continuity and explained why some regions or regional industries lack the ability to create novelty.

The causes for path dependence and lock-ins are manifold. The literature puts emphasis on locally contingent and often mutually reinforcing effects, including the dependence on natural resources, localisation and urbanisation effects, a specialised regional technological regime, sunk costs, region-specific institutions and traditions, and inter-regional dependencies (Martin & Sunley, 2006). In his seminal work, Grabher (1993) differentiates between sources of lock-in, distinguishing between cognitive (shared and common world views, reproducing ways of doing things), functional (inter-organisational hierarchies and relationships limiting the room for manoeuvre of single actors) and political (vested interests and formal as well as informal rules protecting traditional industries) lock-ins. This (conceptual) work on inertia has informed many empirical studies of regional economies facing decline due to a loss of adaptation capacity. Prominent and widely studied empirical cases are so-called 'rustbelt regions' and their transformation from growth centres into old industrial areas (see, for instance, Cooke, 1995; Hassink & Shin, 2005).

Over the past 15 years the focus of (Evolutionary) Economic Geography has shifted from explicating path dependence and lock-ins to the analysis of the development of new paths. In particular the seminal work of Ron Martin (2010) has advanced our understanding of new path development. Martin argues that the focus on (positive or negative) lock-ins is a limitation to the concept, because it focuses attention on continuity rather than change. He argues for a 'path as a process' model that understands path development as a dynamic and ongoing process based on continuous innovation-based adaptation in response to an ever-shifting environment. From this perspective, innovation is seen as the decisive process of breaking with path dependencies that underpins the generation of new development paths and the transformation of existing ones.

Such adaptation processes do not unfold in a vacuum. Indeed, innovation is a place-dependent phenomenon that is shaped by specific contexts, factors and conditions inherited from past development. At the same time, path dynamics in the present will also influence future ones (Martin, 2010). The evolution of regional economic landscapes is thus seen as both a place-dependent and place-shaping process, driven by an on-going interplay between the reproduction of, the deviation from and the transformation of socio-economic and technological structures (Martin & Sunley, 2006). Accordingly, newer EEG models stress that continuity and change alike are always at play in regional industrial evolution. However, the relative intensity between those two might vary in different spatiotemporal contexts (Njøs, 2018). This dissertation project

focuses on episodes dominated by change brought about by radical innovations underlying path transformation.

In sum, EEG frameworks adopt a dynamic perspective (Boschma & Martin, 2007; Hassink et al., 2019) and direct attention to pre-existing local conditions inherited from the past, which are said to provide the context for present and future rounds of economic activities (Martin & Sunley, 2010). This conception of regional industrial evolution has laid the foundation for the burgeoning body of recent work on the renewal of existing and the creation of new development paths (MacKinnon et al., 2019a; Trippl et al., 2020). The idea that new path development is contingent on place specific factors and conditions (Martin, 2010) or regional capabilities (Boschma, 2017) is a fundamental assumption in this literature, to which this dissertation project seeks to contribute to.

So, coming back to aforementioned question (*What does geography bring to the picture*?), the answer is that variation, selection and inheritance (Nelson & Winter, 1982) are themselves highly localised phenomena and, hence, so is the evolution of economic systems from an evolutionary perspective (Schamp, 2017).

All in all, EEG helps to understand why economic systems evolve so unevenly across space by explaining why new industrial paths emerge or existing ones transform in one place and not another (Schamp, 2017). Broadly speaking, EEG casts light on the spatiality of economic novelty (Martin & Sunley, 2006). It provides new tools to unravel processes of innovation-based regional restructuring, which – from the perspective adopted in this thesis – is conceptualised through the evolutionary notion of new path development with a distinct focus on transformations of well-established paths.

2.3 Relatedness, related variety and diversification: The 'Utrecht school'

Over the past few years, the so-called Utrecht school has become the most influential strand within EEG to explain the creation of new economic activities in regions. The main argument is that new industrial paths grow out of existing ones, a phenomenon that is called 'branching'[5] or 'related diversification'. These processes are stimulated by re-combinations of complementary and related economic capabilities existing in a region (Boschma & Frenken, 2011; Neffke et al., 2011). In other words, regional industrial dynamics are mainly explained through expansion into new activities driven by their relatedness to existing ones in the sense that they require similar capabilities (Boschma, 2017; Zhu et al., 2017). As such, the evolution of regional economies is seen as highly path dependent, as new development paths are usually closely related to those already existing in the region (Neffke et al., 2011). Following this train

[5] Branching is based on four key mechanisms, that is, firm diversification, labour mobility, spin offs and networking (Boschma & Frenken, 2011).

of thought, a regional industry mix that consists of a large variety of different yet related branches of economic activities ('related variety') exhibits a high innovation capacity due to the large number of possible re-combinations.

By employing primarily quantitative approaches and using indirect measures of knowledge flows between industries (like patent use, proximity in industrial classifications, co-location or export portfolios) (Schamp, 2017), empirical research has provided evidence that regional economic structural change is indeed strongly conditioned by technological or skill relatedness (Hidalgo et al., 2007; Boschma & Frenken, 2011; Neffke et al., 2011).

Recently, a more radical form of change brought about by unrelated diversification processes has received closer attention (Boschma, 2017; Boschma, et al., 2017). Unrelated diversification is a phenomenon that occurs less frequently than related diversification. Yet, it is important for a region's long-term competitiveness as it allows regions to 'break with their past' and develop industrial specialisations that are entirely new to the region (Balland et al., 2018; Xiao et al., 2018).

In sum, over the years, the Utrecht school of EEG has developed powerful tools to explain regional restructuring and the emergence of new development paths through diversification processes and the '*principle of relatedness*[6]*'* (César A. Hidalgo et al., 2018). However, the Utrecht school has also come under criticism for several reasons. Inspired by Martin and Sunley (2006), scholars have pointed to the need to go beyond the standard related-unrelated diversification dichotomy, offering a more differentiated typology of path development and thereby highlighting the more variegated nature of forms and mechanisms of innovation-based regional restructuring (Tödtling & Trippl, 2013; Grillitsch et al., 2018; Grillitsch & Trippl, 2018; Isaksen et al., 2018b;). Besides branching and unrelated path diversification, a number of other path development types are deemed important. These include path creation (emergence of entirely new industries based on radically new technologies, scientific discoveries, social innovation or new business models); path importation (attraction and anchoring of established industries from outside the region); path renewal (substantial changes of an existing regional path into a new direction based on the 'injection' of new knowledge[7]); path extension (continuation of an existing industrial path along a well-established trajectory based on incremental innovation), and path decline and dissolution (shrinking and disappearance of a mature industrial path due to lack or loss of innovation and renewal capacities).

The Utrecht school has also been contested for propagating a too narrowly conceptualised model of new path development that portrays regional structural change as an endogenous and firm-driven process. It neglects the role of non-firm actors, exogenous stimuli and multi-scalar

[6] The ‚*principle of relatedness*' is an empirical principle describing the probability that a region enters – or exits – an economic activity as a function of the number of related activities present in that location (Hidalgo et al., 2018, p. 451).

[7] Thus, path renewal and path transformation are very similar in essence. The latter, however, particularly underlines the radical nature of change as well as the alterations in the wider surrounding regional support structures associated with path transformations.

configured social, cultural and institutional environments. Moreover, the related-unrelated diversification dichotomy tells us little about radical 'on-path' changes, that is, about path transformations. This criticism has led to calls for broader conceptualisations (Hassink et al., 2019; Trippl, et al., 2020), also by the main representatives of the Utrecht school themselves (Boschma, 2017; Boschma et al., 2017).

2.4 Emerging comprehensive perspectives on new path development

Driven by the success and wide-spread recognition of the Utrecht school but also by its rather narrow conceptualisation of EEG in general and new path development in particular, scholars have forged links to different but complementary strands of literature to compensate for certain shortcomings. Inspiration has been found in work on Regional Innovation Systems (see chapter 3), Technological Innovation Systems (TIS), Global Production Networks (GPN), Transition Studies (e.g. MLP;) and the Sociology of Expectations (SoE). Arguably, this wide range of contributions signals the vitality of the broader endeavour to develop more comprehensive perspectives on new path development (see Table 1).

Table 1: Comprehensive perspectives on NPD: Core contributions and key publications based on complementary strands of literature (not exhaustive)

	RIS	**TIS**	**GPN**	**MLP**	**SoE**
Core contribution to debate on NPD	Incorporating potential and constraints in wider regional environment	Specifying key resources and resource formation processes	Multi-scalar view, non-local sources of assets and influences	Highlighting regime-niche dynamics, institutional change	Incorporating expectations to complement emphasis on 'the past'
Key publications	• Tödtling & Trippl, 2013 • Isaksen & Trippl, 2016	• Binz et al., 2016; • Steen & Hansen, 2018	• MacKinnon, 2012; • MacKinnon et al., 2019a	• Boschma et al., 2017	• Steen, 2016

Source: Own elaboration

The following chapters will summarize and review key advancements brought about by these novel conceptualisations in three broadly defined dimensions. This is done for two reasons. First, the recent trend towards a more comprehensive understanding of new path development is considered as an important part of the wider theoretical background of this thesis and has provided crucial insights for this dissertation project and the four research articles constituting it. Second, the following discussion of the wider field of research also offers the opportunity to look beyond recent advancements in new path development research and reflects more broadly on key theoretical underpinnings, such as the role of institutions or agency in regional development.

2.4.1 Broader views on structural preconditions and the role of institutions

First, new and more comprehensive perspectives adopted a broader view on structural preconditions and their reconfiguration. Accordingly, work at the intersection between relatively narrow EEG models and the GPN literature (MacKinnon, 2012; MacKinnon et al., 2019a) or Transition Studies (Binz et al., 2016; Steen & Hansen, 2018; Njøs et al., 2020) moves beyond the focus on pre-existing regional knowledge endowments and shows that a broader set of regional conditions and resources, as well as their (re-)formation processes, are vital for new path development.

In this context, Binz et al. (2016) have contributed to our understanding of how and where entirely new development paths emerge or existing ones are substantially altered by drawing on insights of the TIS literature. Accordingly, new path development processes are not only conditioned by pre-existing regional capabilities and technological relatedness, but also require creation, mobilisation and anchoring of other key resources (or assets) by firm, as well as non-firm actors. The authors thus have defined four resource formation processes seen as necessary condition for industry emergence: knowledge creation, investment mobilisation, market formation and technology legitimacy, which can be sourced either from inside or anchored from outside the region.

This approach has been picked up by Steen and Hansen (2018) in their analysis of the development of the offshore wind power path in Norway. The authors not only confirm that key conditions beyond knowledge (such as markets) are necessary for new path development to unfold but add the important dimension of path interdependencies to this debate. Accordingly, they show that new path development might depend on resources that can be bound in, or taken away by, another path (in their case the old oil and gas industry). Thus, the relation between regional industrial paths might not necessarily be positive and enabling (as the Utrecht school implicitly suggests through the notion of related diversification).

To conceptualize this more comprehensive view on relevant regional structural preconditions, several authors have employed the notion of the regional asset base (MacKinnon et al., 2019a; Trippl et al., 2020). Following Maskell and Malmberg (1999), they distinguish between (i) natural assets (resources), (ii) infrastructural and material assets, (iii) human assets (labour, skills, knowledge), and (iv) institutional endowments (rules, routines, norms) in addition to (v) industrial assets (technology and firm competencies). Moreover, work on the role of path interdependencies (Steen & Hansen, 2018; Frangenheim et al., 2020; Breul et al., 2021) has shown that it is important to pay close attention to other paths in the region and how multiple paths compete for regional (and non-regional) assets[8].

Carvalho and Vale (2018, p. 291) have cast light another important aspect, as they have put particular attention on the role of institutional factors and introduced the notion of ‘institutional

[8] However, based on Sandén and Hillman (2011), Frangenheim et al. (2020) point out that one should distinguish between scarce and abundant, that is, nonexclusive assets. While the former can only be used by actors in one path (e.g. skilled labour or risk capital), the latter can be used in multiple paths simultaneously (e.g. no patented knowledge, norms and values).

relatedness' (in contrast to the focus on the relatedness of economic capabilities predominantly found in the Utrecht school) that is referring to '*the degree to which institutions associated with certain industries or activities can be transposed to provide resources and legitimacy to new industries*'. Thereby, the authors show that regional institutional configurations and conditions shape the rise of new industrial paths and the alteration of existing ones.

Carvalho and Vale's intervention allows for a broader reflection on the role of institutions in regional development at this point. Comprehensive perspectives on new path development are largely in agreement that narrow EEG models tend to overlook the decisive influence of institutions for the creation of new economic activity (Dawley et al., 2015; MacKinnon et al., 2019a; Hassink et al., 2019), even though main protagonists of the Utrecht school have zoomed in on them before (Boschma & Frenken, 2009; Boschma & Capone, 2015; Boschma, 2017).

Today, there is an increasingly widespread agreement on the fact that institutions matter for regional economic development (Rodríguez-Pose, 2013), not least because of key contributions in Institutional Economic Geography (Gertler, 2010; Martin, 2000). However, defining institutions is a difficult task and there is no commonly acknowledged definition (Rodriguez-Pose, 2013). Accordingly, many adopted the simple and somewhat minimalist definition (Gertler, 2010; Rodriguez-Pose, 2013) by North (1990), who defined institutions as '*the rules of the game in a society*' that shape and constrain the behaviour of economic agents (Gertler, 2010). However, as Rodriguez-Pose (2013) points out, this definition suggests that institutions can be equated with formal or hard institutions (such as laws, property rights, charters, and regulations) and leaves out – equally important – informal or tacit institutions (such as habits, routines, norms and values) (Amin, 1999).

Hence, it is important to acknowledge both formal and informal institutions that are historically inherited ('carriers of history', David, 1994) and locally embedded (Jones & Clark, 2000). They play a manifold role in the creation of new economic activity that goes beyond just regulating but includes conditioning interaction and trade, reducing the risk of instability and conflict, lowering uncertainty and information costs, smoothing the process of knowledge transfer, providing incentives and helping territories to adapt to change (Edquist & Johnson, 1997; Rodríguez-Pose, 2013). Moreover, high regional institutional quality may drive social inclusion, entrepreneurship, responses to the climate crisis and the inflow of skilled migrants (Rodríguez -Pose, 2020). As such, institutions play a vital role in determining the innovation capacity of regions (Morgan, 1997) and should be seen as crucial part of regional structural preconditions for new path development.

However, not always are regional institutional endowments enabling for innovative activity. On the contrary, adaptations to unsuitable or outdated institutional frameworks are often necessary for industrial change to unfold (Hollingsworth, 2000; Martin, 2000). In other words, from an evolutionary perspective, institutional and industrial dynamics tend to co-evolve (Gong & Hassink, 2019; Benner, 2021).

Yet, institutional change is a complex matter. Often, institutional conditions are seen as a static factor and portrayed as a permanent feature of a territory (Rodríguez-Pose, 2020). And indeed, institutions are usually characterised by high levels of inertia and subject to strong path dependencies, which sometimes can be traced back for centuries (Bathelt & Glückler, 2014). Accordingly, incremental change, in the form of long-term processes, is considered more frequent than radical change (North, 1990; Martin, 2000). However, this is not to say that the latter is impossible. Rapid improvements in the quality of institutions in Eastern European countries like Estonia, for instance, strongly contrast with institutions' stasis, rigidity and reluctance to change seen more usually (Rodríguez-Pose, 2020).

The ways in which institutions change is an important inquiry for scholars (Mahoney & Thelen, 2010). In their seminal work, Streeck and Thelen (2005) have differentiated between five types of gradual institutional transformation. First, *displacement*, which refers to the substitution of one institution by another. Second, *layering*, which implies that new elements are attached to existing institutions, thereby changing their status and structure. Third, *drift*, which describes the neglect of institutional maintenance in spite of external change. Fourth, *conversion*, which refers to the redeployment of old institutions to new purposes under changing context conditions. Finally, *exhaustion*, which refers to the gradual breakdown of institutions over time. While these types of change are incremental in nature, Streeck and Thelen (2005) argue that they can lead to fundamental change when gradual and continuous adaptations cumulate.

From a co-evolutionary perspective, Benner (2021) has conceptualised different forms of regional industrial path development as the outcome of interdependent adaptations processes in the industrial and institutional sphere. In respect to path transformation processes, he argues, external shocks through radical innovations may induce the disruption and breakdown of existing institutions and the radical creation of new ones. From this view, displacement and exhaustion unfolding in a rapid manner are particularly relevant forms of institutional change in radical, innovation-based transformation processes. These insights are largely confirmed by this thesis[9], which demonstrates that radical institutional change can happen, even within established industries (Baumgartinger-Seiringer et al., 2021b, paper #1).

The ambition to better understand institutional change in regional industrial development processes has also sparked interest in the role of agency (Sotarauta & Mustikkamäki, 2015; Grillitisch & Sotarauta, 2020). Scholars have begun to incorporate the concepts of institutional work (that is, broadly speaking, actions geared towards creating, maintaining or disrupting institutions, Lawrence & Suddaby, 2006) and institutional entrepreneurship (Battilana et al., 2009) in recent analyses of new path development (see chapter 2.4.3). As Benner (2021, p. 4) points out, these concepts provide lenses *'for understanding permanent processes of renegotiating an economy's institutional context'.*

[9] However, it is important to note that the empirical investigation conducted for this thesis has *also* highlighted that the lack or slowness of institutional change in some dimensions (e.g. in relation to data security) is considered as one of the decisive barriers to path transformation by many actors, in particular those on the firm-level (Baumgartinger-Seiringer et al., 2021a, paper #2; Trippl et al., 2021, paper #3).

However, not all regional institutional configurations are equally changeable. Institutional adaptability varies. From an Organisational Institutionalism perspective (Hinings et al., 2017; Zietsma et al., 2017), the reason is that different structural conditions – that are institutionalised and reinforced to different degrees – allow for different forms of agency as they entail a '*systematic bias*' that privileges some actors and forms of actions over others (Hinings et al., 2017, p. 183). Thereby, simply put, structures tend to either generate periods of reproduction or change depending on the stage of development and on what types of agency are reinforced and amplified (Zietsma et al., 2017). This insight is an important inspiration for the third paper of this dissertation project and the proposed reconsideration of regional structural conditions (Baumgartinger-Seiringer et al., 2021a, see chapter 6.3). Moreover, the fourth paper (Baumgartinger-Seiringer, 2021) investigates how incumbent firms have leveraged institutional power (i.e. precisely the power that stems from being privileged by institutional context conditions, Geels, 2014) as one of four fundamental forms of power in relation to current transformations in the Austrian automotive industry.

All in all, formal and informal regional institutional endowments, their wider implications and institutional change are decisive variables in explaining (the lack of) new path development, even though they are difficult to define, grasp and measure (Rodriguez-Pose, 2013). Some argue that the role of institutions is the missing link in many traditional theoretical approaches to explain what determines the fortunes of territories (Rodríguez-Pose, 2020).

2.4.2 A multi-scalar view and extra-regional influences

Second, more comprehensive perspectives have incorporated a multi-scalar view in their analyses. As outlined before, narrow EEG perspectives portray new path development as a highly localised and endogenous process. This view is increasingly challenged by scholarly work that argues for moving beyond a '*regional fetishism*' (Binz et al., 2016, p. 173) and paying greater attention to exogenous sources and influences on new path development (Dawley et al., 2015; Trippl et al., 2018).

Thus, over the past few years, various contributions have advanced our understanding of the relation between non-local assets and new regional industrial path development (Binz & Truffer, 2017; Crescenzi & Iammarino, 2017; Njøs et al., 2017; Neffke et al., 2018; Yeung, 2021).

Drawing on the GPN approach and previous research (MacKinnon, 2012), MacKinnon et al. (2019a) contend that new path development may involve forging linkages to non-local assets (such as technology, knowledge or skills) through extra-regional networks. This is seen as particularly relevant in the early phases of new path development and for peripheral or latecomer regions. The authors additionally cast light on strategic coupling processes between regional and extra-regional assets and how power relations between local and transnational actors shape such processes.

What is more, there is a promising line of research exploring the role of global innovation networks. Binz and Truffer (2017), for instance, investigated innovation dynamics in emerging

clean-tech industries from a distinct global innovation system perspective, highlighting how innovation subsystems at various scales (from the regional to the international level) interrelate, reflecting the increasing spatial complexity of innovation processes.

Furthermore, scholars have shown that the arrival of new actors can be an important trigger for new path development (Trippl et al., 2018). As such, relocating firms (Neffke et al., 2018), R&D organisations (Isaksen & Trippl, 2017), or individual actors (Saxenian, 2007) can become carriers of assets (such as knowledge or know-how) that induce or support new path development in the receiving region (Trippl et al., 2018). FDIs or mergers and takeovers can be important mechanisms in this regard (Martin & Sunley, 2006).

Moreover, extra-regional knowledge linkages in the form of formal or informal connections (e.g. R&D collaborations, informal connections between former colleagues or conferences and trade fairs) might also play a crucial role for knowledge acquisition underlying new path development (Bathelt et al., 2004; Trippl et al., 2018).

Importantly, research has not only zoomed in on non-local sources of assets, but also on external influences more broadly defined. As such, there is a burgeoning literature on the question of how multi-scalar institutional environments and policy actions influence new path development (Hassink et al., 2019). Studies done by Dawley and colleagues (Dawley, 2014; Dawley et al., 2015) on the offshore wind sector in different regions in Great Britain demonstrate that new path development is shaped by broader macro-political, institutional and economic factors and makes a strong case for the inclusion of policy interventions across multiple scales in the analysis of the development of new paths or the substantial transformation of existing ones. Similarly, MacKinnon et al., (2019b) highlight the important role of nation states in strategic coupling processes for new path development.

Furthermore, industrial dynamics are often triggered by disruptive events, like shocks, crises, the emergence of new competitors, shifts in the market situation or incisive innovations (Martin, 2010; Simmie & Martin, 2010). As industrial paths and regions in which they are embedded in are not isolated systems but part of a globalised world and within a multi-layered policy system (Martin & Sunley, 2006), such pressures for industrial dynamics are often coming from outside. An example would be a disruptive innovation, like the openly demonstrated progress towards autonomous cars by Silicon Valley's tech-giants on California's streets a few years back. In doing so, Google and others were not only putting immense pressures on established automotive firms in Europe but were also opening up the well-established path for new start-ups or spin-offs and their experimentation (Baumgartinger-Seiringer et al., 2021b, paper #1). The trigger for a process towards transformation can thus be understood as changing conditions of the global industrial context due to one or a combination of multiple aforementioned events. How such shifting conditions are ultimately affecting the development of a path embedded in a certain region depends essentially on local characteristics, e.g. the industrial setting, the supportive structures or the attraction and absorption capacity of the RIS (Isaksen & Trippl, 2017; Trippl et al., 2018). In other words, some regions and paths are better suited than others

when it comes to 'translating' extra-regional influences into the place-specific settings (Baumgartinger-Seiringer et al., 2021b, paper #1).

Thus, in brief, a multi-scalar view and the role of extra-regional influences in the form of non-local assets, global innovation networks, actors from outside, the broader institutional context or disruptive exogenous events should not be neglected when seeking to comprehensively unravel the process of new path development.

2.4.3 A multi-actor approach and the role of agency

The third major advancement of comprehensive perspectives on new path development is that they stress the importance of multi-actor approaches for the emergence of new paths or decisive changes in existing ones. Accordingly, scholars have made a strong case for incorporating the role of different actors in the study of new path development (Binz et al., 2016; Hassink et al., 2019), drawing attention to important agents other than firms – which stand in the centre of attention in narrow models of EEG. For instance, various contributions have casted light on how universities, research institutes (Tanner, 2014; Vallance, 2016) and policy makers (Dawley, 2014; Dawley et al., 2015) initiate or support new path development.

Hassink et al. (2019) argue that zooming in on the role of human agency may serve as a useful starting point for realizing a multi-actor approach. In a similar vein, Martin and Sunley (2006, p. 426) stated early on in the debate that '*the events and occurrences that start off a new path of development may include a large element of strategic purpose and deliberate action […] any theory of path creation should attach a prominent role to the importance of strategic agency*'.

Key contributions in this regard (albeit not within the boundaries of EEG) have been put forward by Garud and Karnøe (2001; 2003), who highlight the role of entrepreneurship and entrepreneurial agency in 'mindfully deviating' from existing structures to create new futures and development paths. They also argue that agency is distributed across different actors and that new path development is often based on the efforts of many and their mobilisation of resources (competencies, regulations or markets) that accumulate and – together – co-shape the rise of a new industry or substantial alterations in established ones. Similarly, Simmie (2012) has shown how collective agency may overcome the barriers resulting from path dependency and contribute to the emergence of new paths.

Due in no small part to Garud, Karnoe and Simmie's work, there is now a growing body of literature within the wider EEG research field that seeks to understand new path development processes as an ongoing interplay between structural conditions and agentic processes (Boschma et al., 2017; Isaksen et al., 2019; Grillitsch & Sotarauta, 2020). Indeed, the ways in which agents utilize opportunities found in and provided by structural preconditions and how they overcome constraints, resulting from unfavourable structures, has come under closer scrutiny. This has been a vital step taken forward, as EEG has traditionally emphasised the role of structures over agency in explaining the evolution of regional economies (Grillitsch et al., 2021). As such, the complex interdependence between structures and agency plays an important

role in all articles of this dissertation. To better understand this relationship, it is helpful to unravel and conceptualize agency.

Oftentimes, authors in the new path development research field draw on a recent and broad definition by Sotarauta and Suvinen (2018, p. 90), who understand agency as '*actions or interventions by actors to produce particular effects*'. In a narrower sense and in the context of regional restructuring, agency is often linked to the utilisation of regional assets trough '*deliberate and purposeful action of individuals and groups within or outside an area*' (Maskell & Malmberg, 1999, p. 10; MacKinnon et al., 2019a). From this perspective, the presence of assets (e.g. related economic capabilities) alone is not a sufficient basis for regional structural change. Instead, regional assets can only foster successful new path development when they are identified, harnessed and valorised by actors (MacKinnon et al., 2019b). This understanding has recently been conceptualised through the notion of asset modification (see also Chapter 3), that is, actions of regional or extra-regional actors to create new regional assets, to redeploy existing assets or to destruct old ones (MacKinnon et al., 2019a; Trippl et al., 2020).

In a more general fashion, work on the role of agency in new path development (such as Sotarauta & Suvinen, 2018) has often been influenced by Emirbayer & Mische's seminal work (1998, p. 983), in which they answer the question '*What is agency?*' from a sociological perspective as follows:

> *'…a temporally embedded process of social engagement, informed by the past (in its habitual aspect), but also oriented toward the future (as a capacity to imagine alternative possibilities) and toward the present (as a capacity to contextualize past habits and future projects within the contingencies of the moment). The agentic dimension of social action can only be captured in its full complexity, we argue, if it is analytically situated within the flow of time'.*

Scholars have argued that this perception of agency as a temporally-embedded process is highly relevant for and complementary to the debate in new path development research (Steen, 2016; Steen & Hansen, 2018). Traditionally, evolutionary perspectives ascribe significance to 'the past' and its role in conditioning new path development. However, incorporating the role of agency and seeking to understand what drives agentic processes, has opened the debate to the role of the future (Hassink et al., 2019). In other words, (comprehensive) EEG models often acknowledge Emirbayer and Mische's 'habitual aspect' of agency (being '*informed by the past'*) by highlighting the role of historically inherited regional assets, including norms and routines (Baumgartinger-Seiringer et al., 2021b, paper #1), but tend to neglect the 'projective aspect' in the form of expectations and visions ('*capacity to imagine alternative possibilities*'), despite its pivotal role in driving agency from a sociological perspective (Emirbayer & Mische, 1998; Hassink et al., 2019).

Expectations and visions can be understood as '*wishful enactments of a desired future*' (Borup et al., 2006, p. 286). They are vital for new path development as they hold a generative power in the sense that they contribute to the mobilisation of resources, investments, experimentation

efforts, networking activities and so on (Steen, 2016). However, visions and expectations are not necessarily collective but can be contested and, as such, can become a source of conflict and a barrier to change as they might result in a lack of orientation and directionality (Wanzenböck et al., 2020). Accordingly, creating joint visions and expectations is an important task for new path development to succeed (Sotarauta, 2009), which benefits from geographical proximity (Steen, 2016). These recent advancements towards the integration of 'the role of the future' in analyses of new path development play a particularly important role for the first paper of this thesis (Baumgartinger-Seiringer et al., 2021b).

As mentioned above, one key concern of this recent 'turn towards agency' is to move beyond the strong focus on firms and their actions as driving forces of the evolution of regional economies in EEG. In this regard, Grillitsch and Sotarauta (2020) have put forward a key contribution and introduced the 'trinity of change agency' for regional economic development, which consists of innovative entrepreneurship, institutional entrepreneurship and place leadership. Accordingly, innovative entrepreneurship is only one pillar of change agency. It is, nonetheless, considered crucial for new path development, as it is concerned with breaking existing paths and establishing new ones by realizing perceived opportunities in structural conditions, moving into new fields of activity and creating something new (Grillitsch & Sotarauta, 2020). However, new path development often also depends on the second pillar of change agency, namely institutional entrepreneurship (Battilana et al., 2009), that is, agency oriented towards challenging existing formal (rules and laws) and informal (practices and values) institutional endowments and institutionalizing alternative ones (DiMaggio, 1988). As mentioned before, institutions are relatively stable and usually change slowly, they often support established ways of doing things and economic activity in existing paths (Isaksen & Trippl, 2016, see chapter 2.4.1). Accordingly, institutional entrepreneurship is often vital for new path development to succeed (Grillitisch & Sotarauta, 2020). The third pillar, place leadership, is concerned with identifying new promising ideas with development potential, providing those early ambitions with the necessary resources (such as knowledge or finance) and performing important coordination work towards constructing a shared vision between heterogenous actors. As such, place leadership is seen as a key effort to influence the emergence of new development paths or the transformation of existing ones (Grillitisch & Sotarauta, 2020).

A recent critique of the wider debate on the role of agency in new path development is that it is centred around 'change agency' (Jolly et al., 2020), while little is said about 'maintenance agency', that is agency oriented towards the stabilisation and reproduction of current structures (Henderson, 2020; Jolly et al., 2020; Bækkelund, 2021). According to Jolly et al. (2020: 179), maintenance agency '*involves actions such as introducing new practices to create deterrence for change, supporting the persistence of existing institutional routines, and using narratives to support the routinization of existing practices and adherence to rules*'. It often originates from privileged actors countering pressures for change in order to protect their position and maintain the status quo (Jolly et al., 2020; Bækkelund, 2021). These insights and the role of maintenance agency in new path development are a key motive in the fourth paper of this thesis that seeks to advance perspectives on the role of incumbent firms (Baumgartinger-Seiringer, 2021).

Baumgartinger-Seiringer et al. (2021b, paper #1) add a more positive understanding of maintenance agency (see also Bækkelund, 2021), arguing that new path development processes require not only agency for their initiation and acceleration but also for their consolidation, that is, for their stabilisation and institutionalisation. In contrast to Jolly et al. (2020) who focus attention on impediments to change, the first article of this thesis (Baumgartinger-Seiringer et al., 2021b) suggests that agency can be geared towards the consolidation of change, which is particularly important in later stages of regional industrial change.

3 Embedding new path development in regional systems of innovation

In parallel to advancements based on other strands of literature, a quickly growing body of work has emerged over the last years that has combined EEG models with the RIS concept (Tödtling & Trippl, 2013; Isaksen & Trippl, 2016). Essentially, this scholarly work emphasises the systemic nature of new regional industrial path development. It is based on the fundamental assumption that in order to unravel the rise of new industries or substantial alterations in existing ones, a more comprehensive treatment of the wider regional environment beyond the firm-centred and micro level accounts of narrow EEG models is necessary (Isaksen & Trippl, 2016). This literature contends that the capacity of regional economies (or the lack thereof) to generate processes of new path development is determined by a wider set of regional factors and elements, their enabling and constraining influence and how they interact and work in concert (Trippl et al., 2020).

Drawing on this principal idea, scholars have conceptualised new path development from a distinct systemic perspective and significantly advanced our understanding of how broader regional conditions, their evolution, other actors and other paths within the region are linked to the emergence of new or the deep-rooted change of existing industries (Trippl et al., 2020). In doing so, this literature has drawn on, as well as contributed to the recent progress made in the wider field of more comprehensive perspectives on new path development (see chapters 2.4.1, 2.4.2 & 2.4.3). It is this body of work at the intersection of EEG and RIS which this thesis draws upon and to which it seeks to contribute to.

This chapter will first introduce the notion of RISs, its history and development over the past two to three decades. Then, the state of the art of work of systemic perspectives on new path development based on the RIS concept will be presented. Thereby, this chapter lays the foundation for this dissertation project and the four research articles.

3.1 Regional Innovation Systems

The RIS concept belongs to the broader family of innovation systems approaches (Weber & Truffer, 2017). As such, it is rooted in important broader theoretical foundations.

The wider concept of innovation systems emerged in the 1980s as an answer to the predominant cost-based approach of international trade theory, which argued that competitiveness was achieved mainly by cost efficient production and services. In contrast, the OECD expert group that pioneered the notion of innovation systems stressed the role of learning and highlighted that competitiveness stems from a country's innovativeness (Asheim et al., 2019). This marked

the beginning of the rise of a new key concept that became a guiding paradigm highly influential in both research and policy from the early 1990s onwards (Weber & Truffer, 2017).

The innovation systems approach was built on the foundation of a more sophisticated notion of innovation that emphasised its nonlinear, processual and systemic character, which involves multiple feedback loops (Marques & Morgan, 2021, see also chapter 2.1). In doing so, innovation was seen as a learning process occurring within a wider system that is driven by interactions between different actors (entrepreneurs, policymakers, researchers, etc.) and organisations (firms, research organisations, governance bodies, intermediaries, etc.) and influenced by the surrounding institutional framing (Lundvall, 2010). The concept was the first explicit approach to innovation policy and replaced the previous science and technology policies dominating at the time (Asheim et al., 2019).

These developments were strongly inspired by the theoretical foundations of interactive innovation models (Kline & Rosenberg, 1986), evolutionary economics (Nelson & Winter, 1982) and institutional economics (Hodgson, 1988). Drawing on these theoretical underpinnings, the innovation systems literature departed from neo-classical thinking in economics and rejected the rational choice paradigm and equilibrium thinking. Instead, it stressed the inherently dynamic, cumulative and non-equilibrium nature of innovation and the importance of institutions in shaping and influencing innovation processes (Asheim et al., 2019). Indeed, casting light on the essential role of formal as well as informal institutional endowments (see chapter 2.4.1) was one of the key contributions of the approach (Weber & Truffer, 2017).

Essentially, an innovation system consists of three core pillars: actors, networks and institutions. The notion at the heart of systemic approaches is that the innovation performance of an economy does not only rest on the performance of single elements within the system (like firms, research organisations or governance bodies) but fundamentally on how they interact and work in concert (Gregersen & Johnson, 1997). That is, the elements – different actors, networks and institutions – of an innovation system jointly generate '*emerging properties*' that cannot be created by any of the constituting components alone (Weber & Truffer, 2017, p. 112). In other words, the generated dynamics within an innovation system are more than just an aggregation of individual characteristics (Asheim et al., 2019; Marques & Morgan, 2021).

This is critical for a number of reasons. First, it highlights why actors within innovation systems might have particular advantages over those outside. These so-called 'emerging properties' provide resources on the system-level, such as a high-quality labour pool or mutually agreed norms (Musiolik et al., 2012). These assets are only accessible for actors operating within the system and might substantially boost their innovative capacity. Second, from a conceptual standpoint, it is an important counter argument to the methodological individualism in neoclassical economics or in the management literature (Weber & Truffer, 2017). Third, it allows for a more sophisticated view on how to support innovation and overcome barriers. Accordingly, when recognizing the systemic nature of innovation, it becomes clear that the lack of innovative activity might result from deficiencies on the system-level. Following this train

of thought, Woolthuis et al. (2005) have defined four system failures potentially hindering innovative activities, namely capability failures (actors lack skill or resources), coordination failure (failures in the interactions of actors), institutional failures (unfavourable institutional conditions or when actors are unable to influence institutional structures) and infrastructural failures (lack of reliable or suitable infrastructure)[10].

Based on these broader theoretical foundations, scholars have developed and advanced the concept, moving in different directions. Particularly concerning the delimitation of system boundaries, different approaches to innovation systems have been developed (Asheim et al., 2019). As Weber and Truffer (2017, p. 110) pointed out, '*system boundaries are chosen according to the nature of the problem to be analysed*'. Accordingly, those who examined the conditions of innovation processes in countries developed the concept of national innovation systems (Lundvall, 1992; Nelson, 1993). In contrast, those who studied particular sectors (Malerba, 2004) or technologies (Hekkert et al., 2007; Bergek et al., 2008) drew system boundaries that transcended territorial boarders and developed non-spatial concepts[11] (Weber & Truffer, 2017). Among them is also the recently developed notion of global innovation systems that emphasises the globalisation and multi-scalarity of innovation processes (Binz & Truffer, 2017, see also chapter 2.4.2). While these different concepts developed in somewhat different directions, they share the core argument that innovation systems are both important sources of new variety creation and crucial selection environments (Asheim et al., 2019).

The RIS concept, for its part, was directly influenced by the NIS approach in its beginnings in the early 1990s (Asheim et al., 2019). Accordingly, both concepts draw territorial boundaries and highlight the role of institutional arrangements and configurations (Cooke, 1992; Asheim & Isaksen, 1997). However, the RIS approach in particular emphasises the importance of space and proximity for innovative activity (Cooke et al., 2004). In doing so, it was inspired by other TIMs such as industrial districts, learning regions or innovative milieus (Moulaert & Sekia, 2003).

The ambition to develop a concept of regionally delimited innovation systems was driven by observations that even when actors and organisations share the same national boundaries and (formal) institutions, innovation activities and outputs are distributed unequally (Morgan, 1997). Accordingly, scholars moved the role of geographical proximity between different actors (firms, universities, etc.) and the socially and territorially embedded nature of innovation centre stage. Cooke (1992) and Asheim (1995) were the first to use the concept and pioneered the approach. They stressed innovative activity is not to be separated from the wider regional cultural, historical and institutional context. Hence, the concept emphasises the role of the

[10] In light of debates on the role of innovation in solving societal challenges, Weber and Rohracher (2012) have more recently defined four transformational failures in innovation systems, drawing on insights from Transition Studies. Accordingly, there might be directionality failures (lack of particular goal-orientation, e.g. in the form of SDGs), demand articulation failures (shortcomings in enabling the uptake of innovations by users and consumers), policy coordination failures (insufficient coordination between research, technology, innovation and other policies) and reflexivity failures (lack of reflexivity for shaping long-term transformation paths).

[11] Accordingly, there are potential overlaps and a single firm, for instance, can be part of different innovation systems (Asheim et al., 2019).

region as an environment for the creation and selection of innovations, even in an increasingly globalised world (Asheim et al., 2019).

In essence, a RIS encompasses the set of private and public actors in the region involved in innovation processes and the networks in which they operate, interact and exchange. Support organisations as well as sociocultural endowments and formal and informal institutional set-ups may stimulate (or hinder) cumulative and collective learning and spur entrepreneurial activity and innovation (Asheim & Isaksen, 2002; Coenen et al., 2015; Isaksen & Trippl, 2016). As many crucial elements within a RIS, such as universities or the wider institutional setting, are usually relatively slow in adapting, RISs are often characterised by a high degree of stability (Tödtling & Trippl, 2013).

In addition, the approach puts particular emphasis on subnational informal institutions (Truffer & Weber, 2017). There are two main reasons for this focus (Marques & Morgan, 2021). First, informal institutions are seen as having a crucial role in facilitating knowledge exchange. That is, the openness to new ideas, different backgrounds, entrepreneurialism, trust and so on are linked to innovative activity (see chapter 2.4.1). Second, informal institutional endowments are attributed with explanatory power, as they – usually in contrast to formal ones – vary within the same wider territory (within a nation). Thus, informal institutions can help to unravel disparities within those territories.

A critical question is how to find the delimitation of a RIS, as functional and administrative regional boundaries are often not identical (Asheim et al., 2019). As Asheim et al. (2019) argue, a functional definition is more appropriate as the concept stresses the importance of interactive learning and necessary interactions at the regional level for innovation. This thesis follows a mixed approach. For instance, the Austrian automotive triangle (case study region featured in three of the four research articles) can be seen as a functional automotive region that consists of the three (administratively delimitated) federal states Styria, Upper Austria and Vienna, of which only the former two share a boarder.

A core contribution of the RIS approach is that the concept has provided conceptual tools and arguments to differentiate between various types of regions and distinguish them based on their innovation capacities and needs (Morgan & Coenen, 2020). In doing so, it has been essential in overcoming ‘one-size-fits-all’ models in regional innovation policy approaches that are often based on best practise examples of high-tech areas, which – however – are inappropriate for other regions endowed with different RIS structures (Tödtling & Trippl, 2005).

In order to reflect the empirical variety of regions and to stress that RISs differ substantially, scholars have developed various typologies. For instance, Asheim (2001) has distinguished between territorially embedded RIS, regionally networked RIS and regionalised NIS. Tödtling and Trippl (2005) have analysed different types of regions with respect to their preconditions for innovation and networking and their innovation barriers and differentiate between peripheral regions (organisationally thin regions), old industrial regions (lock-in) and fragmented metropolitan regions. Based on these typologies, the RIS approach has been helpful

in pinpointing the strength and weaknesses of regions in their innovation capacity (Asheim et al., 2019).

Overall, the RIS concept has been around for almost 30 years, has been highly influential, both in research and policy (Marques & Morgan, 2021), and remains relevant in both circles to this day (Doloreux & Porto Gomez, 2017; Isaksen et al., 2018a). However, there has also been outspoken criticism directed towards the approach, revolving largely around two points.

First, critics have argued that in an increasingly globalised economy, a regional perspective on innovation systems seems outdated. Indeed, it is obvious that extra-regional influences are highly important in shaping the innovation capacity of actors and organisations (see chapter 2.4.2). The inflow of specialised knowledge and competencies, trained personnel and so on is often key (Bathelt et al., 2004). Nonetheless, the regional level remains important (see chapter 2.1). Regional capabilities, social interactions, local institutional endowments all still play a decisive role. Accordingly, the openness in the form of extra-regional interactions and knowledge sourcing as well as the absorptive capacity (Cohen & Levinthal, 1990) of a region are important, while its structural endowments remain of high significance (Asheim et al., 2019).

Second, the innovation systems literature has been criticised for being overly static and descriptive (Doloreux & Parto, 2005; Uyarra & Flanagan, 2010). Indeed, Doloreux and Porto Gomez (2017, p. 385) have argued that '*RIS research would benefit from adopting a more dynamic approach that would consider RIS as real, complex evolutionary systems*'. This critique will be taken up again in the next chapter.

An additional recent critique has been formulated in connection to the changing rationale of innovation (see chapter 2.1). The broader family of innovation system approaches is traditionally concerned with innovation as a means of enhancing regional, sectoral or national competitiveness (Weber & Truffer, 2017). However, as outlined before, innovation is increasingly seen as an instrument which can contribute to solving societal problems. This criticism has been picked up by Tödtling et al. (2021), who argue for a critical reassessment of the RIS approach and introduce the notion of 'challenge-oriented RISs' (CoRISs). Accordingly, CoRIS incorporates a more critical view of innovation and the directionality of change processes, is open to new innovation actors and highlights the role of the application and upscaling dimensions.

3.2 The intersection of EEG & RIS: State of the art

The RIS concept is highly suitable and complementary to insights from the EEG literature. It provides a well-developed conceptual ground to understand new path development occurring within a wider regional system, dependent on the historical, cultural and institutional context, driven by interactions between different regional and external actors (firm-level actors as well

as other ones) and influenced by the surrounding institutional framing. Thereby, a systemic conceptualisation on new path development based on the RIS concept opens the debate on innovation-based regional restructuring to more comprehensive perspectives on how regional economies develop and how, where and why new paths come into being and existing ones are fundamentally transformed. It is a rapidly growing field of research, which – to no small part – is due to the circumstance that crises, globalisation and digitalisation demand a fundamental rebuilding of regional economic structures (Asheim et al., 2019).

This chapter will now discuss in more detail the state of the art of this body of work and, in so doing, outlines the frame of the four research articles. Particular emphasis will be placed on four core contributions of this literature in the debate on new path development: (i) the inclusion of a wider set of regional structures, (ii) a thorough reflection on the structural change necessary for new path development to unfold, (iii) the incorporation of different actors and types of agency and (iv) the conceptualisation of new path development in open systems.

The inclusion of a wider set of relevant regional structural conditions

A RIS consists not only of firms and industries in a region, but also of support organisations such as universities, intermediaries or governance agencies and the regional institutional and socio-cultural set-ups (Trippl et al., 2020). Accordingly, systemic perspectives provide a conceptual lens to incorporate the wider regional environment and its enabling or constraining influence on innovative activities and new path development (Martin, 2010; Isaksen & Trippl, 2016; Miörner, 2019).

In order to conceptualize this wider regional environment, scholars working at the intersection of EEG and RIS have employed aforementioned notion of the regional asset base (Trippl et al., 2020), distinguishing between (i) natural, (ii) infrastructural and material, (iii) human, and (iv) institutional assets in addition to (v) industrial assets (Maskell & Malmberg, 1999; MacKinnon et al., 2019a). These assets are seen as the outcome of past rounds of regional economic development and are interpreted as products of a RIS (Trippl et al., 2020). They offer the platform for subsequent rounds of development (Martin, 2010). From this perspective, the uneven geography of innovation and regional development is partly explained through the different regional endowment of assets.

This body of work has also recently begun to investigate the role of other paths in a region and moved beyond the single path view (Frangenheim et al., 2020). Accordingly, a RIS more often than not hosts multiple regional industrial paths which might be (albeit not necessarily) interlinked through the dependence on the same markets and assets available within the RIS. As regions are endowed differently with assets, they differ in their capacity to support several paths at the same time (Frangenheim et al., 2020). Accordingly, the relationship between several paths within the same innovation system can be negative (Steen & Hansen, 2018; Breul et al., 2021; Jolly & Hansen, 2021), as they compete for resources (such as skilled labour, legitimacy or investments), but also positive as developments in one path might facilitate developments in another (Miörner & Trippl, 2019; Baumgartinger-Seiringer et al., 2021b, paper

#1; Trippl et al., 2021, paper #2). In some cases, paths might have no interlinkages despite their co-location and maintain a neutral relationship (Frangenheim et al., 2020).

One core contribution of this literature is to unravel how these broadly defined preconditions (conceptualised as different RIS constellations) are linked to capacities of regions to nurture new or rejuvenate existing development paths (Isaksen & Trippl, 2016). As aforementioned, RISs are relatively stable, often provide customised assets to existing paths and, as a result, tend to support developments in existing and dominating industries (Isaksen et al., 2019). However, despite this general tendency, scholars have shown that different RIS types vary considerably in their potential to support new path development. Drawing on Tödtling and Trippl (2005), Isaksen and Trippl (2016) distinguish three types of RISs based on their organisational thickness and their degree of specialisation and analyse conceptually their capacity to promote new path development. Accordingly, the first type, *organisationally thick and diversified RISs*, often found in dynamic core regions, are usually best equipped. They exhibit a high industrial variety, host open knowledge networks and often numerous research and support organisations and are endowed with supportive institutional set-ups. As such, these RISs have a diverse asset base and a high potential for new path development. The second type, *organisationally thick and specialised RISs*, are usually found in old industrial areas. They are characterised by a narrower and more specialised regional industrial structure. Equally specialised support structures and institutional set-ups are usually tailor-made to the needs of the few (or single) industrial paths. For such regions, it is usually more difficult to promote new path development, as sunk costs in the form of a highly customised asset base, well-established network structures and high levels of alignment support continuity rather than change. Such regions are particularly prone to lock-ins (Grabher, 1993). The third type, *organisationally thin RISs*, are mostly found in peripheral areas. They host few industries, are often dominated by SMEs in traditional or resource-based sectors and lack higher education, R&D organisations or incubators. Thus, these regions are poorly endowed with assets and have little capacities to support new path development. Instead, extension is the usual development pattern. Organisationally thin RIS are often characterised by a branch-plant culture. Accordingly, external actors and extra-regional influences might play an important role (Isaksen & Trippl, 2016).

Recently, Miörner (2020) has further developed the notion that RISs differ substantially in their capacity to support new path development and coined the notion of 'system selectivity', which refers to the general tendency that RISs selectively reinforce some forms of actions and strategies and dampen others. Accordingly, as a consequence of imaginaries, power relations and the directionality prevailing in a certain RIS, not all types of industrial change are equally likely to unfold as the system 'selects' certain forms of change.

This tendency of RISs to support incremental developments in existing paths and their low capacity to help new paths into being or to deeply alter existing ones have been conceptualised through the notion of RIS barriers by Grillitsch and Trippl (2018). The authors distinguish between barriers to breaking with existing paths on the one side (strong capabilities of RIS actors, strong connectedness and interdependencies between actors in the old path and institutions that are customised to support old paths) and barriers that hamper the development

of new path development on the other side (weak capabilities in emerging paths, weak connectedness between actors with relevant knowledge and weak institutional alignments).

Reflecting on the structural change necessary for new path development to unfold
All these contributions suggest – in one way or another – that RISs tend to support continuity rather than change. As a consequence, new path development more often than not requires substantial alterations in RIS structures (Tödtling & Trippl, 2013) in order for the RIS to provide the needed new assets (Miörner & Trippl, 2019). This fundamental assumption resonates well with aforementioned criticism that the RIS concept has long been too descriptive, static and used for snapshot analyses (Doloreux and Parto, 2005; Uyarra and Flanagan, 2010; Doloreux & Porto Gomez, 2017). Herein lies another core contribution of work at the intersection of EEG and RIS, as this body of work adopts a more dynamic approach to the interdependence between new path development and the wider regional structural change necessary.

A key contribution in this respect has been put forward by Tödtling and Trippl (2013), who emphasise that RISs are not necessarily static entities but can be subjects to change. Departing from the three core pillars of an innovation system, that is, actors, networks and institutions, the authors distinguish between three main areas of change. First, they highlight the importance of changes of actors or organisations (e.g. emergence of new industries, inflow of actors from outside, new research organisations or funding agencies). Second, they cast light on the emergence of new or the reorganisation of existing networks (e.g. new business networks/clusters, new extra-regional linkages, new modes of governance). Third, they move attention to changes in formal and, in particular, informal institutional endowments (new culture of collaboration, new approaches in innovation policy approaches, unlearning of existing routines or patterns of behaviour).

These insights are particularly important in the case of mature industries, which – more often than not – are strongly aligned with their surrounding RIS through previous rounds of regional path development. Accordingly, the regional settings this thesis is interested in are often characterised by a highly customised asset base in the form of established actor networks and high alignment of support organisations and formal as well as informal institutions with the well-established focal path.

Following these insights, Miörner and Trippl (2019) have investigated how disruptive changes in traditional and well-established paths are linked to the reconfiguration of the RIS. In doing so, they enriched EEG and RIS perspectives with work in the process-oriented TIS literature. The authors explore how RIS structures are changed in order to provide an old path with the new assets (such as new knowledge, legitimacy, investments or markets) necessary for path transformation to unfold. In their view, these assets are provided by RIS elements through innovation system functions (e.g. a research organisation providing new knowledge or legitimacy). However, for *new* assets to be provided, RIS reconfiguration is required that can come in three different forms. First, a RIS can be reconfigured endogenously in ways that altered elements develop new assets (e.g. through changes in education programs or the establishment of new regional industry networks). Second, RIS elements can be changed in

ways that they support the mobilisation or transfer of assets from elsewhere (e.g. through new inter-regional collaborations). Third, RIS elements can be imported and transplanted to the region (e.g. through relocating R&D units or attracting highly skilled workers).

Inspired by work at the intersection of EEG and the GPN literature (MacKinnon et al., 2019a; MacKinnon et al., 2019b), the transformation of RIS structures necessary to support new path development has been conceptualised through the notion of asset modification (Trippl et al., 2020). Asset modification is understood as the purposive and deliberate alteration of regional, historically-inherited industrial, human, institutional and infrastructural assets through actors within or outside of the region (Maskell & Malmberg, 1999; MacKinnon et al., 2019a; Chen, 2021). From this perspective, asset modification is seen as underlying new path development and RIS reconfiguration. It echoes the assumption that the mere presence of assets (e.g. related economic capabilities) alone is not a sufficient basis for regional structural change. Instead, regional assets can only foster successful new path development when they are identified, harnessed and valorised by actors (MacKinnon et al., 2019b).

While MacKinnon et al. (2019a) accord attention to redeployment or re-use of existing regional assets, other scholars claim that due emphasis should also be given to the creation of new assets, the transplantation of non-local assets, and the destruction of constraining assets (Trippl, et al., 2020). Empirical evidence suggests that the relative significance of these types of asset modification varies enormously, depending on the region and industry under consideration (see, for instance, a recent analysis of how digitalisation triggers new path development in Norwegian regions (Isaksen et al., 2021) and a study of 'green' regional development paths (Trippl et al., 2020). The outcomes of asset modification are manifold and can come in a variety of different forms, e.g. in the generation of new knowledge, the unlearning of old practices, the redeployment of resources such as investments or labour or the abolishing of unsuitable assets such as outdated regulations.

Incorporating the role of different actors and types of agency

The question of how RISs are reconfigured in order to support new path development has sparked interest in the role of agency (Tödtling & Trippl, 2013; Hassink et al., 2019). As Asheim et al. (2019, p. 51) point out: '*RIS do not, however, transform themselves*'. Accordingly, human agency is seen as a prerequisite for changes in RISs. As such, asset modification is conceptualised as being brought about by agency (MacKinnon et al., 2019a; Trippl et al., 2020).

Combining the RIS approach with an agency informed perspective enables a more comprehensive view on the role of multiple actors beyond Schumpeterian entrepreneurs who are at the centre of attention in narrow EEG models (Hassink et al., 2019, see chapter 2.4.3). Accordingly, from a RIS perspective, not only firm actors, but also research and educational organisations, policymakers, as well as support organisations such as incubators or intermediaries play an important part in bringing about changes necessary for new path development to unfold (Trippl et al., 2020). Following this train of thought, scholars have drawn a distinction between firm-level and system-level agency (Isaksen et al., 2019).

On the one hand, this differentiation allows for appreciating innovative firm-level entrepreneurs and their mindful deviation from existing structures (Garud & Karnøe, 2001), who are mainly concerned with alterations within their organisation and who develop new products or services and thereby substantially contribute to the emergence, growth and transformation of industries (Asheim et al., 2019). On the other hand, this distinction does not neglect important actions and interventions that target the adaptation of wider organisational and institutional innovation system structures.

Isaksen et al. (2019, p. 52) define system-level agency as '*actions or interventions able to transform regional innovation systems to better support growing industries and economic restructuring*'. As such, the concept helps to capture (among others) activities that aim at institutional change (see also the concept of institutional entrepreneurship by Battilana et al., 2009, chapter 2.4.3), alterations in the wider knowledge infrastructure (Asheim et al., 2019), the sourcing, mobilizing, and anchoring of local and nonlocal assets (Binz et al., 2016), as well as the creation of local and non-local markets (Frangenheim et al., 2020). As system-level agency is concerned with the wider RIS, it reaches beyond organisational boundaries and often rests on co-operation and joint vision building (Isaksen et al., 2019). Hence, system-level agency can originate from a broad variety of actors with different backgrounds, including firms, researchers, politicians and so on (Grillitsch et al., 2021). Finally, as Asheim et al. (2019) stress, firm-level and system-level agency are often mutually reinforcing as system-level agency can spur firm-level agency and vice versa.

The notion of system-level agency is inspired by the concept of system building (Musiolik et al., 2012; Musiolik et al., 2020), seen as an important activity in developing a TIS (Isaksen et al., 2019; Asheim et al., 2019) and defined as '*the deliberate creation or modification of broader institutional or organisational structures*' (Musiolik et al., 2012, 1035). Among other things, these structures include markets, legitimacy, fitting regulations, educational programs, technical standards and so on. Together these resources constitute the supportive system structures that '*provide externalities, reduce uncertainties and thus facilitate innovation activities for a broad range of actors*' (Musiolik et al., 2020, 3). System building is often collective, carried out by actors from different domains and driven by system builders who identify deficits at the innovation system-level (Musiolik et al., 2020). It is time-consuming, often conflictual, and requires the balancing of interests. Intermediaries might play an important role in coordinating strategies and organizing action (Musiolik et al., 2012; Musiolik et al., 2020).

Miörner and Trippl (2017) have – inspired by work on different types of institutional change (see chapter 2.4.1) – investigated how actors transform a constraining regional environment (support structures and institutional set-ups) into a more enabling one (Martin, 2010). They have thereby investigated in more detail different forms of system-level agency (however without using the term). Accordingly, such changes or reconfigurations come in three different modes, namely layering (support structures are gradually changed by adding new elements), adaptation (changes within or reorientation of existing institutions and organisations) and novel application (new utilisation of the existing support structures or institutions). Based on their

empirical investigation of the digital games industry in Scania (Sweden), Miörner and Trippl (2017) find that the creation of a more enabling environment for new path development has been the outcome of a complex interplay between different actors from different domains and these modes of change. Moreover, it is shown that these processes are multi-dimensional and multi-scalar in nature, involving change in several dimensions (institutional, political, industrial and organisational change) and on different spatial scales.

Conceptualizing new path development in open systems

This, again, brings the openness of RISs in a globalised world to the fore (Coenen et al., 2017). Trippl et al. (2020) conceptualize RISs as 'open systems' (Asheim et al., 2019) and understand new path development as '*essentially influenced by inflows and outflows of non-local knowledge and other assets (through extra-regional networks, activities by multinational companies and labour mobility), inter-regional industrial relations, supraregional institutional structures and regulatory frameworks and policy actions set at higher spatial scales*' (Trippl et al., 2020, p. 190). Accordingly, in line with other recent work, (see chapter 2.4.2), Trippl et al. (2020) emphasise the importance of regional structures, regional agents and their agency in a globalised world, without neglecting exogenous actors and influences on new path development and RIS reconfiguration. These extra-regional influences might originate, for instance, from a region's embeddedness in global value chains, production networks or multi-level governance systems (Patchell & Hayter, 2013).

The fact that RISs are open systems has fuelled interest in the multi-scalarity of new path development and RIS reconfiguration (as has been demonstrated by Miörner & Trippl, 2017; Miörner & Trippl, 2019). Trippl et al. (2018), for their part, have investigated conceptually in which ways non-local knowledge may spark new path development in different types of RISs. The authors focus on various extra-regional knowledge sources for regional structural change, namely the arrival of individual actors from outside the region, relocation of firms and other organisations such as research institutes, and international knowledge linkages. It is argued that regions not only differ in their need for non-local knowledge, but also in their capacity to attract, absorb and transform such impulses into new path development. However, as noted above, it is not only knowledge assets that matter for new path development. Importation and anchoring of other non-local assets (such as finance, legitimisation of novel technologies and practices, etc.) could also play a pivotal role (Binz et al., 2016).

All in all, through these core contributions, the RIS concept enables a more comprehensive understanding of why, where and when new path development does (not) succeed based on a systemic view on regional structures and assets, their necessary adaption for change to unfold and the role of actors and external influences in these processes underlying the rise of entirely new or the substantial transformation of existing industries (that is, the outcome of the process).

4 Path transformation: Advancing a systemic understanding

The previous section has demonstrated the dynamism and vitality of the research field at the intersection between EEG models and the RIS approach. Over the past five to ten years numerous contributions and authors have applied and further advanced a systemic understanding of new path development based on the RIS concept. Drawing on this body of work, this chapter will – in a first step – outline the conceptual framework of the dissertation geared towards unravelling path transformations from a systemic understanding (subsection 4.1).

Departing from this overarching conceptual framework, the articles address several research gaps and thereby contribute to further advancing systemic approaches to new path development in general and path transformation in particular. The research gaps will be identified and specified in a second step in subsection 4.2.

4.1 Conceptual framework for path transformation

This chapter will now summarize the dissertation's conceptual underpinnings. In doing so, it draws fundamentally on state-of-the-art work on systemic approaches to new path development based on the RIS approach (chapter 3.2). Particularly, it is inspired by a recent article unravelling (green) path development from a systemic perspective by placing particular attention on regional preconditions, asset modification and agency (Trippl et al., 2020, co-authored by the author of this thesis). Moreover, it is informed by general advancements made in the broader regional path development literature (outlined in chapter 2.4). The conceptual framework – that has guided this thesis and served as a theoretically-informed point of departure for the four research articles – condenses the reviewed literature and is depicted in a simplified form in Figure 1. It dismantles the process underlying path transformation from a RIS-informed systemic perspective, casting light on four fundamental building blocks:

- **(i)** Structural conditions
- **(ii)** Local and non-local multi actor constellations
- **(iii)** Structure-agency dynamics
- **(iv)** Outcomes: Path transformation

At the centre of attention is the regionally delineated innovation system in which the process of generating path transformation is embedded. The boundaries, however, are permeable. The system is conceptualised as open, characterised by external interactions through global value chains, production and innovation networks or multi-level governance systems (Asheim et al.,

2019). As such, it is vital to pay attention to national and global contexts, dependencies, influences and events (Dawley et al., 2015; Binz & Truffer, 2017; MacKinnon et al., 2019a).

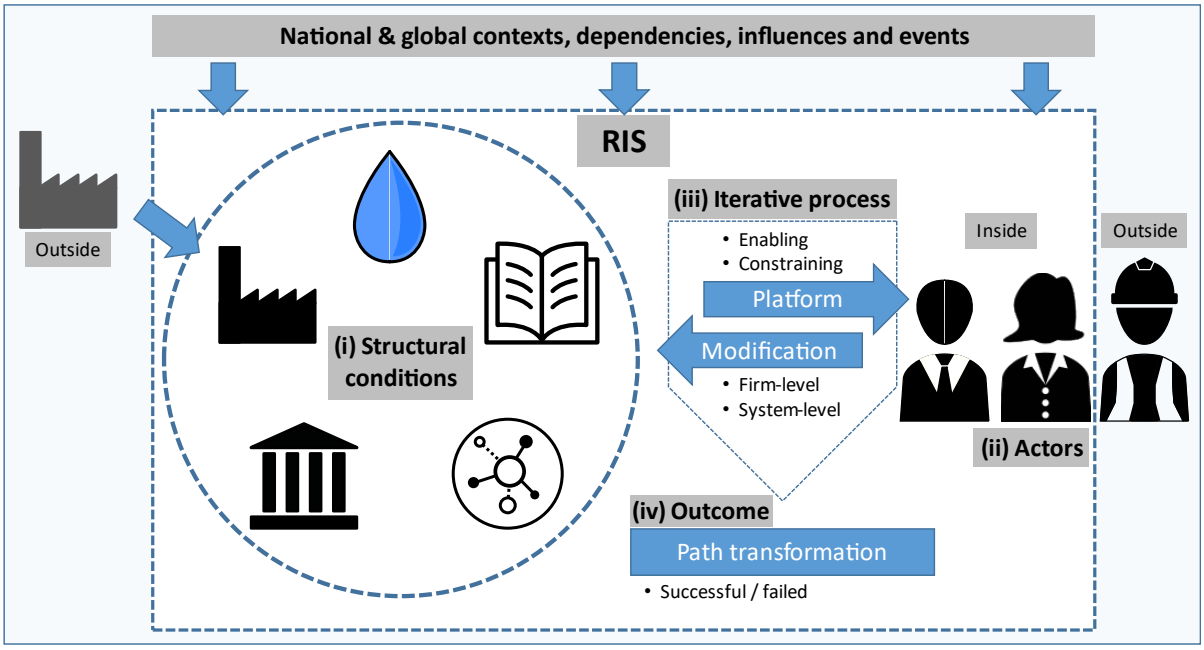

Figure 1: Simplified depiction of the conceptual framework (own elaboration[12])

The process of path transformation within a RIS departs from broadly-defined **(i) structural conditions**. Following other authors (Maskell & Malmberg, 1999; MacKinnon et al., 2019a), these structures are conceptualised as the regional asset base consisting of natural, infrastructural, industrial, human and institutional assets. This can be seen as a response to critique levelled against conventional EEG frameworks that overly emphasised industrial and knowledge-related assets in processes of new path development. These regional assets are understood as products of the RIS (Trippl et al., 2020) and as a historically-inherited platform for actors to act upon (Martin, 2010). However, importantly, not all assets are sourced internally. Sourcing, anchoring and aligning external resources are potentially important mechanisms contributing to path transformation (Binz et al., 2016; MacKinnon et al., 2019a). Moreover, it is important to pay close attention to different (regional) industrial paths, potentially mutually reinforcing effects between them and their competition over (scarce) assets provided by the RIS (Frangenheim et al., 2020).

On the other side of the framework stand the **(ii) actors**, both operating inside the RIS or exerting influence from outside. In contrast to conventional perspectives that place attention mainly on Schumpeterian entrepreneurs and firm-level actors (Hassink et al., 2019), this model emphasises the multi-dimensional and interactive nature of innovation and path transformation and stresses the importance of actors in universities, research institutes (Tanner, 2014; Vallance, 2016), intermediaries or the policy domain (Dawley, 2014) and their agency.

[12] The author would like to express his gratitude to Mathias Baumgartinger-Seiringer for designing and providing the symbols used in Figure 1.

At the core of the conceptual framework is the **(iii) iterative process between structural conditions and actors** underlying path transformation. That is, structures on the one side and actors and their agency on the other side stand in a recursive relationship (Emirbayer & Mische, 1998). One the one hand, historically-inherited structural conditions constitute the platform for actors in the present. As such, broadly speaking, they either provide an enabling or constraining regional environment for new path development (Martin, 2010; Trippl et al., 2020). For instance, a highly diversified and rich asset base is considered enabling for the transformation of paths, while a weakly developed one provides little such opportunities (Isaksen & Trippl, 2016).

On the other hand, actors identify, modify, harness and valorise structural conditions to achieve their goals (MacKinnon et al., 2019b). These processes are conceptualised here as asset modifications brought about by agency. They come in different forms, namely (a) the creation/transplantation of new assets, (b) the redeployment of existing assets and (c) the destruction of old and constraining assets (Trippl et al., 2020). In awareness that new path development is associated with fundamental change not only at the firm-level, but also at the system-level (Tödtling & Trippl, 2013; Isaksen et al., 2019), asset modification is often geared towards altering the organisational and institutional support structures to provide actors pursuing path transformation activities with the needed new assets (Miörner & Trippl, 2019; Trippl et al., 2020).

It's this '*dialectic and recursive interplay between structures and agency*' (Lawrence et al., 2011, p. 55) that underpins the variegated picture of path transformation and determines its **(iv) outcomes**. As such, this process can either succeed or fail, resulting either in the transformation of an established path or not.

4.2 Disentangling path transformation from a systemic perspective: Research gaps & questions

Departing from these conceptual underpinnings, this chapter will now pinpoint the gaps which this thesis aims to fill. While they have been touched upon in the previous chapters, they will be recapitulated and condensed at this point. It is argued here that addressing them will contribute to advancing and levelling up systemic perspectives on new path development in general and path transformation in particular.

In a first step, three overarching research gaps (RG) will now be presented, which – in a general way – are concerned with the broader debate on new path development.

First, research on new path development is characterised by a dichotomy between radical changes leading to the rise of entirely new regional development paths on the one hand and adaptations happening 'on-the-path' (often seen as rather incremental) on the other hand (Martin, 2010; Baumgartinger-Seiringer et al., 2021b, paper #1). Reflecting a broader scholarly

interest in how novelty is generated (Morgan, 2017), one has clearly witnessed a shift of attention towards the former in the most recent years (MacKinnon et al., 2019a), arguably leaving the latter under-researched **[RG1]**. This is particularly the case when it comes to more radical forms of 'on-path' changes. This, however, is problematic, as macro-developments like digitalisation, decarbonisation, the platform economy and so on will only continue to further boost fundamental changes in existing and mature industries in the times to come (Weber & Truffer, 2017; Kumaraswamy et al., 2018). Accordingly, as has been elucidated throughout the previous chapters, this thesis contrasts the recent trend in the wider debate on new path development and investigates, both conceptually and empirically, path transformations.

Second, systemic perspectives argue for incorporating alterations to the wider RIS structures (organisational support structures, institutional set-ups, etc.) in which new path development is embedded (Tödtling & Trippl, 2013; Miörner, 2019). Thereby, work at the intersection between EEG and RIS – almost by default – addresses previous critique that analyses based on innovation systems concepts tend to be overly static (Doloreux & Porto Gomez, 2017). Indeed, moving towards more dynamic views is seen as particularly relevant in contemporary debates. Transformative change (e.g. in response to the SDGs) is a long-term process and innovation system structures can no longer be treated as constant framework conditions for the emergence of innovative activities (a view that was implicitly held by many IS approaches), but have to be considered themselves as decisive evolutionary entities in motion (Weber & Truffer, 2017; Doloreux & Porto Gomez, 2017). As such, the body of literature this dissertation project aims to contribute to is inherently interested in filling this gap by unravelling the complex interdependence between path transformation and RIS rearrangement (Tödtling & Trippl, 2013; Miörner & Trippl, 2019, see chapter 3.2). However, much is yet to learn as empirical applications of systemic approaches are still rather scarce – in particular in respect to comparative case studies (Miörner, 2019). Even more so when it comes to path transformation in mature industries that – often but not always – are particularly well-aligned with their surrounding RIS, indicating a special need for reconfigurations and distinct challenges coming with it **[RG2]**.

Third, even more comprehensive accounts have often-neglected the role of inter-path dependencies for new path development[13] (Steen & Hansen, 2018; Frangenheim et al., 2020). Accordingly, limited attention in the wider regional path development literature has hitherto been devoted to other industries located in the region than the focal path under investigation **[RG3]**. While inter-path relations are not a prime focus, this thesis seeks to contribute to address this gap by incorporating other regional paths as important elements of the RIS in the analysis of path transformations. Thereby, it is possible to cast light on how path development activities in one regional industry (e.g. microelectronics or ICT industry) trigger developments in another (e.g. automotive industry) through mutual dependencies (e.g. dependence on the same scarce assets like skilled labour).

[13] It is important to again note here that the ‚Utrecht school of EEG' is indeed concerned with inter-path relations, albeit largely implicitly. Accordingly, this literature focuses on how old paths function as the basis for new ones based on diversification processes. Thereby, this literature puts attention solely on one direction of influence (old to new) and on positive forms of inter-path relations (Steen & Hansen, 2018; Frangenheim et al., 2020).

Based on these three shortcomings in the extant literature, the first and overarching research question guiding this dissertation has been formulated as follows:

- **RQ1**: *How do radical, innovation-based change processes in mature industries relate to (developments in) other elements of their surrounding RIS, that is, other actors, other industries, organisational support structures and institutional set-ups?*

After investigating these three more general shortcomings, four specific gaps will be outlined in a next step, each one addressing one particular building block of the conceptual framework.

To begin with, the section now turns to the **(i)** structural conditions. Accordingly, it is contended that, first, established concepts and their perspectives on regional structural preconditions are to be reconsidered, as they – arguably – convey a simplistic understanding by portraying structural conditions as either per se enabling or constraining for certain forms of path development. This holds true also for systemic perspectives. In other words, the 'black and white' way of thinking about regional structures obscures the greyscales and nuances when it comes to the potentials for and constraints to new path development in general and path transformation in particular inherited in different regional structural configurations **[RG4]**.

Second, the recent literature on new path development has seen a turn towards **(ii)** the role of different actors and associated types of agency (Boschma et al., 2017; Hassink et al., 2019; Isaksen et al., 2019; Grillitsch & Sotarauta, 2020, see chapter 2.4.3). However, there is arguably a prevailing emphasis on those forms of agency geared towards propelling change processes, whereas little is said about maintenance or reproductive agency aimed at impeding change (Henderson, 2020; Jolly et al., 2020; Bækkelund, 2021). This has also come with a rather one-sided focus on actors attributed with bringing about novelty, such as Schumpeterian or institutional entrepreneurs. Agents who do not belong to these 'usual suspects of change' have recently received very limited attention. Arguably, this is especially problematic in the case of path transformation, as mature industries are characterised by particular actor constellations in which the 'usual suspects' are often less important. In fact, in well-established paths centrally positioned incumbent firms often play a decisive role. In the wider regional path development literature, incumbents are often associated with strengthening existing specialisations (Martin & Sunley, 2010; Neffke et al., 2018). As such, incumbents are often seen as agents who pursue path extension rather than new path development. Here, however, it is argued that research on path transformations would profit from a more comprehensive understanding of the role of incumbent firms as actors of both, maintenance and change **[RG5]**.

Taking these two research gaps together, the second guiding research question has been defined as follows:

- **RQ2**: *What are the enabling and constraining influences of regional structural conditions and incumbencies in processes of path transformation and how to unravel and conceptualize the ambivalence inherent in them?*

What is more, this thesis places particular attention on **(iii)** structure-agency dynamics that condition and drive path transformation and RIS reconfiguration. This process is conceptualised here through the notion of the regional asset base, functioning as a platform for actors to act upon on the one side and asset modification brought about by agency on the other side (see Figure 1). However, given the disruptive nature of radical innovation-based change, one can hardly assume this process to be linear or abrupt, but multifaceted and long-term. Yet, emerging comprehensive models of new path development (MacKinnon et al., 2019a; Trippl et al., 2020) tell us little about how this iterative process between asset base and asset modification evolves over the course of new path development and RIS rearrangement. In order to address this gap, it is arguably necessary to take a distinct temporal perspective and unravel how this process unfolds over time and throughout different stages. Again, an argument can be made that this temporal view is particularly relevant in cases of path transformation, as established ways of doing things (i.e. 'pre-transformation activities') are often deeply entrenched in mature settings (Tödtling & Trippl, 2013), making the radical shift to new ways (i.e. 'transformation activities') on-the-path highly complex. In addition, the contingent and context-specific nature of this process should be further explored. There are limited empirical insights into how the underlying process plays out in different industries or across different regions **[RG6]** (for notable exceptions, see MacKinnon et al., 2019b; Kyllingstad et al., 2021).

Finally, this thesis argues that by exploring all abovementioned shortcomings, it is possible to draw more comprehensive conclusions about the possible **(iv)** outcomes of the process. While established models (often implicitly) argue that the process can result in either successful or failed new path development, thereby placing limited attention on the nuances **[RG7]**, this dissertation offers a novel perspective by investigating in more detail the contingent nature of path transformation and the wider adaptations in the surrounding RIS coming with it. It contrasts different routes of change leading ultimately to different outcomes based on varying structural preconditions, different types of agency and underlying mechanisms.

On the basis of these two research gaps, the third guiding research question has been defined as follows:

- **RQ3**: *What are the characteristics and key features of different development stages, routes and outcomes of path transformation and RIS rearrangement?*

Table 2 provides an overview of the research gaps identified and associated research questions defined, which guide the research endeavours undertaken for this dissertation project. It is argued here that following and addressing them can contribute to advancing systemic perspectives on new path development in general and path transformations in particular. Each article emphasises one key dimension of the theoretical framework outlined in the previous chapter (Figure 1) and, thereby, contributes to this overarching aim in different ways. However, this does not mean that other aspects are neglected, as all four articles are generally underpinned by the conceptual framework and its understanding of path transformation and RIS reconfiguration. Accordingly, the second paper (Trippl et al., 2021), for instance, does not only zoom in on the different outcomes of the process, but also investigates structural conditions and

the unfolding of change. Yet, in the grand scheme it contributes particularly to a more thorough understanding of where path transformation and RIS rearrangement might ultimately lead. Thus, in brief, all four research articles constituting this thesis have a particular focus, yet each is connected – at least loosely – to all three RQs (for a more detailed discussion see Chapter 6).

Table 2: Summary of research gaps and research questions

RG1	Radical changes in mature industries recently under-explored	RQ1
RG2	More dynamic views on RIS structures necessary	
RG3	The role of inter-path dependencies often neglected	
RG4	Influences from regional structural conditions require reconsideration	RQ2
RG5	Incumbents as 'unusual suspects' and their role require reconsideration	
RG6	Little is known about how the process underlying PT unfolds over time and comparatively between regions	RQ3
RG7	Limited research on concrete and context-specific development outcomes	

Source: Own elaboration

In order to address the research gaps, this thesis fundamentally draws on the mobilisation of other strands of literature. Accordingly, this dissertation contends that in order to overcome – for instance – simplistic takes on structural influences or the role of incumbencies (RQ2), Institutional Theory or Transition Studies have important insights to offer. In brief, it is argued here that Economic Geography may benefit from deeper exchange with other disciplines. Chapter 6 will outline in more detail how other branches of literature have been used in the individual research articles to address shortcomings in the various building blocks of the conceptual framework. It also reflects on the pros and cons of such an approach.

The two remaining chapters of this thesis will outline how the three defined research questions are addressed in more detail. The penultimate chapter 5 is concerned with the research design employed. It will describe underlying ontological and epistemological positions, the methodology and methods used for empirical data collection and analysis, as well as the cases and their contexts.

The final chapter 6 will first discuss the four research articles, their connection to the RQs and contributions individually. This is followed by a synthesis of the results of this thesis that demonstrates how the insights gained through the articles combined might help to level up and advance systemic perspectives on path transformation.

5 Research design, cases and contexts

This dissertation – broadly speaking – is placed in the branch of the social sciences. It is, therefore, concerned with the study of societies. In doing so, it is guided by a clearly defined research design consisting of certain ontological and epistemological perspectives and a methodology derived from these perspectives. Informed by these principal considerations, it applies certain methods.

According to the Encyclopaedia Britannica, these aspects of a research design can be defined as follows. Ontology is the philosophical study of being and interested in the nature of reality. It is concerned with questions of what there is (to know). Epistemology is the study of the nature, origin and limits of human knowledge and sometimes referred to as the philosophy of knowledge. It is concerned with our knowledge of reality and the ways and means of how we can attain it. The term 'methodology' refers to the set of rules, principles and procedures that underpin the research process, whereas methods are the concrete tools applied for both, data collection and analysis. This chapter will now outline this dissertation's research design.

5.1 Epistemological and ontological perspectives

This dissertation project is informed by a **critical realist view of the world** (Bhaskar, 1978). Critical realism assumes that the world is not a product of our thought but exists independently of our knowledge about it (Sayer, 2000). It therefore rejects the view that reality is to equate with what can be experienced empirically (Sayer, 2015). Instead, reality is seen as stratified and three domains are distinguished (Bhaskar, 1978):

- the **real**, which refers to the non-visible structures and mechanisms that exist regardless of observation,
- the **actual**, i.e. the events caused by these structures and mechanisms under certain conditions,
- the **empirical**, i.e. what is perceived and measurable by humans.

The goal of scientific endeavours – according to a critical realist's perception – is to relate observations in the *empirical* domain to the *actual* or *real* domain. Based on the principal assumption that the latter two are inaccessible with observations alone, it is considered necessary to apply theoretically informed research to identify the structures and mechanisms behind the empirical within the real and the actual (Sayer 2015). Hence, critical realism argues for 'retroduction' (Sayer, 1992; Yeung, 1997), which means that, from a critical realist worldview, it is necessary for scholars to move beyond '*a description of some phenomenon to a description of something which produces it or is a condition for it*' (Bhaskar, 1989, p. 19).

Accordingly, critical realism is a philosophy that highlights causal mechanisms (Gong & Hassink, 2020). It puts emphasis on and distinguishes between contingency and necessity (i.e. what are contingent/necessary conditions for mechanisms to unfold). This means that critical realism does not seek to explain causation as a matter of determinism, regularity or empirical order (as, for instance, a positivist worldview would suggest, Figure 2) but rather in terms of what produces change (Sayer, 2015). Thereby, the cause of events is highlighted independent of their frequency. Thus, explanation does not necessarily require repeated observations.

Following these notions, critical realism helps to understand how it is possible that the same cause might lead to quite different effects by putting emphasis on circumstances and (spatial or/and historical) contexts: '*Causal powers and empirical outcome is not one of automatic regularity, but is dependent on conditions within which they are located'* (Sayer, 2015, p. 278). Causal mechanisms can lead to quite different outcomes, and the same outcomes can result from different causalities.

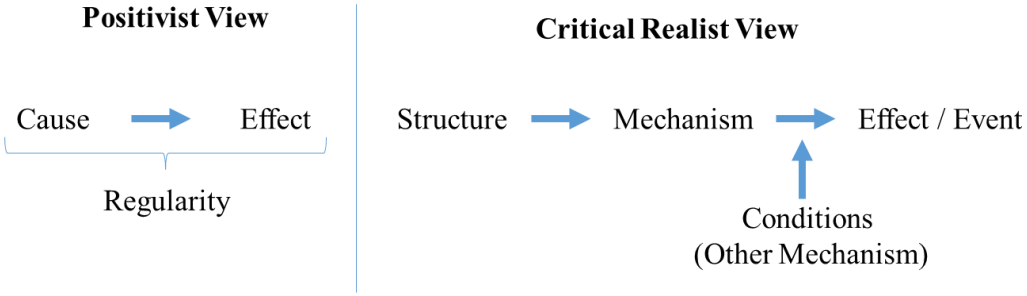

Figure 2: Positivist and critical realist view on causation
(own elaboration, based on Sayer, 2000; Eder, 2019).

These pillars of critical realism are particularly relevant for the discipline of Geography, as it deals predominantly with questions of context conditions, spatial disparities in a broad sense and uneven development in different settings (Asheim, 2020). From a critical realist perspective, it is hardly possible for a geographer to make

> *'…generalizations which are supposed to hold across time and space. The systems which geography and other social sciences study are open, that is, their elements can themselves be undergoing internal qualitative change – actors aging and learning, for example – and the relations among the elements are not constant, with the result that any empirically regular behaviours are unlikely to be durable or widespread. Evolutionary change and disequilibrium rather than equilibrium are the norm'*[14] *(Sayer, 2015, p. 279).*

[14] This quote also demonstrates that evolutionary thinking in the social science and a critical realist view of the world share fundamental assumptions (Njøs, 2018). This has been explicitly recognised by Sayer (2000).

Critical realists seek to understand change and causation in such open and evolving systems. As a consequence, they have to constantly reflect on their own observations which are temporary and unlikely to stand the test of time. Therefore, building on these ontological and epistemological foundations, science can indeed contribute to explaining the ever-changing world and develop reliable knowledge (albeit temporarily), 'the truth' is however not an appropriate goal as our theoretical propositions are never 'final' or 'complete' (Sayer, 2000; 2015). In other words, our developed theories, based on the *empirical* domain, will never fully coincide with the *real* domain.

What is more, not only are our observations temporary, they are – from a critical realist view of the world – also themselves theory-laden (Sayer, 2015). Accordingly, researchers are always biased by previous knowledge, experiences, discourse and, hence, by certain theoretical lenses (Sayer, 1992; Sayer, 2015).

Thus, in short, critical realism stresses the '*fallible and situated character of knowledge*' (Sayer 2000, p. 30). As a consequence, theory development is seen as an ongoing and never-ending process. An important tool in this regard is 're-theorizing', a process of revising, reconfiguring and developing existing theories by applying them in different contexts and test them against new observations in the empirical domain (Gong & Hassink, 2020). This is particularly important for the discipline of Economic Geography, which is inherently a form of 'contextual analysis' (Asheim, 2020). That is, from a geographical perspective one key concern of research lies in the iterative (further) development of theories as a means by which trans-contextual relevance can be achieved and through which insights from one empirical context can be brought to another (Gong & Hassink, 2020).

These insights are of particular importance for this thesis, as it is mainly concerned with unravelling processes and mechanisms of innovation-based regional restructuring in a context-sensitive way. As such, one of the main objectives of this thesis is to move beyond narrow EEG models in explaining new path development, that are often insensitive to contexts, but rather tend to describe empirical regularities (Gong & Hassink, 2020).

Systemic perspectives on new path development are not new (see section 3.2). The goal here is to further advance them by applying them to a certain context and revise and develop these theoretical concepts. This is achieved here, for instance, by testing theories on new path development against the particularities of path transformation. Accordingly, empirical observations conducted for this research project feed back to theory and allow for a certain degree of re-theorisation. However, as this dissertation studies open systems that themselves are subjects to evolutionary changes, the insights gained here (see chapter 6) have to be seen against the background of the spatiotemporal frame in which they have been acquired.

5.2 Methodology

While critical realism in geography does not promote a certain methodology per se, it arguably makes a case for intensive research designs rather than extensive ones. The latter do not necessarily identify causes, but try to explain through generalisations and empirical regularities and are most useful for demonstrating how widespread certain phenomena are (Sayer, 2015). They also usually ignore local contexts as context-dependent actions or properties are often unsuited for quantification (Sayer, 1992). This arguably holds true for the above-mentioned Utrecht school of EEG (and its focus on quantitative studies and related/unrelated diversification) that fails to confront empirical regularities over space (and time) with distinct local particularities (Gong & Hassink, 2020). An intensive research design, in contrast, zooms in on causal connections, follows them where they might lead and is thus more exploratory in nature. It is, however, time consuming and thus rather suited for abstraction (i.e. the process of discovering the deep ontological structures and the related causal powers unfolding under contingent circumstances, Gong & Hassink, 2020) rather than for generalisation about empirical regularities or patterns of covariation (Sayer, 2015).

This thesis will employ an intensive research design based on qualitative case studies (explained in detail in the next chapter). Informed by a critical realist view of the world, the methodology is based on a number of interlinked and fundamental assumptions and an associated set of rules.

First, work in this dissertation rests on state-of-the-art theoretical frameworks in the discipline to examine the research objects (see chapters 2.4 & 3.2), but also on the conviction that in order to develop (temporally) reliable knowledge, these frameworks will require ongoing reconsideration, revision and further re-theorizing.

Second, in awareness that '*causal structures unfold under contingent conditions*' (Sunley, 1996, p. 339), it is acknowledged that the same cause(s) (for instance, global competitive pressures, increasing digitalisation or a new radical innovation) can lead to very different outcomes, depending on the contextual circumstances with which they are confronted (Sayer, 2015). This is a critical insight in particular for paper #2 and paper #3 of this thesis, as these articles compare different cases and indeed find that the same cause (pressure for digitalisation in a globalised automotive industry) has led to substantially different effects (routes of transformation, unfolding of change and development outcomes).

Third, a certain degree of universality is achieved here through (rational) abstraction rather than generalisation (Sayer 1992, Gong & Hassink, 2020). This means that instead of looking for patterns of empirical regularity or predictive laws, the research design aims at analysing underlying mechanisms unfolding contingently in the context of the case studies. As such, the goal is to understand and explain change and causation in open systems (in the form of the transformation of existing paths and rearrangements of surrounding RIS structures), without considering the mechanisms as a matter of regularity across contexts. Following this train of thought, explanation and abstraction is only achieved when '*the ontological structures [are] revealed, and necessary and contingent relations delineated*' (Barnes & Christophers, 2018,

p. 148, cited in Gong & Hassink, 2020). From this point, the insights acquired feed back to the theoretical frameworks applied and are used for further theory development in a contextually informed manner, that is, '*a context-sensitive theorising process*' (Gong & Hassink., 2020, p. 8). Accordingly, a certain degree of universality through qualitative methods and an intensive research design is achieved here analytically rather than empirically (Gobo, 2004; Yin, 2018).

Fourth, a key concern of this dissertation is the study of the role of agency in regional path development. From a critical realist perspective, agency is a crucial causal power producing effects (Grillitsch et al., 2021). It has to be seen in the context of its interplay with structure as the two are mutually constituting each other (Bhaskar, 1997). However, following Archer (1982; 1995), structure and agency should be kept analytically apart to study the interplay and dynamics between them over time and thereby explain causality.

Fifth, as observations are always theory-laden, formed through contemporary discourses, guided by our knowledge and (professional) experience and thus seen through pre-existing conceptual and theoretical lenses (Sayer, 1992; Sayer, 2015), it is important to constantly test the adequacy of our views against new insights (Sayer, 2015). Accordingly, even though 'the truth' is not an appropriate goal, not any interpretation of the world is equally good and plausible (Sayer, 2000). This means that a researcher informed by critical realism is encouraged to maximize the validity and reliability of – always fallible – observations and interpretations by incorporating different angles on the subject, that is, by triangulation (Denzin, 1970; Sayer, 2000). According to Denzin (1970) and Yeung (1997), these different angles can be from a data perspective (time, place, person, geographical level), investigator perspective (multiple observers of the same phenomenon), theoretical perspective (multiple theoretical concepts and frameworks with respect to the same set of objects) or methodological perspective (observations made with the same methods, i.e. 'within-method triangulation' or with different methods, i.e. 'between method triangulation'). In this dissertation project, different data sources, theoretical backgrounds and methods have been triangulated. All four research articles of this thesis draw on a combination of data obtained from various sources. More concretely, in-depth and semi-structured interviews have been triangulated with insights from existing scientific literature (with different theoretical backgrounds) and documents from different sources. Moreover, ongoing research has been presented at numerous scientific conferences, workshops and seminars to receive criticism and triangulate between different investigator and theoretical perspectives (Yeung, 1997; Sayer, 2000).

A final point of the methodology (albeit unrelated to critical realism per se) is concerned with the empirical level of analysis. This thesis – as do many other studies within Economic Geography – chooses the 'region' as the geographical level of analysis (Miörner, 2019). There are several arguments for that. First, the region remains an important territorial unit for understanding the economy (Storper, 1997), even in a globalised world (Asheim et al., 2019). Second, as mentioned before, innovation and industrial change are highly localised phenomena (Martin, 2010), giving a regional perspective a certain advantage in comprehensively studying the rise of new economic activity (Feldman, 2019, see chapter 2.1). Third, on the continuum between the micro and the macro level or the local and the national, the region is an important

middle ground on the meso level (Miörner, 2019). That is, the region as the analytical level offers a particular perspective: neither is it concerned with the heterogeneity on the micro level (individuals, organisations, firms) nor with the rather coarse-grained view on the macro level (supra-regional settings). Instead, the focus in studies within the wider EEG framework lies on the evolution of regional populations of firms, supportive actors and institutions (Schamp, 2017). However, as Njøs (2018) has pointed out, too much emphasis on the meso level comes with the risk of naïvely focusing on regional settings *per se* and neglecting – in particular – exogenous and supra-regional influences (Binz et al., 2016; Trippl et al., 2018). To avoid this pitfall, regions are considered here as open systems and extra-regional influences on innovation-based restructuring, such as inter-regional linkages, the embeddedness of firms or research bodies in global production or innovation networks, influences from higher governance levels and so on (Asheim et al., 2019) are not disregarded (see also chapter 2.4.2 and 4.1).

5.3 Methods for data collection & analysis

Informed by a critical realist view of the world and based on the methodological considerations outlined above, this chapter will now introduce the data sources and concrete research methods used.

As mentioned before, the process of re-theorizing rests on the application of theoretical frameworks in different contexts and tests them against new observations in the empirical domain (Gong & Hassink, 2020). For this dissertation and the constituting four research articles, empirical data has been collected by employing an intensive, qualitative research design on the basis of case studies.

A **case study approach** is suitable in explanatory settings and used for answering why & how questions (Yin, 2018), and thus for the research aim of this thesis. Case studies are typically applied to analyse real world phenomena through in-depth investigations (Flyvbjerg, 2006; Yin, 2018), and, as such, are appropriate for examining and explaining complex innovation-based reformation processes in mature regional industries and their surrounding RIS. Case studies have particular strengths. They offer flexibility, are open to interpretations and suitable to contribute to theory development (George & Bennett, 2005). Moreover, a qualitative research design is seen as particularly suited for the aims underlying this dissertation project, as many problems in narrow EEG models (outlined in chapter 2) are arguably resulting from the strong emphasis put on quantitative research designs (Hassink et al., 2019).

Thus, empirically, this thesis draws on an in-depth investigation of three automotive regions in transition, namely the Austrian automotive triangle (AAT, constituted by the three federal states Styria, Upper Austria and Vienna), the Ontario region (Canada) and West Sweden (to be introduced in more detail in the next chapter). Due to the increasing digitalisation and decarbonisation of the automotive industry (Baumgartinger-Seiringer, 2021, paper #4), all of

these regions (the industries themselves as well as the wider RIS structures) are currently undergoing fundamental innovation-based transformation processes.

A particularity of the cases is that these transformations were still ongoing at the time of data collection (and still are today). This stands in contrast to a majority of work in the wider field of research on regional industrial path development, that often studies such processes ex-post, meaning that the outcomes have already been materialised fully (Steen, 2016). By investigating ongoing processes, it is possible to reveal inconsistencies, contradictions, opposing voices, nuances and complexities related to deep-rooted change that are often overlooked, falsely simplified or over-rationalised in hindsight (Steen, 2016; Baumgartinger-Seiringer et al., 2021b, paper #1), after a mainstream narrative has developed (Jolly et al., 2020). This is especially important for paper #4 (Baumgartinger-Seiringer 2021), in which aspects of agency oriented towards suppressing change (maintenance agency) are explored. Studying on-going processes usually requires qualitative methods, as existing classification schemes and datasets are often unable to capture the emerging novelty associated with transformations (Steen, 2016).

The articles constituting this thesis either employ a single case or a comparative case study approach. While paper #2 (Trippl et al., 2021, AAT & Ontario) and paper #3 (Baumgartinger-Seiringer et al., 2021a, AAT & West Sweden) investigate change processes in two automotive regions comparatively, paper #1 (Baumgartinger-Seiringer et al., 2021b, West Sweden) and paper #4 (Baumgartinger-Seiringer 2021, AAT) focus on single cases. That is, in brief, whether the articles draw on insights from a single or multiple cases was depending on the aim of the respective article.

The single cases of path transformation were used to test and illustrate the conceptual arguments and potentially challenge assumptions made in the conceptual frameworks (Baumgartinger-Seiringer et al., 2021b, paper #1). As such, they can be seen as 'paradigmatic cases' (Flyvbjerg, 2006). The comparative case studies pursue the goal of analysing how similar conditions or processes can produce different outcomes in different contexts, or vice versa (Griffin & Ragin, 1994). Comparative studies are particularly suitable when the cases share a set of commonalities, but also a number of variations in aspects of theoretical relevance (Rihoux & Lobe, 2009), such as disparities in broadly defined RIS structures (Trippl et al., 2021, paper #2; Baumgartinger-Seiringer et al., 2021a, paper #3).

Drawing on multiple cases is beneficial as it provides a strong case for theory building. As Eisenhardt and Graebner (2007, p. 27) highlight, adding additional cases can significantly improve the quality of research and results in more analytical power: '*theory building from multiple cases typically yields more robust, generalizable and testable theory than single-case research*'. However, sampling for multiple cases is more complicated and rests '*less on the uniqueness of a given case, and more on the contribution to theory development within the set of cases*' (Eisenhardt & Graebner, 2007, p. 27). With that being said, the cases in this dissertation have been chosen as they predict contrasting results but based on theoretically anticipated reasons. Hence, the selection is guided by theoretical replication (Yin, 2018, see also chapter 5.4).

Accordingly, not random, statistical or stratified sampling was used, but information-oriented sampling, meaning that the goal was to '*maximise the utility of information from small sample and single cases*' (Flyvbjerg, 2006, p. 230). In a theoretically-informed way, sampling was geared towards finding cases that are particularly suitable to provide relevant insights into the issues of interest. In that way, it is ensured that the cases offer empirical material that supports theory-based expectations or replicate findings from other cases, complements or contradicts them (Eisenhardt and Graebner, 2007; Yin, 2018). These insights are then used to feed back to theoretical frameworks (Gong & Hassink, 2020).

As case studies are designed to allow for an in-depth examination of a complex phenomenon, they usually rely on a number of different data sources (Yin, 2018). For this dissertation (1) semi-structured in-depth interviews, (2) a document analysis and (3) participatory observations have been used, all of which will be explained in more detail now.

First, **in-depth and semi-structured expert interviews** have been the main means of data collection for this dissertation project. In total, insights from 88 interviews with key regional and extra-regional stakeholders have informed the four constituting articles of this thesis. 25 of these interviews have been conducted by the author of this dissertation, 63 by colleagues working on transformations in the automotive industry in West Sweden/Ontario in Canada[15] (see Table 3 for an overview).

Table 3: Overview of the expert interviews

Region	Number of interviews	Period	Researcher in charge	Used in article(s)
AAT	25	2019	Simon Baumgartinger-Seiringer	Article #2, #3 & #4
West Sweden	23	2017-2018	Johan Miörner	Article #1 & #3
Ontario	40	2016-2018	Elena Goracinova	Article #2

Source: Own elaboration

Following a critical realist worldview, qualitative interviews are considered a suitable tool to unravel complex social and institutional processes and uncover underlying mechanisms, which is usually beyond the scope of quantitative approaches (Schoenberger, 1991). This thesis relies strongly on the explanatory power of expert interviews, which constitute the foundation of the three case studies.

As mentioned above, a researcher informed by critical realism is instructed to be guided by a deep theoretical understanding in order to relate observations in the *empirical* domain to the *actual* or *real* domain. Accordingly, the interviews have been structured using a guideline that

[15] This setting comes with particular challenges. While the author of this thesis was able to familiarize himself with the Swedish and Canadian cases (reading the transcripts, lengthy discussions), it is hardly possible to fully grasp the 'whole picture' with this material alone. Therefore, on the one hand, the research setting requires a high amount of exchange and cooperation. On the other hand, however, there are particular advantages, coming e.g. in the forms of an 'in-built' investigator triangulation or mutual learning (Miörner, 2019).

corresponds to state-of-the-art theoretical knowledge in the field. At the same time, these guidelines have been designed to be 'open enough' in order for interviewees to be able to contribute novel perspectives and interpretations. Hence, the interviews have been conducted in a *semi*-structed way. This means that the theoretically-derived questions have been formulated according to the principle of openness. This has given the interview partner enough room (Gläser & Laudel, 2009) and allowed for the exploration of unexpected facts and attitudes arising during the exchange (Silverman, 2011). In this way, the guideline has guaranteed the completeness of the interview, while not predetermining its course (Lamnek & Krell, 2010).

What is more, the guidelines were adopted according to the background of the interview partners. In general, three different guidelines have been used for three broadly defined backgrounds of interviewees, one for (i) firms & their interest representatives, one for the (ii) education & research domain, and, finally, one for the (iii) wider policy domain. Moreover, the single guidelines for each individual interview have been slightly adapted to the particular actor based on background knowledge gained through previous interviews and preparatory analyses of secondary material.

Yet, even though the interviews were open-ended and the single guidelines adapted to the respective background of the interviewee, all interviews followed a similar structure, revolving around four key areas of inquiry (see Trippl et al., 2021, p. 1163, paper #2):

1. The broader picture of the transformation of the automotive industry and its impact on the organisation/department and the region (concrete changes within the entity/region in recent years; changes in partnerships and competitors; changing spatial patterns).
2. Enabling and constraining regional conditions (focus on aspects such as talent, capital, knowledge infrastructure, institutional set-ups, government support).
3. Modification of firm-specific and regional assets (ongoing endeavours; bottlenecks)
4. Visions and expectations (perception of future development; opportunities and challenges for the entity/region; common/contested visions)

The interview process can be further described as follows. Most of the interviews were around an hour long, with some exceptions lasting up to three hours. Usually, the interviews were conducted face-to-face. However, some (around 10%) of them were via telephone calls due to time constraints. Most of the interviews in the AAT have been conducted together with a research assistant. All interviews were recorded (after guaranteeing anonymity and asking for permission by the interviewees, no one declined). In a next step, the interviews have been transcribed, which is important for the subsequent data processing and analysis. The transcriptions have been supplemented with notes taken during the interviews, which helped to capture certain interpretations and nuances (Gläser & Laudel, 2009). This process continued until a point of 'data saturation' was reached, meaning that no or very little additional insights were expected from further interviews (Glaser & Strauss, 2017).

An important question is how the interview partners have been selected. A key concern in this regard is to get a balanced selection of well-informed and centrally positioned informants with

different perspectives, interests and views. With this goal in mind, an initial mapping of actors based on the analysis of secondary data has been performed. This has been followed by a snowballing method (Valentine, 2005), meaning that interview partners have recommended other ones centrally positioned in the industry. The initial mapping and these recommendations have been used together and balanced to guarantee a representative selection of a broad variety of actors within the automotive industry, its support system (more narrowly defined), but also with actors in the broader RIS and NIS (e.g. actors in relevant policy fields like traffic and mobility). In most cases, the interview partners were employees of an organisation for which they were interviewed representatively (Flick, 2007).

However, at this point, it is important to note that data collection based on interviews is not without limitations. These revolve around interpretation, language and meaning (Schoenberger, 1991) as well as interviewee's preoccupations, standpoints, and interests (Smith & Elger, 2014). Accordingly, in order to at least lessen these problems, precision and transparency (e.g. in terms of language used), explanation (to resolve possible misunderstandings during the interviews), reflection and triangulation are key ingredients of a qualitative approach based on interviews (Sayer, 2000; Gläser & Laudel, 2009).

Second, the case study approach underpinning this thesis also rests on data collected through a **document analysis**. Accordingly, publicly available documents like newspaper articles, newsletters, reports, webpages, PR material, legal documents and policy documents have been reviewed and analysed. These documents contain data that have been recorded without the intervention of the researcher (Bowen, 2009). A document analysis is often used in a complementary way to other qualitative methods and, hence, an important means of triangulation (Denzin, 1970).

As Bowen (2009) points out, documents can serve a variety of purposes as part of a research undertaking. Specifically, he outlines five core functions of documentary material:

1. Documents can provide data on the context of the case (background information on conditions that underlie the phenomena under investigation).
2. Document data can help to find the right questions to ask or situation to be observed in the research endeavour (e.g. finding interview questions and partners). This demonstrates the complementary nature of document analyses to interviews.
3. Documents can provide supplementary data and constitute a valuable addition to a knowledge base.
4. Document data can provide a means of tracking change and development (e.g. when interviewees have forgotten details). For instance, researchers can examine periodic reports (such as the 'actions plans for automated driving' published by the ministry for transport in Austria) to trace back how such programs fared over time.
5. Documents can be used to verify or corroborate evidence from other sources. When there is convergence, documents can lead to further robustness of research findings. When there is contradiction, the researcher is expected to investigate further.

Throughout this dissertation project, document analysis has been used for all five functions. The evaluation of data contained in documents has followed several guiding principles. Accordingly, documents have been studied with a critical eye. Caution and reflection are important as one should avoid an unbalanced selection of documents, critically scrutinize the original purpose (information about the author, target audience, etc.) and assess the relevance of the document (Bowen, 2009).

Third and finally, **participatory observations** in thematically relevant conferences and workshops were used to complement data from the interviews and the document analysis. Broadly defined, the thematic focus of these events was centred around discussing current transformations in the automotive industry and their implications, either specifically for firms or – more generally –for policy and society. At the conferences and workshops field notes have been taken, which further contributed to the robustness of the case studies (Bryman, 2016). These participatory observations have been helpful to understand how certain topics are discussed and debated in the field, what problems are recognised, prevailing expectations and visions and so on. In brief, they provided insights into how real-world events were unfolding in real time.

The data collected has been **coded and analysed using a qualitative content analysis** (Gläser & Laudel, 2009). Based on theoretical considerations and the research questions (Saldaña, 2015), a coding scheme has been developed with which the relevant information in the material was selected and categorised (‘extraction’). Importantly, the coding scheme remains open during this step, meaning that it can be expanded if relevant information emerges that is not captured by the pre-defined codes (‘in-vivo coding’). Through this procedure, the original material was systematically condensed and structured in a theoretically-informed way. In a next step, the data set obtained was summarised, sorted and checked for contradictions (‘reprocessing’) (Gläser & Laudel, 2009). Coding and analysing of data were supported by software. For each individual paper, the coded material was revisited with the respective research perspective in mind.

With the research approach clarified, the next chapter will now introduce the empirical cases and their wider context. Thereby, it provides background information seen as necessary to understand the contingent unfolding of innovation-based restructuring processes in the three automotive regions under investigation.

5.4 Cases and contexts

Following a theoretically-informed sampling, this dissertation investigates the automotive industry located in three regions, Ontario, West Sweden and the Austrian automotive triangle (AAT). This is for a number of reasons. First, the three regions share a set of commonalities, but also exhibit a number of theoretically-relevant variations (Rihoux & Lobe, 2009), making them interesting cases for re-theorisation based on comparisons. Second, the automotive

industry is mature in all regions, making it well-suited for this thesis in light of its interest in transformation processes in well-established paths as well as in the wider RIS these paths are embedded in. Third, these three regional automotive industries are currently facing multiple pressures for transformation, resulting from different upheavals connected either to particularities of these regions or to global trends in the industry more generally. Accordingly, innovation-based restructuring can be considered vital for all three regional industries. All these points will now be explored in more detail.

In general, the automotive industry exhibits a number of characteristics deemed important here to understand ongoing transformation processes. To begin with, the industry is a key sector in all three regions and has a longstanding history there. It has a high economic significance due to employment and value-creation effects (Schneider et al., 2018). Accordingly, the automotive industry has often forged strong ties to other upstream and downstream industries. Moreover, it is often supported by organisations like intermediaries, incubators, (technical) universities and other research and educational organisations. The role of the state is generally important, not only because of the usually high levels of support due to the many jobs and taxes provided by automotive firms, other firms connected to the automotive industry and the wider support structures they are embedded in, but also because of the significance of tariffs, economic stimuli and environmental and safety regulations in the automotive industry generally (Dicken, 2015). The industry is very capital intensive and highly elaborated. As a result, it is usually characterised by a certain actor structure and hierarchy with large incumbent firms (often acting internationally) on top.

Moreover, profound and ongoing restructuring processes in automotive GPNs play an important role in contemporary transformations in the AAT, Ontario and West Sweden. The stratification of the global automotive industry and its geographical patterns have often been described in the form of a hierarchical continuum between core and periphery locations based on the industry's division of labour (Layan & Lung, 2004; Lampón et al., 2016; Pavlínek, 2022). Thereby, broadly speaking, work has distinguished automotive locations between powerful regions or countries at the core of global production networks like the USA, Japan or Germany on the one side, and less powerful, often lower-cost locations in the periphery on the other. Additionally, scholars have argued that there is an intermediate type of locations positioned neither at the core nor the periphery (Hudson & Schamp, 1995; Mordue & Sweeney, 2020). All three regions investigated in this thesis share that they are considered to be part of this intermediate type called the **'semi-periphery'** of the global automotive industry (Pavlínek, 2018; Mordue & Sweeney, 2020).

Pavlínek (2018) defines semi-peripheral automotive locations as follows. They are characterised by high levels of foreign ownership and lack a domestically owned OEM (Original Equipment Manufacturer). In contrast to countries in the (integrated) periphery (e.g. in Eastern Europe or Mexico), semi-peripheral regions have relatively high production cost due to a high standard of living and expensive labour, but lack the power and often the strategic functions (especially R&D) that are associated with the core (Pavlínek, 2022). As a

consequence, semi-peripheral locations face an enormous pressure due to the increasing integration of the periphery in GPNs.

Accordingly, lower cost and peripheral automotive regions threaten to (further) oust semi-peripheral locations like Austria, Sweden or Canada from their positions in GPNs drawing on four distinct assets: low-cost labour, geographic proximity to large markets, membership in trade agreements and investment incentives (e.g. by governments) (Pavlínek, 2018). For instance, the rise of Mexico as an automotive production location has had profound negative implications for manufacturing in Canada due to the latter's competitive disadvantages (Sweeney & Mordue, 2017; Yates & Holmes, 2019). As a consequence, the semi-periphery usually exhibits a nominal and/or relative (in relation to macro-regional (North-America, Europe) or global levels) decline of vehicle production since 2000 (Table 4), highlighting the profound, dynamic and on-going restructuring in the global automotive industry.

Table 4: Vehicle Production in selected semi-peripheral locations, 2000 & 2018

Country	**2000**			**2018**		
	Vehicle Production	% of global production	% of macro-regional production	Vehicle Production	% of global production	% of macro-regional production
Austria	141.026	0,24%	0,70%	164.900	0,17%	0,77%
Canada	2.961.636	5,07%	16,73%	2.014.485	2,11%	11,55%
Sweden	301.343	0,52%	1,49%	222.000	0,24%	1,06%

Source: modified, based on Mordue & Sweeney (2020)

In light of these changes, locations like Ontario, West Sweden and the AAT are pressured to redefine or even re-establish their competitive advantages (Mordue & Sweeney, 2020). And, as scholars have argued, the ways in which semi-peripheral regions have taken up this challenge is under-researched (Mordue & Sweeney, 2020). This thesis investigates such endeavours in the case study regions through the lens of path transformation. As such, the results of this dissertation project contribute to close gaps in this regard.

Yet, despite these communalities, the three selected automotive regions exhibit a number of important differences. To begin with, the industries' degrees of embeddedness in their respective region differ, having important implications for innovation and valuation processes (Binz & Truffer, 2017). Ontario's automotive path is rather weakly embedded, has experienced difficulties to get mandates for R&D from parent companies with HQs elsewhere, limited innovation support structures and, hence, has traditionally prioritised production over innovation-related activities (Anastakis, 2005; Trippl et al., 2021, paper #2). In contrast, the industries in West Sweden and the AAT are more firmly connected to other innovation system elements in their regions, are deeply embedded and show an historically-inherited higher degree of innovation capacity (Baumgartinger-Seiringer et al., 2021a, paper #3). As such, the Austrian and Swedish industries are strongly backed by and aligned with their surrounding RISs, contrasting the Canadian case. However, despite the similarities between the former two, an

analysis of preconditions in West Sweden and the AAT in paper #3 of this thesis has shown that regional structural elements are more coherent and aligned in Austria than in Sweden. This means that they are mutually reinforcing in terms of the direction of change and long-term goals in the AAT, but not so much in West Sweden (Baumgartinger-Seiringer et al., 2021a).

The differences in the historical profiles of the industries are also reflected in different routes through which the locations got their semi-peripheral status. While the Canadian industry was once considered as part of the integrated periphery (low production cost, low-value-added, labour rather than knowledge-intensive, producing for US automakers, etc.), Sweden's was part of the automotive core until the acquisition of formerly domestically owned automaker Volvo by Ford in 1999. Albeit local ownership and control has disappeared, it has retained some strategic functions associated with core locations (e.g. high concentration of knowledge and innovation, R&D heavy, strong institutional support, etc.) (Mordue & Sweeney, 2020). In this respect, the AAT is something of a special case, as it is traditionally peripheral (high export quota, no domestically owned OEM, etc.), but specialised in supplying high-quality products, in particular to German automakers to which many firms in the AAT have historically-strong ties. Based on high levels of innovativeness and well-elaborated support structures that are more in line with (former) core regions than with peripheral locations (Trippl et al., 2021, paper #2; Pavlínek, 2022), the AAT was able to offset the strong decline of production usually found in semi-peripheral automotive regions (Table 4). Indeed, the Austrian industry has undergone a quite dynamic development over the last two decades: since 2000 production value has tripled and the number of jobs increased by 55% (Högelsberger & Maneka, 2020). As such, the AAT can be characterised by a longer history as a hybrid type, with typical elements of a peripheral location but combined with some features of core regions.

In brief, the automotive industries in Ontario, West Sweden and the AAT find themselves in similar situations due to commonalities resulting from their semi-peripheral position in the global automotive industry. However, the regional structural preconditions in the three cases – coming in the form of different degrees of regional embeddedness, routes of development, endowment of support organisations and institutional set-ups and innovation capacities – differ. As a consequence, the key challenges connected to the redefinition of the regions' competitive advantages (Mordue & Sweeney, 2020) and, hence, the deep-rooted restructuring processes ongoing in all three locations vary (Table 5; Baumgartinger-Seiringer et al., 2021a, paper #3; Trippl et al., 2021, paper #2).

However, the current transformations have not only to be seen against the backdrop of this rearrangement of balances between and within automotive regions in GPNs, but also in the context of shifting conditions in the automotive industry more generally. One of the most important developments in this respect, in particular for regions that are specialised in supplying core locations, is the **trend of de-verticalisation**. Accordingly, assemblers increasingly pass responsibilities to lower-tier firms due to the growing complexity (e.g. due to the increasing use of electronics in cars) and ever faster development cycles (Dicken, 2015). Initially, this development started in a climate of crisis back in the 1970s when production networks became more international and supplier gained importance (Högelsberger & Maneka, 2020). Over the

years, there has been a massive decline in the number of suppliers based on a strong trend of concentration. The ones surviving are now often large firms that are very close to OEMs (Tier 0,5), like Delphi, Bosch and Magna (Dicken, 2015). Today, supplier firms are often highly sophisticated and provide whole systems rather than single parts. These developments have led to reconfigurations in power balances between OEMs and suppliers, at the expense of the former (Dicken, 2015). In light of these changes, there is the opportunity for supplier firms (in the AAT, Ontario and West Sweden) to jump in the value chain based on innovative activities, not only for traditional automotive companies but also for players in complementary paths like the ICT or microelectronics industries (Trippl et al., 2021, paper #2).

Table 5: Characteristics of the three automotive case study regions in comparison: AAT, Ontario (Canada) & West Sweden

Region	Regional embeddedness	Route of development	RIS structures	Key challenges
AAT	Relatively high	Traditionally in semi-peripheral position	Thick and well-aligned	Rearranging an established system
Ontario (Canada)	Relatively low	Previously peripheral location in GPNs	Relatively thin and weakly aligned	Upgrading to higher-value-added
West Sweden	Relatively high	Previously core location in GPNs	Thick but relatively weak alignment	Re-consolidation and re-alignment

Source: Own elaboration

While the increasing de-verticalisation has been a long-term changing context condition, there are in particular two current upheavals with the potential to fundamentally alter the industry over a shorter time horizon: decarbonisation and digitalisation[16] (Baumgartinger-Seiringer, 2021). After a long period of stability with only incremental changes in the automotive sector, these developments are now expected to boost fundamental changes (Schippl & Truffer, 2020). Accordingly, the climate crisis and the need to ban emissions from all socio-technical systems, including the mobility system, but also developments connected to the increasing digitalisation of the industry (like the emergence of new technologies, the increasing inflow of ICT knowledge, rapid progress in electrification, traffic management or new modes of transport through mobility as a service approaches) lead to major upheavals. In other words, after periods characterised by mainly path extension, we now see processes of path transformation unfolding (Miörner & Trippl, 2019). In what follows, these two megatrends and their implications for the automotive regions under investigation will be briefly outlined.

[16] While this thesis is generally more concerned with restructuring processes connected to the industry's increasing digitalisation (in particular in papers #1, #2 & #3), decarbonisation is an important changing context condition that is crucial to understand current ongoings in the automotive sector, also in respect to developments towards self-driving cars. Paper #4 specifically investigates the relationship between the two from an agency perspective (see chapter 6).

The car industry is an historically stable one, where a successful model based on an individually owned car with combustion engine is deeply entrenched. As Späth et al. (2016) have pointed out, it has a remarkable capacity to withstand transition pressures. However, the industry is now shaken by the climate crisis. Accordingly, there is a widespread agreement that fundamental change is necessary. Thus, mobility is a key field in which **decarbonisation** and sustainability transitions must happen in a rapid manner (Späth et al., 2016; Pichler et al., 2021). There have been, however, discussions on how to achieve this goal and very different approaches have been brought forward. In this respect, one can differentiate between three types of change (Manderscheid, 2020):

(1) A '*Antriebswende'*, which refers to an incremental shift in the propulsion technology to minimize emissions by substituting fossil fuels. This type goes along with mainly technological novelty, e.g. in the form of hybrid technology.
(2) A '*Verkehrswende'*, that is, reducing or replacing private car traffic with other modes of transport – in particular with public or so-called active transport (walking and cycling). Car-sharing models can also play a role. Thus, this type of change is mainly concerned with a reorganisation of traffic patterns, but often depends on a certain density that is usually only found in metropolitan areas.
(3) A '*Mobilitätswende'*, which refers to a more radical and comprehensive reconsideration of our mobility system that is deeply embedded in our material, discursive and social structures. As such, the '*car hegemony*' (Haas, 2020) is not just seen as the (currently) dominating solution to meet society's mobility needs but understood as a defining feature of the social, spatiotemporal and cultural order. Hence, representatives of this approach argue for a general rethinking of underlying orientations, dynamics and constraints coming with our mobility system (Pichler et al., 2021).

Over time, decarbonisation – in many countries – has been equated with the electrification of cars (Späth et al., 2016), that is, with the least severe change in form of a '*Antriebswende'* (Manderscheid 2020). One of the reasons is that e-cars – in contrast to other solutions like a '*Verkehrswende'* – are particularly compatible with the interests of the automotive industry, as they do not challenge the prevailing car-ownership norm (Späth et al., 2016). However, regions that are strongly specialised in combustion engine technology, like the AAT, are subjected to strong path dependencies (Högelsberger & Maneka, 2020; Baumgartinger-Seiringer 2021, paper #4), making decarbonisation through electrification of the propulsion system a transformation with a high disruptive potential ('jobs vs. environment' dilemma, Pichler et al., 2021) that requires large scale asset modification processes.

Not only the increasing concerns about environmental damage caused by the automotive industry, but also the decreasing interest in car-ownership amongst younger adults, particularly in urban areas, as well as ongoing discussions on possible modal shifts towards forms of mobility that are less emission and space intensive all together (*Verkehrs- or Mobilitätswende*), have fuelled doubts about the industry's future (Schippl & Truffer, 2020). In times like these, many place high hopes in the **digitalisation** of the industry and the advent of connected and automated vehicles (C/AVs) as a new field of innovation and a way to cope with a possible downturn (Baumgartinger-Seiringer, 2021, paper #4; Trippl et al., 2021, paper #2).

Accordingly, firm-level as well as system-level actors (e.g. in universities, research institutes or intermediaries) in all three regions under investigation in this dissertation have begun to modify the regional asset base in order to move into software related domains. These rearrangement activities have started around the year 2012 and are still ongoing.

Importantly, digitalisation blurs the boundaries between industries and sectors. This can be seen, for instance, in relation to trends like 'Edutainment' (boundaries between education & entertainment), the platform economy (property and product) or the internet of things (physical and digital) (Kumaraswamy et al., 2018). This is also very much the case for the automotive industry. Accordingly, the increasing digitalisation and automation of cars has blurred boundaries between the automotive industry and other paths (such as ICT and microelectronics), having important implications for restructuring processes in all three automotive regions (see chapter 6). What is more, the transformation has also led to new linkages between automotive players on the one side, and – for instance – insurance companies, motorway operators or research organisations on the other side. As such, this upheaval is an exciting one to investigate RIS reconfigurations coming with path transformations.

To summarize, the automotive industry is generally well-suited for the interests of this thesis, as it is per definition a mature industry, has a high importance for host countries' economies and is well connected, making it an interesting case to study innovation-based restructuring processes from a systemic perspective. The three selected case study regions, Ontario, West Sweden and the AAT, share a set of commonalities. They are all part of the semi-periphery of the global automotive industry and face great pressures to redefine their competitive edge, not only because of the increasing integration of low-cost and peripheral locations that threaten to significantly decrease their market shares, but also because of changing conditions brought about by the industry's increasing decarbonisation and digitalisation. However, there is not only necessity for change but also opportunity. All three regions possess distinct assets (like historically-inherited knowledge in the active safety segment, other highly complementary paths located in the region, or high levels of innovativeness) in order to take up these challenges. Moreover, the ongoing de-verticalisation of the global automotive industry is a chance for supplier locations to jump in the value chain.

In realist terms, all these pressures and opportunities for change can be considered as important causal powers at work. However, as outlined above, the relationship between cause and effect is not of automatic regularity but depends on the conditions of the contexts in which they operate (Sayer, 2015). Accordingly, these causal powers are mediated by and have to be seen in the context of different circumstances in Ontario, West Sweden and the AAT in the form of different degrees of regional embeddedness, thickness of RIS structures, historical development patterns and distinct challenges (Table 5). Ultimately, these context conditions lead to different routes of change and outcomes, which will be further specified in the next chapter and, in particular, in the research articles.

Last but not least, it should be mentioned here that the focus on *one* industry in three regions with relatively similar context conditions can be seen as a limitation of the thesis' research

design. The automotive industry (in Ontario, West Sweden and the AAT) is characterised by certain particularities, e.g. in terms of its actor structure, geographical patterns, capital-intensity, elaboration and contemporary problems and opportunities. Hence, the results of this dissertation project have to been seen against the background of this particular industrial context and will require further context-sensitive re-theorizing in other industrial, temporal and regional settings (Gong & Hassink, 2020).

6 Findings, conclusions and outlook

After introducing the topic, aims and structure of the thesis (chapter 1), embedding it in the wider theoretical background (chapter 2), laying the groundwork by outlining the concrete branch of literature to which this work seeks to contribute to (chapter 3), developing the conceptual framework (chapter 4), and specifying the research design, the cases and their contexts (chapter 5), this final chapter will now turn to the dissertation's main findings. In doing so, it will first summarize the four constituting research articles individually. Table 6 will additionally provide an overview of the papers and pinpoint the most important information and their highlights. While such an overview has been presented already in chapter 1.2, the following summary will be more comprehensive and relate the single articles to the overall research questions of the thesis. This is followed by a conclusion, an outline of possible avenues for future research and, finally, some policy implications derived from the main findings.

6.1 Paper #1: Towards a stage model of regional industrial path transformation

The first paper of the thesis (Baumgartinger-Seiringer et al., 2021b) argues for more attention on temporal patterns of radical changes happening 'on-the-path'. The article contends that the shift from pre-transformation activities towards transformation activities (practices the deviate from those dominant in the past) is complex and long-term, and thus best understood over time and through a model that distinguishes between different successive stages. In doing so, it is inspired by previous approaches like cluster life cycles models (Menzel & Fornahl, 2010).

The paper develops a conceptual framework that consists of four key dimensions: (i) the historically inherited regional asset base, (ii) the role of local as well as non-local actors, (iii) the influence of visions and expectations (i.e. 'the future') and (iv) resulting asset modification processes brought about by firm and system-level agency. These key factors are considered suitable to capture regional industrial transformations and themselves undergo substantial changes during such processes. To unravel the unfolding of these dynamics, the paper suggests three stages of path transformation: an initiation, an acceleration and a consolidation stage.

The initiation stage is usually triggered by new possibilities or emerging pressures that challenge historically grown structures. In this early stage, actors are still predominantly concerned with established fields of action, the number of actors engaging in transformation activities is small. A reason is that expectations and visions are still ambiguous. While some pioneers are driven by their belief in new possibilities, the majority remains in an observant state due to great uncertainties. As many assets do not pre-exist for new solution, the main type of asset modification is expected to be asset creation, often based on experimentation.

Table 6: Overview of the four research articles (own elaboration)

#	Title	Highlights	Region(s)	Authors	Publication status
1	Towards a stage model of regional industrial path transformation	• Investigates the transformation of an established path and RIS rearrangement from a **processual** perspective • Develops a stage model of path transformation and distinguishes between an initiation, an acceleration and a consolidation stage • Investigates different stages with particular specificities and challenges, finds that asset modification varies between stages • Particular emphasis on the role of agency, driven by visions and expectations, i.e. 'the future' → link to Sociology of Expectations	West Sweden	**Simon Baumgartinger-Seiringer**, Johan Miörner & Michaela Trippl	Published in *'Industry & Innovation'* (2021)
2	Automotive regions in transition: Preparing for connected and automated vehicles	• Investigates the transformation of established paths and RIS rearrangement & and their **outcomes** from a **comparative** perspective between two regions • Highlights the role of broadly defined regional preconditions as platforms for asset modification processes brought about by agency • Contrasts a 'reorientation route' (found in the AAT) with an 'upgrading route' (found in Ontario)	Austrian automotive triangle, Ontario (Canada)	Michaela Trippl, **Simon Baumgartinger-Seiringer**, Elena Goracinova, David A Wolfe	Published in *'Environment and Planning A: Economy and Space'* (2021)
3	Reconsidering structural conditions for industrial renewal	• Investigates the renewal of industries from a **structural** perspective • Seeks to move beyond the enabling/constraining dichotomy prevailing in the field in relation to structural preconditions • Draws on the concept of 'institutional infrastructure' and adopts its view that the elaboration and coherence of structural elements are key • Conceptualises potentials for and constrains to regional industrial change processes in each structural configuration	Austrian automotive triangle, West Sweden	**Simon Baumgartinger-Seiringer**, Lea Fuenfschilling, Johan Miörner, Michaela Trippl	Published in *'Regional Studies'* (2021)
4	The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency	• Emphasises the role of powerful incumbent firms in the transformation of an existing path and RIS rearrangement → **actor** perspective • Inspired by Management and Transition Studies, it is highlighted that incumbents engage in both, change and maintenance agency • Places attention on how they leverage distinct channels of power to either stabilize or reconfigure the surrounding RIS in their favour • Unravels how incumbents in the AAT have driven digitalisation and mitigated decarbonisation over the period of 2012-2019	Austrian automotive triangle	**Simon Baumgartinger-Seiringer**	Submitted to an international peer-reviewed journal, currently *'under review'* (2021)

The acceleration stage is characterised by a strong intensification of transformation activities. However, many assets are still oriented towards pre-transformation activities. As a result, this stage is characterised by a co-existence of old and new. A growing number of actors – both at the firm and the system-level – are reorienting their activities, often drawing on advancements made by early pioneers. While expectations and visions are still ambiguous and sometimes conflictual, the acceleration stage comes with a growing recognition of potentials entailed in new ways of doing things. Consequently, many seek to unlock and redeploy existing assets towards transformation activities.

In the final stage, the consolidation stage, transformation activities are largely replacing pre-transformation activities. This is also reflected in a critical mass of actors shifting from old to new. Visions and expectations are re-consolidating. While asset creation and redeployment still matter, asset destruction, that is, the removal of constraining structures no longer needed, becomes crucial.

In sum, the three stages come with quite specific characteristics, but also challenges. Early on, actors are often confronted with a highly aligned system, meaning that they often have to work around institutionalised logics. Once a transformation has gained momentum, challenges are connected to the competition over scarce assets or growing requirements of transformation activities old structures cannot meet. In the final stage, when asset destruction becomes predominant, difficulties might arise as abandoning old structures is often controversial, connected to vested interest and sunk costs.

Empirically, the stage model is applied to the current transformation of West Sweden's automotive path towards a more digitalised industry and the development of self-driving cars. The empirical investigation largely confirms the conceptual arguments, but reveals some interesting deviations. For instance, as West Sweden has traditionally strong competencies in the active safety segment, suitable assets to build upon were already present in the region, making asset creation less important in the initiation stage than assumed. Moreover, as the transformation is still ongoing, large scale asset destruction processes are yet to be observed. A key empirical insight of the article is connected to inter-path relationships between the automotive and the ICT industry located in West Sweden. The growing need for software specialists in the former has not only led to opportunities for collaboration, but also to competition over scarce resources (skilled labour, funding). As such, path interdependencies have intensified throughout the unfolding of path transformations and were partly positive and partly negative in nature.

Theoretically, one main contribution of the article is to investigate visions and expectations and their role in the engagement of actors in firm-level and system-level agency. In this respect, the paper draws on a link forged by Steen (2016) between EEG and the Sociology of Expectations (Borup et al., 2006). In doing so, the paper complements the strong emphasis in EEG models on how the past influences path development processes by incorporating 'the future' (Hassink et al., 2019). Thereby, the generative power of visions is confirmed and the role of system-level agency in developing joint expectations highlighted.

Moreover, the paper offers important insights in light of recent discussions on change and maintenance agency (see chapter 2.4.3), as it adds a more positive understanding of maintenance agency, arguing that there is the need for agentic activities geared towards consolidating change. From this perspective, maintenance or reproductive agency are not necessarily hindering but can play an important role in stabilizing new path development processes (see also Bækkelund, 2021).

All in all, the first article of the dissertation investigates innovation-based restructuring processes in mature paths and the wider RIS they are embedded in from a **processual** perspective. It is mainly concerned with understanding how such transformations unfold over time. In that way, the first paper contributions strongly to answering RQ1[17] and RQ3. It also holds some insights in respect to the role of incumbents (temporal patterns of their engagement in transformations, their barriers to becoming early movers, vested interests and asset destruction) and more comprehensive views on structural conditions (role of other paths in the region, incorporation of a broad asset base) but is rather loosely connected to RQ2 (Figure 3).

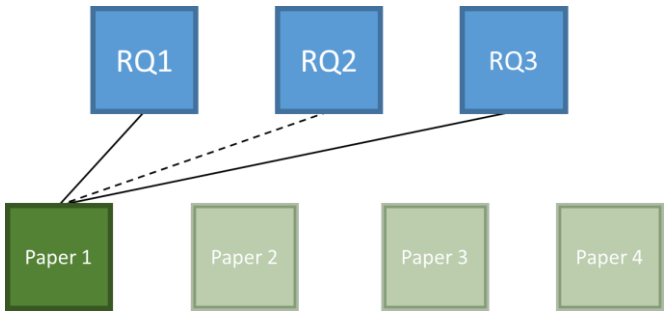

Figure 3: Paper #1 and its connection to the RQs (own elaboration)

6.2 Paper #2: Automotive regions in transition: Preparing for C/AVs

The second paper of this dissertation project (Trippl et al., 2021) departs from the question how regions cope with radical and potentially path-breaking innovations. It seeks to investigate, both conceptually and empirically, how automotive regions respond to current pressures for transformations and reinvent themselves in light of the increasing digitalisation of the industry and the goal of developing connected and automated vehicles (C/AVs).

In the article, a conceptual framework is developed that emphasises the need to understand innovation-based regional restructuring in a comprehensive way. Accordingly, the role of

[17] **RQ1**: *How do radical, innovation-based change processes in mature industries relate to (developments in) other elements of their surrounding RIS, that is, other actors, other industries, organisational support structures and institutional set-ups?*

RQ2: *What are the enabling and constraining influences of regional structural conditions and incumbencies in processes of path transformation and how to unravel and conceptualize the ambivalence inherent in them?*

RQ3: *What are the characteristics and key features of different development stages, routes and outcomes of path transformation and RIS rearrangement?*

multiple (non-) local actors (firms and innovation system actors), other paths in the region, support organisations and institutional set-ups is highlighted. In a similar manner to the first paper, the concept of asset modification brought about by firm-level and system-level agency is employed. Moreover, the paper stresses the various forms in which new path development might unfold, ranging from renewal and diversification to path creation (see chapter 2.3).

With all that in mind, the article investigates how radical change processes in mature paths and in the wider regional structures unfold in comparison between regions, based on different initial regional preconditions in the form of the industry mix, the innovation capabilities of organisations in the RIS, the way in which regions are embedded in GPNs and the degree of alignment between the focal path and the RIS. All of which are seen as providing a broadly defined platform for distinct routes of transformation, underpinned by asset modification processes. More concretely, the article contrasts a 'reorientation route' and an 'upgrading route'.

The former is expected to be taken in regions with a well elaborated and aligned system, driven by incumbent firms that seek to reorient through renewal activities and complemented by diversification activities originating from other regional industrial paths. This is accompanied by major modifications in the wider system. Adherence to historically developed assets and strong ties between different players might substantially hamper these change processes.

The latter is expected to be taken in regions with weaker innovation capacities and a focal path exhibiting a lower degree of embeddedness in the RIS. In such settings, potential for renewal is limited. However, as mentioned before, radical innovation might open windows of opportunities and reveal new regional potential, e.g. in the form of untapped assets or other regional paths. Yet, in order to exploit these assets, efforts geared towards upgrading of and alignment between system elements are necessary. Key activities might be diversification endeavours of firms in complementary paths.

Empirically, Ontario and the AAT are compared, which share similar problems due to their semi-peripheral position in global automotive production networks (see chapter 5.4), but differ substantially in their structural preconditions for change. As such, the reorientation route is found in the AAT, where an innovative automotive sector engages in path transformation processes, while the microelectronics industry located in the region is increasingly diversifying into the automotive space. In addition, a well-aligned RIS is substantially rearranged to cope with the challenges coming with C/AVs. That is, one can observe a de-locking and re-aligning of a highly elaborated system through substantial asset modification. In contrast, Ontario follows an upgrading route. Historically low levels of innovation capacities in the automotive path and a low degree of embeddedness in the RIS provide a weak platform for renewal. However, Ontario hosts a vibrant ICT path, that is both, increasingly recognizing its potential (diversifications) but also increasingly being recognised by other players in light of the advent of C/AVs, in particular by foreign automotive OEMs. Accordingly, asset modification is oriented towards further developing and aligning a rather fragmented system to tap into this

new regional potential. As such, one can observe an upgrading of the automotive path and surrounding support structures (e.g. in universities).

All in all, the second paper offers a **comparative** perspective on innovation-based transformation processes in mature paths and the wider RIS they are embedded in (RQ1). It is mainly concerned with how such processes unfold between different regions (RQ2) that share a set of commonalities, but also theoretically-relevant variations (in the form of broadly defined preconditions). It has shown how the same cause (the advent of C/AVs) has led to substantially different **outcomes** in different contexts. It offers theoretically-informed explanations for these variations. Moreover, the paper underlines the importance of path interdependencies. Regional potential and the resulting asset modification processes in the two case studies can only be comprehensively understood when incorporating other regional paths in the analysis, namely the microelectronics and the ICT path. The paper is therefore mainly connected to RQ1 and RQ3, but again provides insights also for RQ2 in the sense that it highlights the role of broadly defined preconditions (Figure 4).

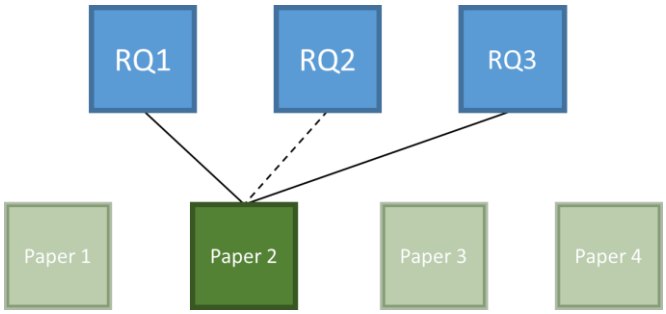

Figure 4: Paper #2 and its connection to the RQs (own elaboration)

6.3 Paper #3: Reconsidering structural conditions for industrial renewal

The third paper (Baumgartinger-Seiringer et al., 2021a) argues for more wisdom when discussing regional structural preconditions for industrial change processes. It departs from the problematisation that conventional perspectives, both in narrow EEG conceptualisations but also in more comprehensive approaches, offer rather simplistic takes on potentials and constraints inherent in regional structures. Accordingly, most of these contributions imply that once certain conditions are provided, particular types of development will likely occur (e.g. regions with a high level of average relatedness of industrial capabilities will likely diversify into new related fields or regions with a thin RIS will likely lack the capacity to bring forth entirely new paths). As such, they often portray structural preconditions as either per se enabling or constraining for certain forms of industrial development.

In an attempt to overcome this limitation, the article turns to Institutional Theory, the literature in Organisational Institutionalism and, more precisely, to the concept of institutional infrastructures (IIS). Generally, Institutional Theory has a long tradition in studying and unravelling field-level change, whereas industries can be considered as prime examples for fields (Wooten & Hoffman, 2008). Hence, this literature can be seen as complementary to the regional path development literature, not least because research in Institutional Theory has

shown that fields differ in their capacity to change and innovate. A concept brought forward to explain such differences is the notion of IIS, which has been used to define and typologize field conditions based on the set of relevant structural elements that prevail in a field (Hinings et al., 2017). The concept casts light on those elements that are deemed instrumental for creating, maintaining or disrupting institutions. Among such elements are, for instance, collective interest organisations, regulatory bodies, educational programs and so on.

However, not only does the concept define relevant structural elements, but it assesses how they work in concert by casting light on two decisive properties, namely the degree of elaboration and coherence of the prevailing elements. The degree of elaboration refers to how many elements are present in a field and how well-developed and institutionalised they are. In contrast, the degree of coherence indicates whether the elements are reinforcing or competing with each other. Different degrees of elaboration and coherence come with different potentials for and constraints to field-level change (Hinings et al., 2017; Zietsma et al., 2017).

The article argues that this theoretical lens offers highly valuable tools to move beyond simplistic takes on structural conditions in the study of innovation-based new path development processes. To begin with, it is helpful to specify the *relevant* structural preconditions. As such, an analysis based on the concept of IIS differs from the RIS concept insofar as the latter, at least in principle[18], incorporates RIS elements of the entire region, whereas the former defines the set of relevant structural elements for a particular industry. Moreover, the degree of elaboration and coherence of these structural elements can help to make more nuanced statements about potentials and constraints inherent in structures.

Accordingly, a high level of elaboration implies that a large number of elements are in place (resembling the notion of thickness, Zukauskaite et al., 2017). This can be beneficial for innovation-based change as these elements can be used as a platform for change. However, it also implies that many elements have to change, meaning that highly elaborated structures might be rather resistant to alterations. In contrast, low levels of elaboration indicate a poor endowment of structural elements (thinness). While this might be constraining (no platform), it can also allow for a certain leeway, autonomy and flexibility for the creation of novelty.

Similarly, the degree of coherence can be high (‘unitary’) or low (‘competing’). While in case of the former, change will likely be agreed on, it is difficult to set in motion in the first place. In case of the latter, change might be stimulated based on high levels of autonomy, however, low coherence often comes with fragmentation and conflict, and might thus be paralyzing.

Following these considerations, it is possible to categorize regional industries and their structural configurations based on their degree of elaboration and coherence (established, contested, aligned, fragmented). Drawing on the concept of IIS, work in the field of organisational institutionalism and insights from the wider field of regional path development

[18] However, one could argue that many empirical analyses based on the RIS concept are also characterised by a focus on structures for a particular industry only.

research, the article highlights and specifies different potentials for and constraints to innovation-based change in each of the categories (Table 7).

Table 7: Degrees of elaboration & coherence: Implications for change

	Unitary (high coherence)	**Competing (low coherence)**
High elaboration	*Established* + structure for change; agreement on objectives - hard to set change in motion	*Contested* + structure for change; likelihood for change - conflict is likely
Low elaboration	*Aligned* + leeway and opportunity, change is likely to be agreed on - long way to go, missing stability	*Fragmented* + extensive room for change - require both 'construction & persuasive work'

Source: Baumgartinger-Seiringer et al., 2021a, p. 7

Moreover, the article also investigates what impact these different structural configurations have on agentic processes (Zietsma et al., 2017). In doing so, it again draws on the useful distinction made between change and maintenance agency (Jolly et al., 2020). Accordingly, in established structural conditions, for instance, maintenance agency might be privileged as it is in line with the strongly institutionalised ways of doing things, whereas change agency is seen as rather contradictory to them.

Empirically, the article compares path transformations in the AAT and West Sweden and their development towards C/AVs. While the former is characterised by a distinct *established* structural configuration, the latter can be characterised as *contested*. Accordingly, both regional industries exhibit well-elaborated automotive structures, yet they differ in respect to the degree of coherence, which was lower in Sweden. The empirical analysis has shown that the high elaboration in both regions hampered the initiation of change, which was seen as inconsistent. However, the lower levels of coherence in West Sweden allowed for more experimentation and change agency early on. In the AAT's highly coherent structures, change is now, after a slow start, unfolding quickly. Moreover, the investigation has shown that the unfolding of change differs in both regions. While structures in the AAT have become even more coherent due to the transformation, West Sweden's automotive structures are losing their strong focus.

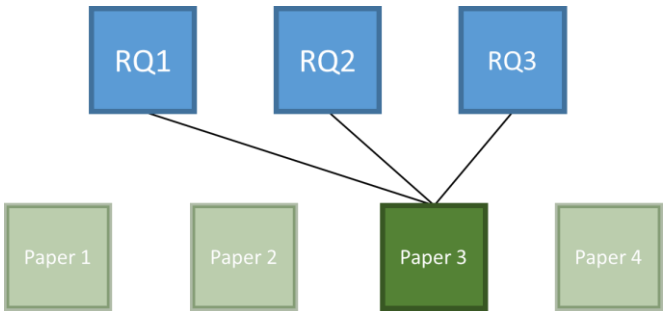

Figure 5: Paper #3 and its connection to the RQs (own elaboration)

All in all, the third article offers a **structural** perspective on transformation processes in mature industries and change in the wider regional structures (RQ1). It is mainly concerned with how such processes unfold based on the structural preconditions in which they are embedded in. In doing so, the paper seeks to move beyond the enabling/constraining dichotomy prevailing in

conventional perspectives and offers a novel understanding of potentials for and constrains to regional industrial change processes in different structural configurations (RQ2). Moreover, it provides insights into how current transformations unfold comparatively in different automotive regions (RQ3). It is therefore concerned with all three RQs (Figure 5).

6.4 Paper #4: The role of powerful incumbent firms: shaping PD through change and maintenance agency

The dissertation's final paper (Baumgartinger-Seiringer, 2021) advocates for more comprehensive perspectives on relevant actors and different types of agency in new path development. It problematises that the current interest in the rise of entirely new paths has come with a rather one-sided focus on change agency. Only recently, scholars have complemented this view with work on the role of maintenance agency (see chapter 2.4.3). It is argued that the emphasis put on change agency does not only obscure the wider range of agentic practices in new path development, but also limits our understanding of the role of different actors, as it highlights mainly those that bring novelty to the region.

An actor group that has often been neglected and received limited attention are incumbent firms. This can be seen as particularly problematic when it comes to exploring radical change processes in well-established paths and the wider RIS they are embedded in. Mature paths are often characterised by a particular actor constellation and the presence of incumbent firms, that is, often large and powerful actors centrally positioned with vested interests. The conventional wisdom in the path development research fields understands them as actors that tend to strengthen existing paths, that is, they are usually invested in maintenance activities leading to path extension. And indeed, there is quite some conceptual and empirical evidence for this behaviour, for instance in Management or Transition Studies.

However, recent discussions in these strands of literature have also shown that incumbents are more dynamic than often assumed and not only resist change, but sometimes (simultaneously) embrace and exploit new opportunities (Turnheim & Sovacool, 2020). In other words, incumbent firms are both, actors of change and maintenance. Drawing on these recent insights, this article's aim is to advance perspectives on incumbents in path transformation. This ambition opens up a variety of questions, ranging from who to when and beyond. This paper focuses mainly on how incumbents exert influence to drive or hinder regional industrial change. In doing so, it casts particular attention on incumbent firms' interventions to reconfigure or stabilize their surrounding RIS to support their intentions. In other words, emphasis is placed on their system-level agency, which can be both, oriented towards change and/or maintenance.

In order to unravel these questions, the article understands incumbents as actors who hold a particular position in RISs. They are often deeply embedded and well-connected to other RIS elements due to their engagement in (numerous) previous rounds of economic development and, as such, seen as particularly effective in modifying the regional asset base. Based on this

fundamental assumption, the article then conceptualises how incumbent firms leverage their superior structural position through various channels of power. In doing so, it – again – draws on insights from Transition Studies.

A key contribution in this field is Geels' (2014) work on different forms of power used to mitigate and resist transitions. Accordingly, incumbents hold instrumental, discursive, material and institutional power to do so. However, following more recent perspectives, paper #4 argues that these very channels cannot only be used for resistance, but also for change agency. In other words, the article develops a conceptual framework that unravels how incumbent firms exert influence based on various forms of power used to promote or stall regional industrial change by either reconfiguring or stabilizing their surrounding RIS. In essence, the paper argues that the regional presence of incumbencies is an important and context-specific cause for (the lack of) change.

Empirically, the framework is applied to the role of incumbent firms in transformations in the AAT. It is revealed how they've leveraged their power to actively drive the path's digitalisation and resist its decarbonisation over the period of 2012 to 2019. That is, they engaged in change and maintenance agency simultaneously and thereby contributed strongly to steering path transformations and RIS reconfiguration/stabilisation in the AAT.

All in all, the fourth paper of the dissertation investigates innovation-based restructuring processes in mature paths and the wider RIS they are embedded in from an **actor-based** perspective (RQ1). It is mainly concerned with how the direction and pace of such transformations are influenced by large and powerful incumbent firms. To overcome the rather simplistic views on their role in the regional path development literature, the article draws on insights from Management and, in particular, from Transition Studies (RQ2). Moreover, it provides several insights into how transformations in mature paths unfold over time based on changing strategies of incumbent firms (loosely connected to RQ3, Figure 6).

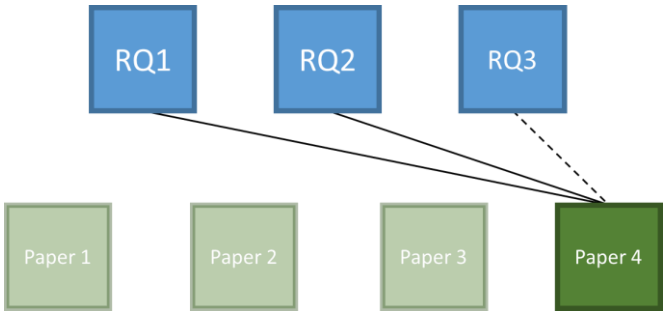

Figure 6: Paper #4 and its connection to the RQs (own elaboration)

6.5 Conclusion

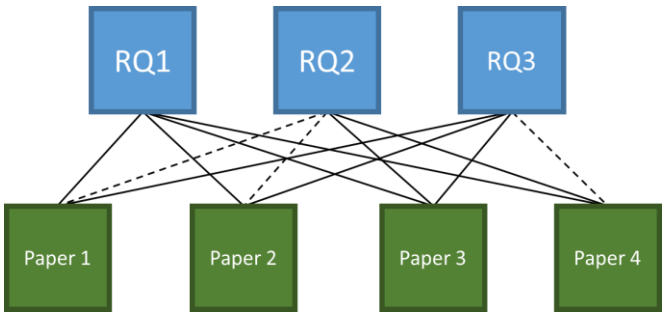

Figure 7: All papers & their connection to the RQs (own elaboration)

This dissertation project has contributed to the broader debate on innovation-based regional restructuring, which was grasped through the evolutionary concept of 'new path development', referring to the rise of entirely new paths or the substantial alteration of established ones. Here, a distinct focus has been put on the latter, that is, on episodes of radical innovation processes happening 'on-the-path' in mature industries. Thereby, this thesis has sought to overcome the rather one-sided focus on the creation of entirely new paths in the recent debate. From a systemic perspective, the dissertation has explored how such on-path-changes are related to the rearrangement of elements in the wider surrounding RIS, in which these paths are embedded in (RQ1). It has examined how to uncover ambivalences and grey-scales in the role of structural preconditions and incumbencies in the transformation of mature paths (RQ2). Finally, it has investigated how these processes unfold over time and comparatively between regions (RQ3). Each of the four research articles constituting this dissertation has developed a different angle on the subject. Therefore, the emphasis put on the various RQs differs from article to article. Yet, each of them is connected to all RQs (Figure 7).

In essence, the thesis includes a processual, a comparative, a structural and an actor-based perspective on innovation-based transformation processes in well-established industries, making the papers coherent due to their shared focus and complementary due to their different angles on the subject.

Importantly, each article has cast light on and provided insights in connection to one of four fundamental building blocks of the conceptual framework of this thesis (structures, actors, process, outcome). Combining these different angles, this dissertation argues for a reconsideration of new path development with a distinct focus on path transformations from a RIS-informed systemic view by providing more nuanced perspectives on each of the four key dimensions. Thereby, this thesis contributes more broadly to current debates in the field. Figure 8 – based on a schematic depiction of the conceptual framework and its four building blocks (Figure 1, explained in chapter 4.1) – summarises the key advancements made.

Accordingly, the thesis, first, makes a strong case for **getting structural conditions right**. It was highlighted here that the unfolding of path transformation is strongly conditioned by broadly defined and historically-inherited regional structures. Indeed, pre-existing regional organisational and institutional structural endowments play a critical role. Hence, from a comprehensive perspective it is vital to include other regional paths, the wider regional support structures (in the form of support organisations, intermediaries, universities, and so on) and the

regional institutional set-up in the analyses of regional industrial change. What is more, extra-regional asset sourcing is an important mechanism underlying new path development (Binz et al., 2016). This dissertation has clearly demonstrated all that. However, it has also been shown that implications of structural conditions are more complex than the 'enabling vs. constraining dichotomy' predominant in many conceptual frameworks. Instead, it was argued here that a reassessment of structural influences is necessary. By drawing on insights from Institutional Theory, the dissertation made the case for considering the elaboration and coherence as decisive features of relevant structural elements instead of focusing generally on the presence of regional industrial/economic capabilities or the degree of thickness and specialisation of the whole RIS (paper #3). Thereby, it is possible to pinpoint the distinct positive and negative dimensions inherited in structural conditions in a more nuanced way (Table 7). As such, this dissertation argues that structures matter, but in a less deterministic way than often assumed in the extant literature. The thesis then followed recent contributions and conceptualised these broadly defined regional structures as platforms for change processes (Martin, 2010; MacKinnon et al., 2019a).

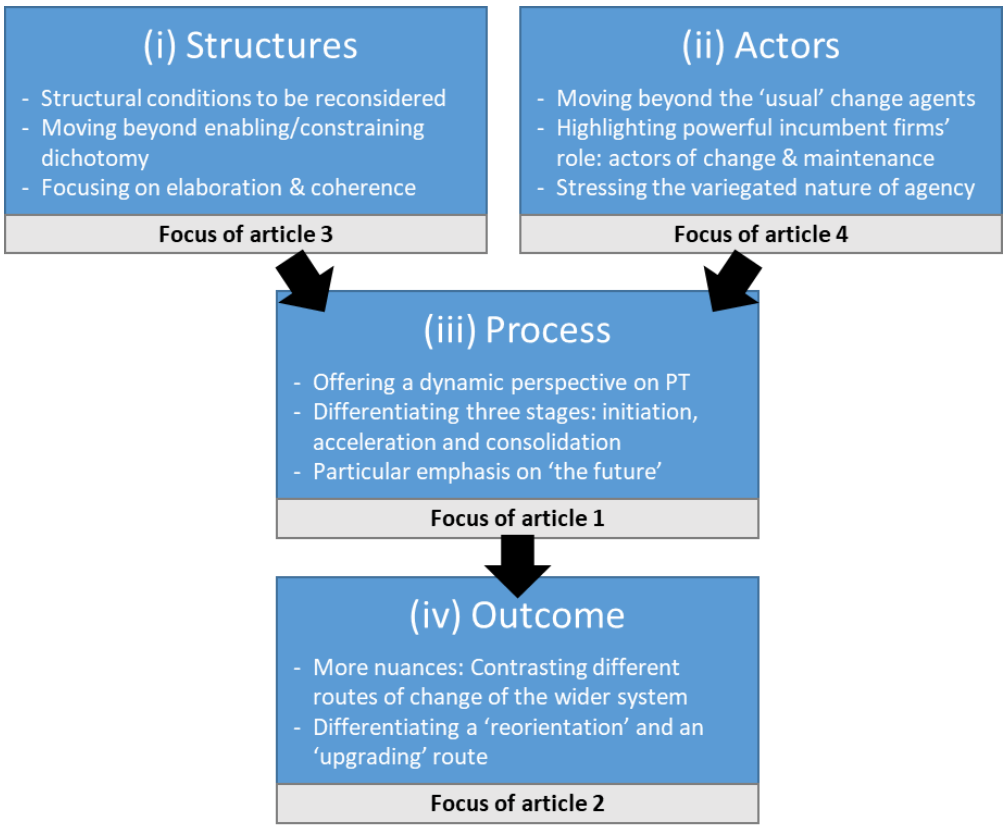

Figure 8: Schematic depiction of the conceptual framework and key advancements made by this dissertation project (own elaboration)

Second, the thesis argues for **reconsidering the circle of relevant agents and types of agency** in analyses of path transformation. Accordingly, while structures matter, their mere existence is insufficient to explain the transformation of industrial development paths. Instead, multiple (local & non-local) actors must identify, modify, harness and valorise potentials entailed in

structural conditions through agency for a transformation to unfold (MacKinnon et al., 2019a; Trippl et al., 2020; see also chapter 2.4.3). Departing from this fundamental and established understanding, several advancements have been made in this thesis in the context of actors and their agency. To begin with, this dissertation project has cast light on incumbent firms, actors who have received limited attention in the debate on new path development but who are highly important (particularly in the context of path transformation). Paper #4 has demonstrated how they steer the direction and pace of (new) regional path development through their engagement in firm-level as well as system-level agency that both can be oriented towards either change or maintenance. Thus, this thesis makes a strong case for combining the notion of firm-level and system-level agency with the concept of change and maintenance agency. While the former is mainly concerned with their field of influence (restricted to a firm/organisation or geared towards adaptations of the wider RIS), the latter generally distinguishes agentic practices based on their fundamental goal (change/maintenance). As such, these two conceptualisations of agency are arguably highly complementary. Moreover, types of agency oriented towards the acceleration and consolidation of change have been investigated (paper #1). The latter can be seen as a more positive form of reproductive agency (Bækkelund, 2021). Accordingly, while maintenance agency (as a negative form of reproductive agency) is geared towards suppressing change, agency oriented towards consolidation seeks to stabilize and institutionalize new ways of doing things. In essence, these contributions help to deepen our understanding of the variegated picture of agency that drives new path development in general and path transformations in particular.

Third, the thesis has further **unravelled the process of path transformation**. In exploring the temporal patterns of innovation-based regional industrial change and the accompanying reconfiguration of the RIS, this dissertation has argued for a processual perspective and developed a stage model. In doing so, it was elucidated how change processes not only require initiation, but also acceleration and consolidation. As such, the interplay between structures and agency underlying path transformation is best understood as dynamic. It is contingent on broadly defined preconditions, which are subject to evolution as actors constantly work on those structures. Accordingly, as the initial 'structural platform' differs (in different spatiotemporal contexts) and evolves, so does the agency that is required to drive the unfolding of path transformation. Hence, it was shown how different modes of change are the predominant form in different stages of change. Moreover, the role of the future in driving this iterative process has been further explored (paper #1) by drawing on insights in Sociology of Expectations (Borup et al., 2006), which have been brought to work on regional path development before (Steen, 2016). It was confirmed that 'the future' is indeed a driving force for actors, thus a crucial factor for understanding their engagement in transformative activities and an important complement to the predominant focus in EEG on 'the past' (Hassink et al., 2019). Therefore, as visions and expectations themselves are subject to development throughout the process of path transformation, they are an important explanatory variable in explaining its unfolding.

Fourth and finally, this dissertation has explored **the outcome of processes underlying path transformation**. While established perspectives offer little nuances and consider the process (often implicitly) to either result in a new/transformed path or not, this dissertation has also

incorporated development outcomes in the wider RIS accompanying successful processes of path transformation. In doing so, it has contrasted how this process has ultimately resulted in the upgrading of a regional automotive system in one spatiotemporal context, and to the reorientation in another. Hence, the thesis has investigated where – based on varying structural preconditions, different types of agency and underlying mechanisms – path transformation might lead. However, this is not to say that a conceptual framework based on this dissertation would argue that reorientation or upgrading are the only possible outcomes. On the contrary, it would be intriguing to explore different spatiotemporal contexts and find alternative outcomes. In particular, it would it be interesting to study cases of unsuccessful efforts and failed attempts and learn more about the barriers to change.

The applicability of this revised view on new path development (importantly, also beyond path transformation) has been demonstrated by a recent article investigating new path emergence in unlikely places (Baumgartinger-Seiringer et al., 2022, co-authored by the author of this thesis). This paper examined how a wine industry (new to the region) developed *ex nihilo* in Quebec, Canada. Accordingly, this new path had no obvious relationship to historical conditions, to pre-existing regional, institutional, or technological capabilities nor to favourable natural conditions and yet, over the past forty years, it emerged and developed into a fully established, legitimised and supported path. While established perspectives would probably have difficulties explaining such a phenomenon, a conceptual framework drawing on key ideas proposed in this dissertation could do so. The article (Baumgartinger-Seiringer et al., 2022), first, builds on a reconsideration of structural conditions beyond the conventional wisdom. However, as outlined above, structural conditions alone are insufficient to explain the how, where, why and when paths develop in regions. Accordingly, the paper, second, follows recent advancements in the regional path development literature and contends that structural influences are inseparably linked to the role of agency. Drawing on the processual view presented here, the article proposes a dynamic, multi-actor view on agency, distinguishes between an initiation and a consolidation phase. It elucidates how entrepreneurial pioneers planted the seeds in the former and how actors who institutionalize and consolidate change turn those seeds into a fully established paths in the latter by rearranging the surrounding RIS (developing a knowledge base, coordination efforts, market formation, support structures and so on). Thus, this new article demonstrates the value of conceptual arguments developed in this thesis and their trans-contextual relevance.

Importantly, many proposed advancements in this dissertation draw fundamentally on insights from other strands of literature like Relational Sociology (Emirbayer & Mische, 1998), Sociology of Expectations (Borup et al., 2006; Steen, 2016), Transition Studies (Geels, 2002; Geels, 2014; Turnheim & Sovacool, 2020), Management Studies (Kumaraswamy et al., 2018; Patala et al., 2019) and Organisational Institutionalism (Hinings et al., 2017; Zietsma et al., 2017). These insights have been instrumental in casting light on blind-spots, filling certain gaps and thereby contribute to a more comprehensive picture. Thus, this dissertation project has made a strong case for the explanatory power that rests in the dialog between different theoretical perspectives (beyond the sphere of Economic Geography).

Hence, combining different theoretical standpoints comes with great potential value. As Cairney (2013) points out, theoretical integration may offer new perspectives from different angles, the opportunity to advance our knowledge, and might give rise to new exciting research agendas[19]. In a similar vein, Shaw et al. (2018, p.4) argue that '*scholars may well find insights, solutions, and "New Ways of Seeing" by borrowing, juxtaposing, and merging outside perspectives*' with theory that exists already within a field. However, there are also particular difficulties. These revolve around different understandings of the world (ontological question), different perspectives on how we can attain knowledge about it (epistemological question) or the use of key terms within different intellectual traditions (e.g. 'evolution' as a key term in natural science used for a good metaphor in the social sciences) (Cairney, 2013). In order to address these problems, as Shaw et al. (2018) argue, it is important to be mindful of two important caveats. First, researchers must make sure that there is a certain degree of 'compatibility' in key dimensions such as epistemology. Combining theories with fundamentally incompatible assumptions on these dimensions will be problematic, if not impossible. Second, 'communication clarity' is important. Accordingly, scholars should carefully trace and compare definitions, concepts and labels before attempting to integrate the overarching theories containing them. In this respect, not only points of congruence but also of divergence can help to derive new insights that have been eluding a field of research (e.g. where are the differences in the understanding of 'institutions' and what can we learn from those?) (Shaw et al., 2018).

Finally, this dissertation project has not only contributed on a conceptual level, but also on an empirical one. It has investigated and compared three automotive regions in Austria, Canada and Sweden, which currently find themselves in processes of radical change in light of increasing digitalisation and decarbonisation. The AAT, West Sweden and Ontario are all part of the so-called semi-periphery of the global automotive industry and, as such, in search of new competitive advantages in the context of rearrangements of the spatial division of labour in GPNs. Despite interesting similarities, this thesis has shown that all three regions share decisive differences from a systemic perspective (Table 5), which are, on the one hand, crucial to unravel the context specific unfolding of transformations, however, on the other hand, difficult to capture quantitatively. Thus, this thesis advocates for more qualitative methods in this field of research in order to come to grips with the processes and causalities of industry emergence and transformation (Dawley, 2014; Hassink et al., 2019).

All in all, this dissertation has contributed to a better understanding of the *how*, *where*, *why* and *when* of new path development (with a distinct focus on path transformation) and, thereby, added a small piece to the larger mosaic of innovation-based regional restructuring.

[19] Arguably, theoretical combinations are particularly important in the highly pluralistic discipline of Human Geography, which often makes use of 'hybrid theories' (Weichhart, 2009).

6.6 Avenues for future research

The findings of the four research articles and the overarching results of this dissertation point towards a number of avenues for future research, which stand at the centre of this chapter.

This dissertation has brought forward the argument that regional industrial path transformations are best grasped through a systemic perspective on its four underlying key dimensions. Accordingly, success or failure depends on a wider system and its enabling and constraining influence. This perspective opens up an avenue with several starting points for future research on path transformations, both conceptually and empirically.

To begin with, the multi-scalarity underlying path transformations and RIS reconfiguration deserves more attention. This thesis has clearly demonstrated the value of conceptualizing regional industrial change as unfolding in open systems (Asheim et al., 2019), but investigating the role of multi-scalar interplays *in detail* was beyond the scope of this work. From a Global Innovation Systems perspective, ISs at various spatial scales can be seen as subsystems in a wider multi-scalar arrangement of interacting ISs (Binz & Truffer, 2017; Rohe, 2020). Similarly, in their work on regional configurations of TIS, Rohe and Mattes (2022, p. 61) emphasise '*arrangements in which TIS structures - organizations and institutions with a specific technology focus – overlap with regional innovation systems. Such overlaps might create place-specific dynamics that impact both innovation systems*'. Yet, research on the ways in which territorially embedded transformation processes on the one hand relate to supra-regional sectoral and technological dynamics on the other hand is still in its infancy (Heiberg & Truffer, 2021). Such interdependencies require further examination. Departing from this dissertation's perspectives, one could explore how different structural conditions (Established, Contested, Aligned, Fragmented; see Table 7) and actor constellation (e.g. dominance of incumbents or newcomers) or stages of development (initiation, acceleration, consolidation) in a particular sub-systemic regional context affect various interdependencies with other systems at the regional, national and global level, such as multi-scalar coupling processes, resource flows and synergies (Heiberg & Truffer, 2021).

In the context of the automotive industry, future studies should investigate path transformation in non-semi-peripheral regions. While the present thesis has provided insights into how radical change unfolds in this intermediate type of automotive locations in GPNs, it would be intriguing to find out more about how core and peripheral regions respond to current disruptions in comparison. They come with decisively different RIS properties in the form of structural conditions (e.g. in relation to knowledge and institutional endowments, product complexity, support organisations or embeddedness in global innovation networks) and actor constellations (e.g. in relation to foreign ownership, the number of global players with domestic headquarters or branch plants). As such, based on the conceptual framework proposed here, it can be anticipated that transformation pressures are translated profoundly differently into these place-specific settings, expectedly leading to different processes and ultimately to other outcomes in the regional automotive systems (Pavlínek, 2022).

However, as outlined before, this thesis' strong focus on one industry only, an industry with a number of specificities (e.g. actor structure, geographical patterns, capital-intensity, contemporary problems and opportunities), can be seen as a shortcoming. From a critical realist view of the world, theory is a process and theory development is an ongoing process (Sayer, 2000). Accordingly, it would be equally or even more interesting to reapply the theoretical findings on path transformations to other contexts than an automotive one (such as other mature regional industries, spatiotemporal settings). Hence, future research should aim at further re-theorizing the insights gained through this dissertation project in a context-sensitive way (Gong & Hassink, 2020). Thereby, one could test and polish the results provided here through further feedback to theory.

Furthermore, future research should be related to the relationship between different disruptions. Accordingly, another avenue for future research, presented on the basis of this dissertation, is concerned with interdependencies of disruptions and their role in shaping regional restructuring. While most empirical attention here was devoted to innovation-based transformations brought about by the increasing digitalisation of the automotive industry, it became clear that these alterations have to be seen against the backdrop of climate change and (the lack of) efforts to decarbonize the industry. Paper #4 has more explicitly dealt with the relationship between digitalisation and decarbonisation and found that the AAT was not conducive to development per se in the period of investigation but favoured digitalisation over decarbonisation. The reason is – as was argued in the paper – that digitalisation is less disruptive in relative terms and more compatible with the automotive system's regional set-up (Baumgartinger-Seiringer, 2021). In doing so, the article confirmed that change processes are selectively chosen based on RIS characteristics (Miörner, 2020). In addition, it was shown that the two upheavals both reinforced (e.g. legitimizing digitalisation with growing sustainability concerns) and hindered (assets allocated to one cannot be used for the other) each other (Baumgartinger-Seiringer, 2021). Accordingly, future work should explore more thoroughly the complex interdependencies between disruptions[20]. What (additional) factors determine the prioritisation of responses to different upheavals? What is the role of firm-level and system-level agency in this respect? How can we move beyond a hitherto often neutral or indifferent stance towards innovation? In respect to the latter question, the recent introduction of 'challenge-oriented RISs' by Tödtling et al. (2021) is a promising step towards incorporating a more critical view of innovation and the directionality of change processes into the debate.

In addition, it would be exciting do learn more about the variegated nature of path transformation in relation to different *types* of upheavals. While disruptions are by definition radical forms of change, they come in different shapes (e.g. in relation to their temporal range or underlying cause). In this respect, linking insights from this thesis to research on regional industrial resilience and its focus on the role of shocks (slow burn vs. sudden crises) in shaping regional industrial development paths (Martin & Sunley, 2015) would be a logical next step. Another source of inspiration might be found in the Entrepreneurship literature, which

[20] A similar call has recently been formulated in Transition Studies, arguing that the relationship between digitalisation and sustainability transition is of high importance but surprisingly poorly understood (Andersen et al., 2021).

distinguishes between necessity and opportunity driven change (Reynolds et al., 2001). Inspired by this dissertation, further research could then investigate patterns between different types of disruptions on the one side and different regional structural conditions, varying actor constellation and the potentially uneven unfolding of change on the other side.

What is more, not only should forthcoming work engage more deeply with the relationship between different disruptions, but also between regional paths (Hassink et al., 2019). This dissertation project has clearly demonstrated the importance of path interdependencies for comprehensively understanding regional industrial change. Accordingly, the presence of an ICT path in Ontario and West Sweden and a microelectronics path in the AAT has substantially influenced patterns of path transformation in the automotive industry. It was shown that this relationship can be positive for both paths. For instance, the strong competencies in AI technology in Ontario's ICT path has substantially upgraded the asset base of the whole region and thereby enabled opportunities for renewed life in the automotive industry. Similarly, the increasing engagement of microelectronic firms in the C/AV space in the AAT has contributed to reorienting a well-established automotive system towards new ways of doing things. However, the case of Western Sweden has also shown that competition for the same scarce regional assets (skilled labour, legitimacy, etc.) can hinder positive developments in either path or even might lead to negative ones. As such, empirical insights have confirmed first conceptual advancements in regard to inter-path relations (Frangenheim et al., 2020; Breul et al., 2021). However, much is yet to learn in this debate, e.g. in respect to patterns (between industries or over time) and channels of influence (relative importance, regional vs. interregional) between paths.

From a systemic perspective based on the RIS approach, a RIS supports not only one but (depending on the thickness) a number of regional paths (Miörner & Trippl, 2019). This leads to the question how asset provision within a RIS can be orchestrated and managed, but also highlights the importance of extra-regional asset sourcing (Binz et al., 2016; Frangenheim et al., 2020). When regional restructuring is considered as the sum of development activities in all regional paths, then restructuring can easily become a zero-sum game when expansions and transformations in one path lead to a downturn in another. As such, shaping a supportive relationship between regional paths is also an important task for regional policymakers (Frangenheim et al., 2020). Thus, in brief, inter-path dynamics are another important part of a larger picture of regional restructuring, which requires more investigation.

The final avenue for future research proposed here is related to the so called 'dark side' of Economic Geography, that has received more interest lately, not least due to a recently formulated 'invitation' by Phelps et al. (2018) to move beyond the strong emphasis in the field of Economic Geography on 'bright sides' of regional development. Instead, as the authors argue, the research community should study more thoroughly the negative consequences of (uneven) regional development, unwanted effects on regions 'left behind' (Rodríguez-Pose, 2018) and their inhabitants and, more generally, structurally weak regions (Phelps et al., 2018). Indeed, research on new path development is preoccupied with examining successful cases of industry emergence and renewal in regions. As a consequence, 'path failures' remain poorly

understood. It was only recently that scholars have begun to conceptualize trajectories of path decline in the form of path contraction, path downgrading and path delocalisation (Blažek et al., 2020, co-authored by the author of this thesis) to complement the positive types of path development (creation, importation, renewal, etc.). In this respect, more conceptual and empirical work on the 'dark side' of regional industrial path development is required to better understand the manifold sources and consequences of path decline and dissolution.

The RIS approach is characterised by a similar tendency, as Phelps et al. (2018, p. 239-240) themselves rightfully point out: '*Almost by definition, literature on RIS […] has very obviously tended to focus on high technology and innovative regional economies. […] Look hard and there is little if any mention of absent, failed, failing, or dysfunctional RIS when presumably these are the majority*'. Admittedly, just like many other studies, the research conducted for this thesis has investigated cases of success, in which automotive regions found one way or another to respond to current pressures for change. However, arguably, the four research articles have at least cast light on some nuances of 'dark sides'. For instance, the structural reconsideration propagated here focuses on constraining dimensions in all different structural configurations defined (paper #3). Research on the AAT in particular has further explored these 'dark sides' in highly elaborated and coherent settings, showing how strong ties and mutually reinforcing elements have indeed rigidified the industry and initially hampered the transformation towards C/AVs (paper #2). Moreover, it was shown how maintenance agency (Jolly et al., 2020) might bar the way to progress (paper #3 & #4). In addition, asset destruction, its role in promoting new ways of things and its conflictual nature (Trippl et al., 2020) have been investigated (Paper #1 & #2), which can be considered highly relevant in light of recent discussions on the role of *exnovation* in industrial change processes (Heyen et al., 2017). However, much more research in this respect is needed. Fruitful questions to follow might be: What is the role of different actors in driving asset destruction processes? How can such processes be mediated and orchestrated? How can we intensify such processes in order to accelerate and consolidate (sustainable) change, e.g. by boosting the acceptance and legitimacy of asset destruction? How can the positive dimension of reproductive agency be promoted and the negative one restricted? How can it be prevented that socially beneficial disruptions are stalled or postponed through maintenance agency? How to design consensual but also (if necessary) coercive approaches (Heyen et al., 2017)? How can such transition processes be made 'just' (Newell & Mulvaney, 2013)? And, last not least, what to do with established industries that fail to transform?

In more general terms, the work on new path development and the RIS approach would profit from a more capacious understanding of innovation (Coenen & Morgan, 2020; Marques & Morgan, 2021). Not all innovation is desirable and innovation is not desirable for all. This, however, is often implicitly assumed in EEG and RIS approaches (Weber & Truffer, 2017; Phelps et al., 2018). Moreover, the body of literature is still skewed towards market-based and technology-driven innovation (Coenen & Morgan, 2020; Tödtling et al., 2021).

Thus, recent work in the field has begun to put the question of directionality of path development and innovation systems centre stage (Weber & Rohracher, 2012). Attention is

increasingly devoted to legitimacy, responsibility and public value of innovation (Uyarra et al., 2019), to the challenge-orientation of innovation systems (Tödtling et al., 2021) and the role of innovation and new industrial policies in providing directionality (Mazzucato, 2016). In order to become better suited to inform and inspire such policies, work on new path development and RIS studies need to engage even more with current discussions about the societal desirability of innovation and regional (economic) restructuring and detrimental effects of regional industrial development. A highly promising research field in this regard is concerned with the inclusivity of innovation and with regions which do not profit from innovation (Marques & Morgan, 2021), regions where transformations fail and paths decline (Blažek et al., 2020), regions that might become 'left-behind' (Martin et al., 2021) and, eventually, take revenge at the ballot box as their inhabitants express their dissatisfaction by voting for populist parties – with possibly disturbing consequences for our democracies (Essletzbichler et al., 2018; Rodriguez-Pose, 2018).

6.7 Policy recommendations

Lastly, the results of this thesis also hold a number of implications for policymakers and the design of regional innovation policies. These recommendations will be related to the policy instrument of 'smart specialisation', which not only is heavily inspired by evolutionary ideas and the RIS concept and, thus, highly complementary to ideas presented in this dissertation, but also currently the single most important instrument in Europe employed to trigger and facilitate innovation-based regional restructuring and path transformations.

As the name suggests, smart specialisation argues for a strategic innovation policy. It emphasises the need of identifying and analysing place-specific potentials inherited from previous rounds of regional development (Foray, 2014, 2015; McCann & Ortega-Argilés, 2015). This process is carried out in a broad manner, including a large number of regional stakeholders. Building on these comparative advantages of a given region as a platform, smart specialisation seeks to develop a shared vision among regional actors and define those fields of priority in which transformation processes should be supported and facilitated, resulting, ideally, in innovation-based regional restructuring (Foray, 2014; European Commission, 2015). In doing so, smart specialisation can be seen as a departure from more traditional innovation policy strategies, which often attempted to imitate successful strategies implemented elsewhere (Asheim et al., 2019). As such, it is an instrument that moves beyond 'one size fits all' approaches to regional innovation policy (Tödtling & Trippl, 2005). Moreover, smart specialisation refrains from 'picking winners' in a top-down manner, but highlights the importance of broad bottom-up processes (Asheim et al., 2019).

Trippl et al. (2019) have highlighted that RIS characteristics shape smart specialisation practices and play an important role in influencing (a) stakeholder involvement and the participatory process that stands at the beginning of designing a smart specialisation strategy, (b) the subsequent selection of key priorities and, finally, (c) the implementation of smart

specialisation. Arguably, findings of this dissertation hold additional insights for all three of these key processes. Hence, in light of these discussions, this thesis can shed some light on several important aspects and thereby help to possibly further refine this innovation policy instrument.

First, smart specialisation, by definition, is about transforming economic regional structures, not about slightly altering the status quo (Foray, 2014). Previous research has shown that '*there are major risks of such a transformative process being captured by incumbent firms*' (Kyriakou, 2017, p. 6). That is, there is the danger that powerful actors dominate the **participatory process** and, as a consequence, other subsequent processes of smart specialisation and shape them in ways to mitigate potentially adverse effects on their vested interests. Trippl et al. (2019) show that such risk is highest in less-developed regions characterised by organisational thinness and a high degree of industrial specialisation. These regions usually host one or few industrial paths only, leaving powerful firms in these industries in a particularly influential position (Isaksen & Trippl, 2016).

However, this dissertation has made the case for reconsidering the role of incumbents as they not only engage in maintenance but also in change agency. Moreover, incumbent firms are highly capable of propelling such transformation processes when they opt for change due to their various forms of power and influence on their surrounding RIS (paper #4). As such, they can become important strategic partners of change. Yet, this is not to say that incumbents are easily persuaded. As '*paragons of the current state of affairs*' (Kyriakou, 2017, p. 9), they indeed often protect the status quo from which they usually benefit (Turnheim & Sovacool, 2020). In addition, incumbent firms and policymakers often form core-alliances due to mutual dependencies, potentially standing in the way of successfully implementing any kind of transformative innovation policy (Geels, 2014). Thus, from the more comprehensive perspective on the role of incumbent firms in regional industrial change proposed here, this thesis suggests that policy needs to find ways to harness incumbents' transformative potential while suppressing their resistance.

Kyriakou (2017, p. 9) argues that in order to prevent incumbent capture, it is important to '*give voice to the voiceless*' and to keep the participatory process open to newcomers. Indeed, keeping smart specialisation inclusive might not only help to avoid further entrenching incumbents, but also to trigger their potential to pursue economic transformation by moving them out of their comfort zone and exposing them to new ideas. In this sense, smart specialisation should not (only) be seen in danger of being captured by incumbent firms, but – if done right – as a means by which their change agency can be activated.

Another way to approach these issues is the implementation of directionality and challenge or mission orientation on the RIS level, thereby uniting all participating actors (from the civil society to powerful incumbents) behind a common goal by placing societal challenges at the

core of innovation processes[21] (Mazzucato, 2016; Tödtling et al., 2021). At the same time, this would be an important step towards bringing smart specialisation strategies (S3) to the next level and developing it into an instrument for regional *sustainable* development (S4: smart specialisation for sustainability, McCann & Soete, 2020).

Second, smart specialisation is strongly informed by evolutionary notions and highlights the importance of historically-inherited strengths in the form of regional assets, knowledge bases and industrial capabilities. While this is without question an important step towards more 'spatial wisdom' in innovation policies, this dissertation project has shown that structural influences are complex and more than simply 'enabling' for a certain field of priority of restructuring. Accordingly, when it comes to the **selection process** in smart specialisation, a more fine-grained understanding of potentials for and constraints to industrial change entailed in structural conditions might help to make more informed decisions. This is not to say that one should move back to 'anything goes anywhere' or 'one size fits all' (Tödtling & Trippl, 2005) kinds of approaches based on the conviction that there is all-encompassing potential everywhere, but insights from this thesis might help to find more appreciation for the complexity of structural implications and, in particular, for strengths in structures that are commonly perceived as weak (see also the case of the rise of the wine industry in Quebec, Baumgartinger-Seiringer et al., 2022).

Third and finally, when it comes to the **implementation** of smart specialisation strategies, there has previously been a strong focus on initiating transformative processes. This is hardly surprising given that the instrument is still rather young. Yet, this dissertation project has demonstrated the importance not only of initiating transformative processes, but also accelerating and consolidating them. It has been shown that different stages of transformation come with different characteristics and challenges (see chapter 6.1). Arguably, the two later stages are more prone to conflict, as they often come with competition over scarce assets and the abandoning of pre-transformation activities and associated vested interests. Hence, starting up transformations (initiating) is essentially different from scaling them up (accelerating), which is essentially different from consolidating them. Accordingly, this thesis suggests that smart specialisation and policymakers should already now take a processual perspective and prepare subsequent phases of change.

[21] However, clearly, these issues cannot be solved at the regional level alone. Instead, tools for transformative regional innovation policy must be embedded in enabling institutional conditions provided by the national and supra-national (EU) levels (Hassink et al., 2021). Hence, multi-scalar contexts and multiple governance levels have to be taken into account (Tödtling et al., 2021).

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Towards a stage model of regional industrial path transformation

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ABSTRACT

The recent debate on innovation-based structural change in Evolutionary Economic Geography is characterised by a strong focus on the rise of new industrial paths. This paper seeks to shift attention and cast light on radical innovation activities occurring within existing paths without necessarily leading to their dissolution. Departing from a systemic perspective of path development we propose a stage model of path transformation. We outline how radical change becomes initiated, reinforced and finally consolidated in established industrial paths. Particular attention is devoted to the ways in which actors – influenced by 'the past' and driven by visions and expectations (that is, 'the future') – exert agency to stimulate asset modification processes that are assumed to underpin path transformation and the reconfiguration of the wider support structures. The framework is applied to the analysis of the automotive industry in West Sweden, which is currently transforming towards the development of self-driving cars.

KEYWORDS

Path transformation; evolutionary economic geography; stage model; assets; agency

1. Introduction

The rise of Evolutionary Economic Geography (EEG) has led to a renewed interest in the mechanisms and processes of innovation-based development of industrial paths.[1] The debate is characterised by a dichotomy between on-going, gradual change driven by incremental innovations leading to minor adjustments of existing paths on the one hand and radical change triggered by disruptive innovations believed to underpin the rise of new paths on the other hand. The past few years have witnessed a shift of attention towards the latter (MacKinnon et al. 2019).

This paper seeks to provide a more nuanced view, focusing attention on how radical transformation activities may take place within mature regional industrial paths. We argue that radical innovations can happen 'on the path' and do not necessarily lead to its dissolution. We scrutinise the unfolding of the transformation of an industrial path and its wider regional set-up (that is, the regional support structures) over time. We contend

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[1]Drawing on the definition of a newly created path (Binz, Truffer, and Coenen 2016, 177), an existing path can be defined as 'a set of functionally related firms and supportive actors and institutions that are established and legitimized [. . .]'.

that due to the disruptive nature of radical innovation, one can hardly assume such transformations to be linear and abrupt but rather to be complex and long-term processes, featuring a transition from pre-transformation to transformation activities. It is argued that transformation activities, that is, activities and practices that deviate from those dominant in the past (pre-transformation activities), are manifested in distinct forms of asset modification processes. The aim of this paper is to contribute to a more thorough understanding of how such transformation activities become initiated, intensified and finally consolidated.

To address this question we draw on systemic conceptualisations of path development and propose a stage model of path transformation. In the next section we will provide a critical review of EEG accounts of regional industrial path development. In section 3 we draw on broader conceptualisations of regional industrial change and outline our conceptual model. It centre stages the nature of asset modification processes that underpin the transformation of mature industrial paths (and the wider support structures they are embedded in) and explicates how multiple actors and their agency – influenced by the past and driven by future prospects – engage in radical 'on path' changes. We explicate how these processes differ between three stages of path transformation, that is, the initiation stage, the acceleration stage, and the consolidation stage. Section 4 applies the stage model to the empirical case of the automotive industry in West Sweden, which is currently undergoing major change processes triggered by the advent of self-driving cars. Our empirical findings largely confirm our conceptual arguments but also reveal some 'deviations' that require further research. Finally, section 5 concludes.

2. Regional industrial path development: EEG perspectives

Innovation and adaptation processes are place-dependent phenomena (Martin 2010). Evolutionary Economic Geography (EEG) explains the current state of affairs from history, placing emphasis on assets, skills and competencies developed in the past, which influence present and future choices (Martin 2010; Martin and Sunley 2006). These essential ideas underpin the notion of 'path dependence'.

At the core of EEG thinking is the duality of continuity and change in regional industrial evolution. Continuity in an evolving system is understood as on-going, gradual change in order to respond to constant competitive pressures (Martin 2010). EEG understands this form of steady adaptation as the norm, while also acknowledging the possible occurrence of events that may trigger radical discontinuities. This dichotomy, however, is problematic. It suggests that gradual change is happening 'on the path' (Martin 2010), while radical change results either in path dissolution or in the creation of new paths. In this article we maintain that radical innovation activities may also occur within mature industrial paths and institutional settings. We refer to such processes as 'path transformation', that is, radical, innovation-based forms of path development, where an established path and the regional support structures it is embedded in are undergoing major change.

EEG has significantly enhanced understanding of how regional structural change unfolds over time. However, recent contributions have highlighted several shortcomings of EEG models. First, EEG portrays path development as a firm-driven process, neglecting the importance of other actors such as universities (Vallance 2016) and policy makers

(Dawley 2014). Second, there is a strong focus on the redeployment of technological and skill assets. Other assets such as institutional endowments (MacKinnon et al. 2019; Maskell and Malmberg 1999) tend to be overlooked. Further, recent work suggests that it is not only the re-use of existing assets that matters. Since established innovation systems are often poorly equipped to support radical change, creation of new assets and the destruction of old constraining ones are vitally important. One also needs to acknowledge that such asset modification processes may be contested. Innovation-based change might lead to intra-path and inter-path conflicts and competition over scarce assets (Frangenheim, Trippl, and Chlebna 2020). Third, EEG offers substantial insights into how 'the past' influences structural change but has thus far done little to incorporate the role of 'the future' in the form of visions and expectations into analyses of path development (Hassink, Isaksen, and Trippl 2019). From a sociological perspective, future prospects are a vital driver for engagement and agency of actors (Emirbayer and Mische 1998).

Recent work has begun to integrate the insights outlined above into a systemic perspective of path development (Trippl et al. 2020), arguing that the rise of new and the renewal of existing paths require substantial asset modification processes. Redeployment of existing assets, creation of new assets and destruction of old constraining assets are said to reflect reconfiguration processes of (multiscalar) innovation systems and are seen as brought about by firm-level and system-level agency.

In order to better understand how such processes take place in mature industries facing radical change, we propose a stage model of path transformation and examine the ways in which multiple actors engage in asset modification throughout the process of path transformation.

3. Towards a stage model of path transformation

This section provides a more detailed account of key elements of recent broader conceptualisations of path development, which have begun to complement established EEG perspectives (section 3.1). Building on these insights, we outline how path transformation may unfold through three phases (section 3.2).

3.1. Setting the scene: key factors brought forward in recent conceptualisations of path development

The idea that **historically grown structures** set the possibilities for socio-economic actors in the present is at the core of evolutionary thinking: previous choices and activities influence subsequent ones (Martin and Sunley 2006, 409). The regional asset base is seen to reflect previous rounds of path development and serves as a platform for future ones (MacKinnon et al. 2019; Trippl et al. 2020). In this regard, different types of assets constituting the regional asset base have been identified (MacKinnon et al. 2019; Maskell and Malmberg 1999): natural assets (resources), infrastructural and material assets, industrial assets (technological and firm-based competences), human assets (skills and knowledge), and institutional endowments (rules, routines and norms). Furthermore, financial assets must not be neglected. More often than not, mobilising

financial resources is of crucial importance to modify infrastructural, industrial, human and other types of assets.

Natural resources (such as sources of energy supply) and infrastructural assets (digital as well as material ones) form the often-overlooked basis for economic activity. Industrial assets refer to the competences, routines and networks of firms. They are a core focus of conventional EEG perspectives and seen as the driver of economic evolution. Human assets not only imply the regional labour force and their skills, but also knowledge created in research organisations and higher education institutes (Vallance 2016). Institutional assets, which constitute 'the way of doing things' also matter. They range from formal institutions such as laws and regulations to informal ones like common norms, values and trust and thus also reflect social capital within regions (see for instance Westlund and Kobayashi 2013). One the one hand, such historically grown place-specific endowments provide stability for socio-economic actors. On the other hand, they tend to favour the old over the new and thus might hamper new path development (Zukauskaite, Trippl, and Plechero 2017). Industrial change is therefore often contingent on institutional change (Boschma et al. 2017).

Regional industrial path development and transformation will only unfold if **local (and non-local) actors** harness and valorise the regional asset base (MacKinnon et al. 2019). In contrast to firm-centred views prevailing in conventional EEG models, systemic perspectives of path development (Tödtling and Trippl 2013) suggest adopting a multi-actor approach. In line with this view, our framework appreciates the role played by non-firm actors such as universities or research institutes (Vallance 2016), policy actors, support organisations, intermediaries (Dawley 2014), and so on. These actors may fuel path transformation by pursuing system level changes. This calls for consideration of what is called system level agency[2] (Isaksen and Jakobsen 2017) in addition to firm level agency.

The main difference between those two types of agency lies in their field and scope of influence (Hassink, Isaksen, and Trippl 2019). While firm level agency is mainly concerned with changes within a firm or organisation, system level agency is geared towards broader regional adaptations and based on actions to transform regional innovation systems to better support industrial change (Isaksen and Jakobsen 2017), e.g. by establishing research institutes to develop new knowledge, creating protected space for transformation activities or contributing to legitimisation of a new technology (Binz, Truffer, and Coenen 2016). Path transformation thus requires both firm level and system level agency. The latter is particularly important for modifying infrastructural, human and institutional assets.

Yet, to understand the complexity of agency, one has to grasp it in its inter-temporality: agency refers to the '*capacity to contextualise past habits and future projects within the contingencies of the moment*' (Emirbayer and Mische 1998, 963). While our model acknowledges the habitual aspect of agency through the relation between the regional asset base (involving routines, norms etc.) and actors, we particularly highlight the role of **visions and expectations** in moving the process towards path transformation forward. By so doing, we complement the prevailing focus of EEG models on how the past influences path development by explicitly recognising the role of the future in shaping transformation activities. Steen (2016) highlights the generative power of the future in path development. Accordingly, socio-

economic actors can be understood as strategic entities that pursue goals and undertake activities to achieve them. Actors' visions and expectations thus contribute to the mobilisation of resources, experimentation efforts, network activities and so on (Steen 2016).

Visions can be individual or collective in nature. While contested visions might be a source of conflict and a barrier to change, shared visions provide orientation and directionality for actors (Wanzenböck et al. 2019). Future prospects are a matter of continuous re-evaluation and they change over time. The emergence of joint expectations often takes time, requires efforts by system level agents (Sotarauta 2009) and benefits from geographical proximity (Steen 2016).

3.1.1. Path transformation through asset modification

Due to its radical nature, path transformation comes with profound alterations of historically grown regional structures, implying a modification of the regional asset base (MacKinnon et al. 2019). As Maskell and Malmberg (1999, 10) point out, regional assets can be '*modified or reconstructed by the deliberate and purposeful action of individuals and groups within or outside the area*'. Accordingly, actors – influenced by the past and driven by future prospects (Emirbayer and Mische 1998) – are engaging in asset modification, using different strategies throughout the path transformation process. Recent contributions distinguish between various types of asset modification, including the recombination of existing assets, creation of new assets and the destruction of old assets (Trippl et al. 2020). While each of these types is vital for change, we claim that their relative importance is changing throughout the unfolding of regional industrial path transformation.

Different strategies of asset modification are key not only to alterations within the industry but also to create a supportive environment for path transformation. This is because established asset configurations support and stabilise pre-transformation activities. Put differently, they are often well aligned to existing paths and are thus poorly equipped to provide the capabilities, infrastructure, or institutional settings necessary for disruptive innovations and radical shifts to unfold (Tödtling and Trippl 2013). Such processes might involve conflicts of interests. They are thus often controversial and might be contested.

Finally, path transformation per definition represents a radical, innovation-based form of alterations of well-established paths and regional support structures. Yet, such change processes are also shaped by national or even global dependencies, influences and events (Martin 2010; Simmie and Martin 2010). How shifting non-local conditions are affecting the development of a certain place depends on local characteristics. Accordingly, these two influences are not mutually exclusive: while one has to acknowledge the multi-scalar nature and geographical complexity of regional economic evolution, some regions still remain better suited than others to deal with extra-regional pressures.

[2]Agency can be defined as deliberate and purposive actions or interventions by actors in order to produce particular effects (Emirbayer and Mische 1998; Sotarauta and Suvinen 2018).

3.2. The unfolding of industrial path transformation

The key factors discussed above, that is, historically grown structures, number and connections of relevant actors, the role visions play for their agency and the resulting asset modification processes can be expected to vary between early and later phases of industrial reorientation. To capture these dynamics, we suggest a stage model of path transformation, distinguishing between three phases, namely, initiation stage, acceleration stage, and consolidation stage.[3]

Stage models of economic development are popular within the economic geography and regional science literature. Amongst other concepts,[4] cluster life cycles have received the most attention (Menzel and Fornahl 2010; Fornahl and Hassink 2017) in recent years. This literature seeks to move beyond overly static perspectives on clusters and conceptualises their evolution in different phases from emergence and growth to maturity and decline. This sequence is either explained through the industrial life cycle (where a cluster's evolution is strongly connected to the development of its overarching technological-industrial orientation), or through agglomeration effects, which themselves are believed to have a life cycle (Martin and Sunley 2011).

Cluster life cycle approaches differ from the model suggested in this paper in various ways. They put focus on the whole lifespan (from emergence to decline) of a clustered industry. In contrast, our model casts light on mature industries and pays attention to a particular phase of their evolution, namely their transformation based on radical innovations. Additionally, the cluster life cycle approach gives limited appreciation to the wider regional environment and (non-firm-level) agency (Trippl et al. 2015). These dimensions are at the heart of the approach outlined in this paper.

Yet, there are similarities. As with all conceptualisations based on the notion of stages, our model might evoke ideas of linearity or universality. However, rather than implying deterministic claims, the transformation stages outlined in this paper point to ideal-type processes. Stage models in general are searching for commonalities rather than differences (Markard 2018) and should be seen as '*a heuristic device to organize empirical cases [...] without denying the indeterminate outcome of the* process' (Frenken, Cefis, and Stam 2015, 15). Therefore, we acknowledge the possibility of failure at any stage of transformation. Moreover, some key processes may lag behind or outpace others and thereby deviate from the 'typical' (Markard 2018). Additionally, external shocks or newly emerging problems or opportunities might lead to setbacks or leaps forward.

3.2.1. Initiation stage

The initiation stage is usually enabled by new possibilities or emerging pressures. Path transformation might be initiated by disruptive events taking place within or outside the region, like crisis, the emergence of new competitors, market shifts or radical innovations (Martin 2010; Simmie and Martin 2010). Such discontinuities challenge historically grown structures.

In this phase, many actors are still focusing on their established fields of action (or what we call 'pre-transformation activities'), while only a small number of first movers engage in early experimentation (Foray 2014). Path transformation is often initiated by

innovative entrepreneurs who deviate from existing products and processes (Garud and Peter 2001) and exploit emerging opportunities. Early movers may be large corporations or agile start-ups. Early transformation activities may also be induced or supported by system-level actors. Knowledge generated in universities or new policy incentives may be sources of path transformation (Sotarauta and Suvinen 2018).

We assume expectations and visions to be ambiguous in the initiation stage. Pioneers of change seek to exploit emerging opportunities. Driven by strong beliefs in the innovation, they find themselves in 'early sense-making processes'. However, radical innovations that challenge dominant paradigms are characterised by great uncertainty. There is no clear vision of what the outcome might actually be. This leaves many actors in an observant state (Sotarauta and Mustikkamäki 2015).

Many assets – like technological competencies or favourable regulations – do not pre-exist for completely new solutions (like self-driving cars, which are in focus in the empirical part of this article). There are strong reasons to assume that in the initiation stage pioneers of change do not only engage in redeploying and recombining existing assets but also in creating new ones.

In the initiation stage, it is only few knowledgeable non-firm actors who create the necessary regional assets (e.g. educational programmes, fitting regulations and norms, etc.) They often have to work around institutionalised logics of highly aligned structures (Sotarauta and Mustikkamäki 2015).

3.2.2. Acceleration stage

In the acceleration stage, transformation activities experience intensification. Opportunities created in the initiation stage are increasingly utilised. Newly established structures serve as a foundation to build upon. The process towards transformation gains momentum due to reinforcing effects. Yet, many assets are still 'locked-in' and oriented towards pre-transformation activities, resulting in a 'co-existence' of old and new structures within the industry and the support system.

The spreading of economic knowledge demonstrates future opportunities to a larger number of actors (Foray 2014). Thus, in this phase more and more incumbents are following the early movers. They are reorienting their activities, longing to complement or exploit opportunities created by the pioneers of change (Simmie 2012). At the same time, the number of spin-offs and start-ups might increase as well. Similarly, a growing number of system-level actors are expected to engage in asset modification endeavours.

Moving beyond the initial stage of path transformation requires collective belief formation (Sotarauta and Mustikkamäki 2015). This is a challenging issue. There are often conflicting opinions about the route towards path transformation. Therefore, system-level agency is expected to play a key role in this stage, contributing to setting the agenda and thereby creating a joint vision by bringing together different actors, resolving conflicts and shaping interpretations (Sotarauta 2009).

Despite varying expectations, we assume that *reorientation of existing assets* gains momentum in the acceleration phase due to the growing recognition of promising future

[3]Similar phases have been used in the transition literature (Markard 2018).
[4]See also Martin's (2010) 'path as a process model' and Foray's (2014) conceptualisation of the Entrepreneurial Discovery Process (EDP).

prospects. An important question is how to unlock assets in use or to 'import' the necessary knowledge and other resources from elsewhere. This can either take place within organisations (e.g. in-house innovation, recruitment of skilled labour) or by acquisition of assets (e.g. mergers and acquisitions) and collaboration with other actors. Established organisations may unlock and reorient existing assets and recombine these with new (related) ones (Boschma et al. 2017). This might enable incumbents to regain their competitive edge.

Additionally, in the acceleration phase a broader set of regional assets (including complementary infrastructural, human and institutional assets) is being shaped. A growing number and variety of actors is undertaking efforts to deliberately reconfigure support structures (Trippl et al. 2020). System-level actors can for instance facilitate the reorientation of activities within research labs or provide the needed infrastructure. Organisations and institutions are formed that represent the views and goals of new actors or of reorienting incumbents. At the same time, regional assets oriented towards pre-transformation activities are increasingly questioned due to their incompatibility with newly emerging structures.

The intensification of path transformation activities may come with particular challenges. They might result from growing requirements the old regional structures cannot meet or from competition over scarce assets. The former may lead to conflicting ideas concerning the direction of change (varying expectations) or legislative difficulties (testing, insurance, regulations, risk-management, etc.), the latter to inter-path conflicts (competition over skilled labour, funding, public attention, etc.) (Frangenheim, Trippl, and Chlebna 2020) or problems related to the behaviour of consumers (acceptance, demand, etc.).

3.2.3. Consolidation stage

In this stage, the reorientation of a broad variety of assets cumulates and ultimately leads to a broader shift of regional structures. New activities are increasingly replacing old ones, thereby revealing assets no longer needed or unable to reorient.

More and more actors depart from pre-transformation activities. Eventually reaching the necessary critical mass marks an important point of discontinuity (Simmie 2012). Reinforcing effects, i.e. increasing returns and positive externalities, gain further momentum. In this phase firms commercialise the new knowledge (Simmie, Sternberg, and Carpenter 2014) and abandon old structures. Not only firms but also the majority of system level actors are focusing on transformation activities and new practices.

The belief formation in the consolidation stage is ultimately resulting in a '*collective [. . .] understanding of what might be at stake*' (Sotarauta and Mustikkamäki 2015, 353). Formation of joint visions and widely shared expectations are believed to intensify substantially in the consolidation phase. This can be expected to influence asset modification processes. The creation of novel and the reorientation of existing assets might still matter but these processes do not represent the entire picture: For the process towards path transformation to ultimately consolidate, *destruction of old constraining assets* and destabilisation of structures suppressing change (Kivimaa and Kern 2016) are necessary. Destruction is particularly relevant in later phases when alternative innovations have already gained momentum (Kivimaa and Kern 2016). Accordingly, firm-level and system-level actors alike are believed to intensify their efforts to remove constraining

structures. This leads to a further adaptation of regional structures, which facilitate new activities and positive lock-in effects (Martin and Sunley 2006). The majority of regional assets are reoriented towards the new activities. In the consolidation phase the 'old rules of the game' are disregarded or adopted and the new ones are aligned and institutionalised.

Destroying, altering or de-aligning constraining assets does not come without frictions. For firm-level actors it can be an expensive procedure due to sunk costs. Closures of those unable to adapt are likely to be observed. There are also obstacles to activities by system-level actors such as incumbents' interests, strong networks and rigid formal and informal institutions. Destructing constraining assets is often politically controversial (Kivimaa and Kern 2016). Therefore, the challenges in this stage are often intra-path or intra-regional in nature. Dismantling old structures requires disruptive activities by

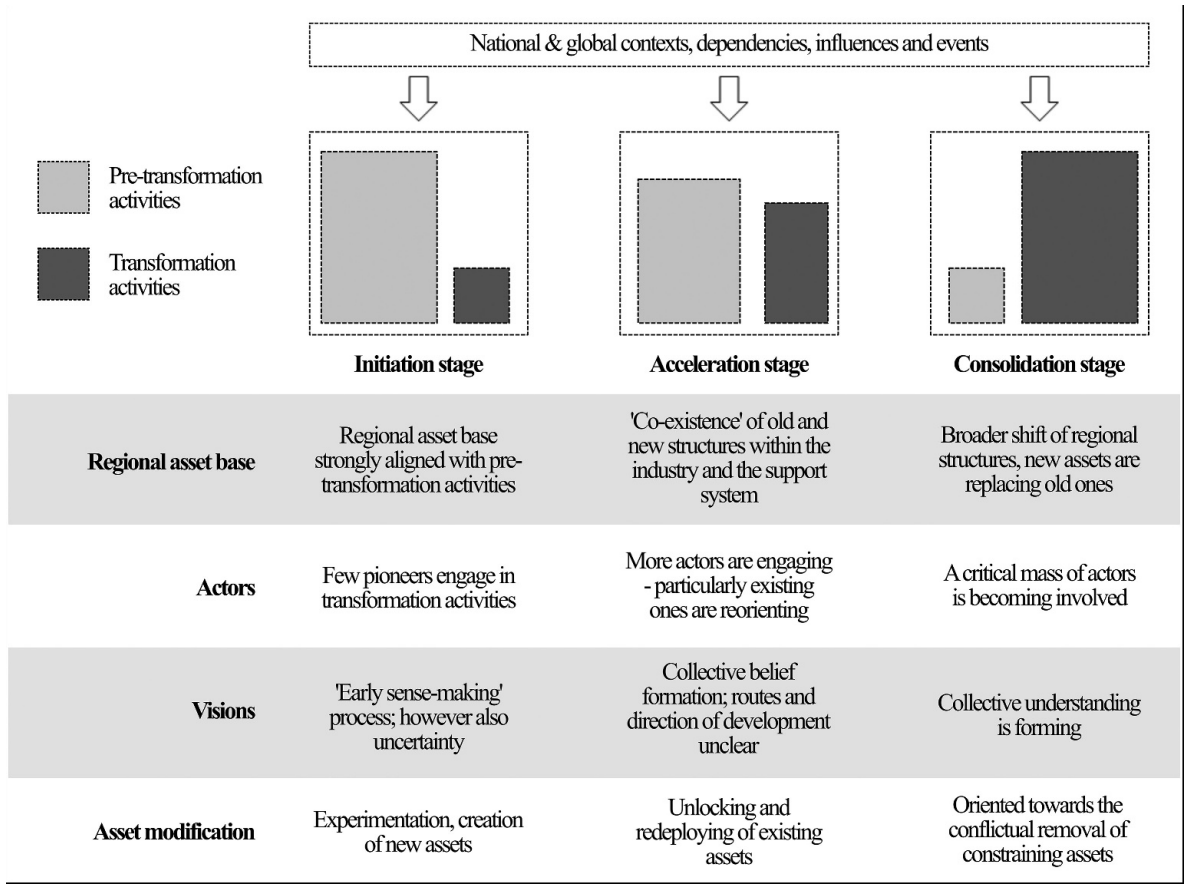

Figure 1. Path transformation and development of key dimensions throughout the stages according to the model.

actors from different domains.[5]

To summarise, our model unravels radical 'on path' transformations by distinguishing between three stages of development, each of them coming with specific conditions ('past and future') that drive actors' agency and result in different processes of asset modification (Figure 1).

3.2.4. Analytical dimensions

To distinguish between the different stages of transformation, we propose to use different analytical indicators for the key dimensions underlying the model, that is, actors and their actions, the development of visions and expectations, and changes in the regional asset base.

Actors and their activities capture the relative degree of activity associated with transformation activities in contrast to pre-transformation activities. Indicators can thus be the number of actors engaging in transformation activities, the extent of research and entrepreneurial activities in transformation areas and changes in the size of networks (Markard 2018). We expect the ratio between pre-transformation and transformation activities measured through these indicators to change significantly throughout the stages (quantitatively and qualitatively), where the latter initially represent only niche activities, then grow to a comparable size to pre-transformation activities (co-existence) and finally become the main field of action within the path.

Visions and expectations as '*wishful enactments of a desired future*' (Borup et al. 2006, 286) are a generative force (resources, commitment, and actions). They can help to bridge boundaries and are crucial for legitimising future technological situations and capabilities (Steen 2016). While elusive, the materialisation of visions and expectations in form of artefacts or actions throughout the stages can be used as a measure (Borup et al. 2006). Indicators can be the number[6] and content of respective newspaper articles or relevant conferences, the formation of associations or other organisations committed to a certain future goal or early regulations associated with transformation activities. We expect ambiguous and often contested prospects in initial stages that continuously develop into more consolidated expectations over time.

Finally, structural changes point to alterations of the historically grown regional asset base. To distinguish between phases, we suggest using the different modes of asset modification, that is, asset creation, redeployment and destruction. We argue that their relative importance varies between different phases of transformation. Asset creation is expected to play a pivotal role in the initiation stage, redeployment in the acceleration stage and destruction in the consolidation stage. Indicators will depend on the type of asset under consideration. For industrial assets, modifications from the firm level should be considered, e.g. in form of the redistribution of financial and other resources (such as labour, investments) between pre-transformation and transformation activities or the dismantling of pre-transformation areas in later stages. Changes within universities and research institutes (e.g. new curricula, financial assets mobilised for new R&D programmes) or training courses within firms indicate the modification of human assets. Alterations of institutional endowments can be seen in adjustments of regulations to fit transformation activities, changes in user acceptance or the abolishing of old regulations. Lastly, infrastructural asset modification is reflected in the establishment or alteration of digital as well as material infrastructure to boost transformation activities (e.g. test sites) or in the dismantling of old infrastructural elements.

[5]Focusing on the policy domain, Kivimaa and Kern (2016) identify four ways to destabilise existing systems, namely control policies (e.g. taxes and regulations), significant changes in regime rules (major changes in legislation), reduced support for dominant regime technologies (e.g. withdrawing subsidies) and changes in social networks through replacement of key actors (e.g. in policy advisory councils).

As many of these analytical dimensions are hard to capture with quantitative approaches, this paper argues for more qualitative research designs in EEG (see also Hassink, Isaksen, and Trippl 2019). What is more, it is crucial to understand the description of both the phases as well as the indicators as mid-stage characteristics, where differences between the stages are most pronounced. Furthermore, as with similar conceptualisations, it is hardly possible to define clear-cut thresholds to identify transitions from one phase to another, as shifts between stages might be rather smooth (Markard 2018).

4. Empirical case: self-driving cars in West Sweden

To illustrate our conceptual arguments and to provide additional insights into the stages of path transformation, we apply our framework to the empirical case of the automotive industry in West Sweden, which is currently undergoing disruptive changes due to the advent of self-driving cars. In other words, we use a case study methodology to complement the conceptual discussion, identifying a 'paradigmatic case' (Flyvbjerg 2006) of path transformation that serves to illustrate, and potentially challenge, the assumptions made in the conceptual discussion.

The data collection took place in two steps. First, a document study was performed, in which newspaper articles, newsletters, reports, PR material, financial information, legal documents, and policy documents were reviewed. The document study served to identify relevant interview partners and as a starting point for the narrative explored in the interviews. It also helped to contextualise findings from the interviews. Second, semi-structured interviews with key actors were conducted. In total, 23 respondents were interviewed between March 2017 and May 2018. All interviews were transcribed and coded, using categories derived from the analytical framework (Saldaña 2015). Interviews were conducted until a state of (albeit temporally contingent) 'data saturation' (Glaser and Strauss 2017) had been reached. Previous studies of path development have highlighted the potential downsides of studying processes in hindsight, when outcomes have been materialised (Steen 2016). By studying an ongoing process, we aim to provide nuances to the complexities involved in path transformation, being aware of the difficulties involved with identifying critical events and narratives as they are happening.

The roots of the automotive industry in West Sweden date back to the beginning of the 20th century. Today the region is home to firms from all parts of the value chain, ranging from OEMs such as Volvo Cars and Volvo AB (trucks), to global suppliers such as Autoliv, smaller suppliers, automotive technology firms and consultants. The automotive industry is supported by a strong regional innovation system, endowed with knowledge providers such as Chalmers University, innovation support organisations and other intermediaries. The automotive industry in West Sweden is known for its competence in safety technology. From the introduction of three-point safety belts in the 1960s, to the invention of side-impact airbags by Autoliv in the 1990s, safety technology has been one

[6]However, as expectations tend to follow a certain temporal pattering in form of early hype, later disappointment and finally more grounded views (in particular in capital-intensive sectors to attract attention of sponsors and to protect niche activities in early stages) (Borup et al. 2006), the absolute number of such artefacts or actions is often not sufficient to distinguish between transformation stages. Thus, a content analysis and additional qualitative and 'prospective' data (Steen 2016) are often necessary.

of the industry's competitive edges. During the beginning of the 2000s, one could observe a reorientation of the regional innovation system from 'passive' to 'active' safety features, that is, technologically sophisticated features intended to help avoiding accidents rather than just reducing the damage when accidents occur (James et al. 2016). In 2009, Google announced that they would establish a unit to develop self-driving cars. In our empirical material, this has been highlighted as the 'global trigger' for path transformation in the car industry. In the following sections, we outline how this process has unfolded over time in the automotive industry of West Sweden.

The first signs of path transformation in West Sweden that could be discerned in the empirical material are statements by Volvo executives in newspaper articles about SDCs and the Google project, which aimed at downplaying the radicalness of what Google had recently introduced as 'SDC technology'. They highlighted a close relation between SDCs and pre-transformation activities and existing assets (such as ongoing R&D activities and technological competence related to active safety). For example, the appointed 'technical leader for active safety functions' at Volvo Cars expressed in a press release from 2009 that:

'[some autonomous driving features] require no hocus-pocus technology [. . .]. Instead, the focus is on adapting existing technology.' (SP 2009).

The beginning of the initiation stage can be identified as the time when the first transformation activities started to emerge, with a subsequent increase of activity among regional actors. For additional robustness, we have analysed the number of hits in Swedish newspaper articles for terms capturing articles about Volvo and self-driving car activities.[7] After appearing in a handful of articles per year in the beginning of the 2010s, the number of articles increased in 2012. This finding is also confirmed by our interviews, pointing to the period immediately after 2012 as the beginning of the transformation process.

4.1. Initiation stage

4.1.1. Actor base

While the initiation stage did not come with major changes to the regional actor base, our document analysis and interviews point to the establishment of the 'Drive Me' consortium as a key event. The consortium was initiated by Volvo Cars and initially involved the Swedish Transport Agency, the Swedish Transport Administration, the City of Gothenburg and Lindholmen Science Park (a regional support organisation). While the size of the regional actor base remained more or less constant, the Drive Me consortium represented a first step towards establishing a network around issues related to SDCs, including both regional and national actors.

4.1.2. Visions

Early transformation activities focused extensively on vision development and sense-making activities. One can observe a rapid increase of articles during the period 2012 (79 results) –2015 (850 results), indicating how visions and expectations are materialised in the public discussion. This is exemplified also through the establishment of a newsletter about self-driving technology (edited by a regional research institute) in 2013, which was highlighted by public actor interview partners as an important source of information.

At the same time, our empirical analysis shows that one of the key tasks for regional actors was to 'translate' visions of SDCs prevailing in the media to expectations about future development that would fit the regional setting. Through a content analysis of newspaper articles from the time, it is possible to observe a shift in how public sector actors, such as the local city planning authority, were envisioning alternative solutions to the future of urban mobility. Public actors quickly adopted the idea of SDCs as part of a broader strategy for mobility system transition. Among automotive actors, transformation activities in the initiation stage included both plans to turn existing safety technology into autonomous features, and to create visions for how future technological development could unfold. This could been seen as a type of 'catch-all' strategy, demonstrating various potential benefits of SDCs.

4.1.3. Asset modification

Transformation activities in the initiation stage reflected a realignment of existing technology towards autonomous driving, rather than a divergence from the existing technological knowledge base. During the early stage, it is even possible to label SDC technology as a continuation of existing active safety development, drawing extensively on pre-transformation activities. As one interview partner put it:

> *'I would say that it is a natural continuation of previous activities. It is not something that just suddenly comes from nowhere . . . [. . .] We did the move from passive to active safety, this was a shift. Now, it has exploded in terms of application [. . .] but I still see it as a natural continuation.'* (Interview)

With respect to industrial assets, it was thus a matter of reusing and recombining assets aligned to pre-transformation activities, and 'packaging' active safety technology in SDC visions rather than creating entirely new ones. This process was backed by the strong support system centred around active safety technology, including financial support for transformation activities. The availability of funding for transformation activities was also influenced by the 'hype' around SDCs that was emerging in the media, through the materialisation of visions (see above).

Early transformation activities targeted other dimensions than technological knowledge. Examples include the creation of human assets such as novel knowledge about user behaviour, involving researchers active in disciplines such as ethnography and interaction design. Actors also engaged in demonstration activities intended to increase the legitimacy of SDCs, organised largely within the context of Drive Me. However, in interviews with firm representatives, it was expressed that organisational structures and established ways of working prevented incumbents from engaging in more experimental activities, which required more iterative, agile development processes. Even though transformation activities were performed by incumbent actors, firm-based competences and other industrial assets supported these activities only when they did not depart too far from the active safety segment.

[7]Searches were made by using the Swedish newspaper archive Mediearkivet Retriever, which covers virtually all Swedish printed and online news outlets and is searchable from the 1970s onward. We checked for the number of combined hits for [självkörande AND volvo] and [autonomy AND volvo]. Searches using other combinations of terms resulted in similar outcomes.

Asset modification thus focused on the re-deployment of existing assets, with the creation of new entirely new assets playing a less important role. For instance, research efforts within the active safety segment of the industry were 're-branded' as SDC activities. Creation of new assets did thus not unfold at the same pace as the development of visions.

4.2. Acceleration stage

4.2.1. Actor base

One of the first signs of the path transformation processes gaining momentum was the expansion of the regional actor base. From initially taking place within the incumbent firms, small existing firms, newcomers and non-firm actors started to engage in transformation activities. For example, key players entered the Drive Me consortium. Chalmers University of Technology and Autoliv both joined in 2015, two years after the project was initiated. Furthermore, existing technology firms, both active in the automotive industry and in other regional industries such as IT, began to initiate international collaborations to strengthen their competences in the field. This took place in parallel to the emergence of new actors dedicated to SDC development. Partly in response to the need for more agile and fast-moving development processes, Volvo Cars and Autoliv decided to transfer their software development in active safety to a new joint venture, a spin-off named Zenuity. The new firm was announced in early 2017 and is the 'flagship' of autonomous technology and SDC development in the two incumbent firms' portfolios. Another example is Venoeer (a spin-off of Autoliv) concerned with developing advanced electronics for active safety and autonomous driving. However, our interviews highlighted the fact that whilst spin-off processes from the large incumbent firms to some extent can help them become more flexible, they do not fully compensate for the weak entrepreneurial climate in the region. Interview partners in the automotive industry acknowledged the need for engaging more with small actors but lacked the means and experience to do so.

The intensification of transformation activities also led to inter-path conflicts. For example, the increased contact surfaces between the automotive industry and the IT industry did not only lead to opportunities for collaboration but also to competition over resources such as software specialists and regional funding. One interview expressed that:

> *For a while, a lot of people left [an IT firm located in the region] . . . for us. They were almost angry at us.'* (Interview with automotive firm representative)

4.2.2. Visions

Another indicator for the acceleration of the transformation process is reflected in a rapid increase in newspaper articles about Volvo and self-driving cars between 2015 and 2016 (from 850 to over 3.000 results), indicating an increased public awareness. Interviews taken and analysis of newsletters suggest that the number of conferences, workshops, seminars and other activities also increased substantially during the same time. Development of visions continued throughout the acceleration stage, reflecting an increased interest in what SDCs could mean for the region, both in terms of potentials

for economic development and in terms of providing opportunities and challenges for mobility systems and spatial planning. For example, in a press release from 2016 Volvo Cars communicated that SDCs 'promises to free up congested roads, reduce pollution and allows drivers to use their time in their cars more valuably'. Similar statements can be found in local planning documents. Furthermore, a series of 'co-creation workshops' were organised at Lindholmen Science Park in which automotive actors and local planning officials met to discuss the potential benefits of SDCs.

However, while some core assumptions about the importance of SDCs for the future of West Sweden's automotive industry were forming among regional actors, our interviews also point to a number of contested visions about the route and direction of SDC development. When the city of Gothenburg was working with long-term visions and planning perspectives involving SDCs, they deviated from the 'car ownership norm' prevailing in the automotive industry, anchoring their visions in possible trajectories in which new mobility services are introduced alongside autonomous technology. The existence of contested visions has not materialised into actual conflicts among actors but it is possible to observe a clear divide. Many system level actors perceive autonomous driving technology as an alternative to private car ownership, whilst automotive firms see it mainly as an addition to the existing car-based mobility paradigm.

Finally, our interviews point to a shift from perceiving SDCs as being part of the active safety segment of the automotive industry towards becoming an own field with a number of defining features. In terms of the materialisation of visions, this can be observed in the ways through which automotive actors started to highlight the importance of software development in their activities with regional support organisations such as Lindholmen Science Park and Chalmers University.

4.2.3. Asset modification

Asset modification processes intensified during the acceleration stage. In terms of industrial assets, automotive actors went from reapplying existing active safety technology in the initiation stage to developing new dedicated SDC technology in the acceleration stage. One executive from Zenuity stated that:

> *'We are continuously updating a gap-list describing what is missing in order to execute the strategy that we have [towards unsupervised driving]'* (Interview)

This involved both the creation of new assets and the 'de-locking' of assets aligned to existing paths. One prominent example of the latter is how Volvo Cars and Autoliv transferred all patents and other intellectual property rights related to active safety software to Zenuity (see above), in order for the new firm to be able to use them in new ways than would have been possible within incumbent structures. In one of our interviews with Zenuity, it was expressed that the separation from the incumbent firms gave them long-term stability that would not have been possible if being organised as a joint project within existing structures. Similarly, inter-path interactions, primarily between the regional automotive industry and the IT industry, are also indications of de-locking processes of regional assets and redirecting them to SDC activities. This is illustrated by intensified interactions between IT firms and automotive firms, both in terms of collaborations in projects and in terms of labour mobility from IT firms to the automotive industry.

Apart from industrial assets, the acceleration stage involved the modification also of human, institutional and infrastructural asset to an extent that could not be observed during the initiation stage. In terms of human assets, courses and education programmes at Chalmers University were increasingly adapted to reflect the increasing need for software developers and engineers trained specifically in autonomous technology. For instance, a new group focusing on vehicle engineering and autonomous systems was established, offering courses in the context of international master programmes at the university. In addition, a prestigious student 'driverless racing car' competition was introduced in 2016, promoting students to engage in projects related to self-driving technology.

The acceleration stage also included a strong focus on the modification of institutional assets. For example, transformation activities included the dismantling of old standards and modes of working in the automotive industry, illustrating the beginning of a full departure from pre-transformation activities. In one of our interviews with an executive at Volvo Cars, it was expressed that:

> *"we [had to] transform our product development principles to more agile teams, scale up all the teams and get them to collaborate. We talk about 400-500 teams that should collaborate in an agile framework."* (Interview with executive at Volvo Cars)

Furthermore, the acceleration stage was characterised by an intense engagement with the adaptation of formal laws and regulations shaping the context for product trials and experimentation activities. Firm actors engaged in system-level agency to dismantle legislative barriers, most notably through activities seeking to adapt regulations for SDC trials. For example, Volvo Cars provided inputs to an investigation at the national level, aimed at mapping the legal preconditions for automated transport in broad terms. After intense lobbying efforts from regional actors and several rounds of discussions, a special national regulation for SDC trials and routines for issuing permits was in place at the end of 2017.

Finally, the acceleration stage featured the modification of infrastructural assets. The maturing of SDC technology implies an '*explosion in terms of testing and verification*' (Interview). Our empirical analysis demonstrates the importance of test infrastructure for supporting SDC development and attracting actors from other regions and countries to the region. In particular, test environments for road safety such as 'Asta Zero' (established in 2014) have been highlighted as crucial for testing and certifying SDC technology. According to interview partners, the establishment of Asta Zero was driven by regional interests, in particular Volvo Cars, who initially unsuccessfully lobbied for the construction of a test lane on a national highway between Gothenburg and the Volvo headquarters in Torslanda. Instead, they mobilised support for the establishment of a dedicated test facility in the region in collaboration with a nationally funded test-bed programme (Test Site Sweden) and secured funding from a range of different sources.

4.3. Consolidation stage

The 'broad commercialisation' of autonomous technology expected during the consolidation stage is yet to be observed in West Sweden (and elsewhere). The

commercialisation of new SDC technology is still taking place within the active safety segment of the industry, illustrating an interesting case of how new, potentially radical, technologies are introduced in 'old' market segments while waiting for new market possibilities to materialise. Industrial path transformation is thus 'running ahead' of the broader societal shift, as one can observe signs of consolidation in terms of the actor base, visions and asset modification.

4.3.1. Actor base

The number of actors involved in SDC activities has been growing continuously. Several dedicated SDC technology firms have emerged in the region, through spin-off and start-up processes and relocation from other regions. In addition, firms in other industries, most notably the IT industry, have diversified into SDC technology and inter-path acquisitions have taken place. This has been complemented by a continued engagement by actors from the public sector and regional support organisations.

4.3.2. Visions

Efforts concerned with belief formation have now consolidated to a shared understanding of SDCs as the future of the automotive industry in West Sweden. This is manifested in different ways. Autonomous driving has become an integral part of urban planning policies in Gothenburg and regional strategies refer to West Sweden as a 'self-driving region'. As of summer 2019, regional politicians wrote a debate article in a major Swedish tabloid, arguing for the importance of SDCs for the future of the region, and announced a substantial regional investment to increase the competitiveness of the regional vehicle industry (Expressen 2019). Empirical evidence thus suggests a broad consensus among public actors about the importance of supporting SDC development.

In addition, regional firms operating in different industries are signalling their interest in different aspects of autonomous technology through investments, such as the establishment of an AI research centre, and acquisitions. However, our study also shows that there is still no established consensus about what SDCs will mean for society. The contested visions outlined in the acceleration stage still prevail. Actors' decisions are based on different, sometimes incompatible, logics. An illustrative example is how the vision of reaching the more or less completely self-driving car is highlighted in the media and in discussions with public actors, while goals and strategies internal to the automotive firms are more oriented towards increasing the functionality of their existing cars, adding layers of self-driving features that will support the driver and car owner.

At the same time, our newspaper analysis indicates that the interest among journalists and the general public has shown signs of decline recently with around 30% fewer newspaper articles published in 2019 than in 2018. This should not be interpreted as an indication of a slow-down of transformation activities but rather indicates the consolidation of visions and expectations related to SDCs. While the 'hype' that was driving the initiation and acceleration stages has started to fade, transformation activities now relate to a broader set of objectives, such as digitalisation more broadly, and a shift towards software development and artificial intelligence as the competitive edge of the regional industry.

4.3.3. Asset modification

Some implications of the contradictions mentioned above can be observed in asset modification processes. Asset modification continues to target the re-deployment and re-orientation of existing regional assets, in combination with the creation of new assets. The destruction of old assets is however not as prominent as would be expected from the theoretical discussion. In some areas, existing assets still form barriers to full-scale transformation and whilst the empirical analysis shows early signs of how actors are acknowledging the need to destruct such assets, things are yet to take off on a broader scale. For example, several interview partners have highlighted how the main 'product' of the automotive industry is shifting from 'cars' towards 'software'.

Our empirical analysis also indicates that there are still institutional assets preserving 'old ways of doing things'. A case in point are old hierarchies and modes of working in the incumbent automotive firms. Our interview partners highlighted how platform-based development models among incumbent automotive firms need to shift towards more agile processes, inspired by how development projects are run in the software industry.

The most prominent signs of consolidation are instead found in the regional support structures emerging around SDCs. Throughout the acceleration stage, a number of support elements were introduced to deal with some of the challenges identified. Examples include organisations and initiatives promoting the attraction of extra-regional assets (like global start-ups and talent), as well as new research centres focused on technologies particularly important for SDC development such as AI and vehicle electronics. Our interviews also point to a consolidation of the funding system for R&D and innovation activities, now focused more explicitly on autonomous technology and AI. In addition, financial investments in the region by Geely, Volvo Cars Chinese owners, have increased substantially throughout the period of analysis and is a major factor for the dynamics of the path transformation process.

Also in terms of institutional endowments, the special regulations for SDC trials have been 'tried out' in practice. In 2018, Zenuity obtained a permit which allowed only trials with 'hands on the wheel' and banned automatic lane switching, followed by a permit with fewer restrictions in January 2019. The latest permit is, according to statements by Zenuity in the media, sufficient to perform the planned trials.

To summarise (Figure 2), as of the end of 2019, the path transformation process leading towards SDCs in West Sweden is still ongoing; some aspects have been consolidated while others remain fragmented and contested.

5. Conclusions

Over the past years, evolutionary economic geography (EEG) has contributed to our understanding of how and where industrial paths arise. In contrast, radical 'on path' changes have received limited attention and remain underexplored. In this paper we highlight the need to gain more insights into how such transformations of existing industries take place. We propose a stage model to cast light on the temporal pattern of change. Differentiating between three stages (initiation, acceleration and consolidation), we contribute to a more thorough understanding of how transformation activities within well-established paths unfold over time. Each stage in our model is believed to feature specific characteristics, pointing to the need to examine industrial restructuring from a process perspective.

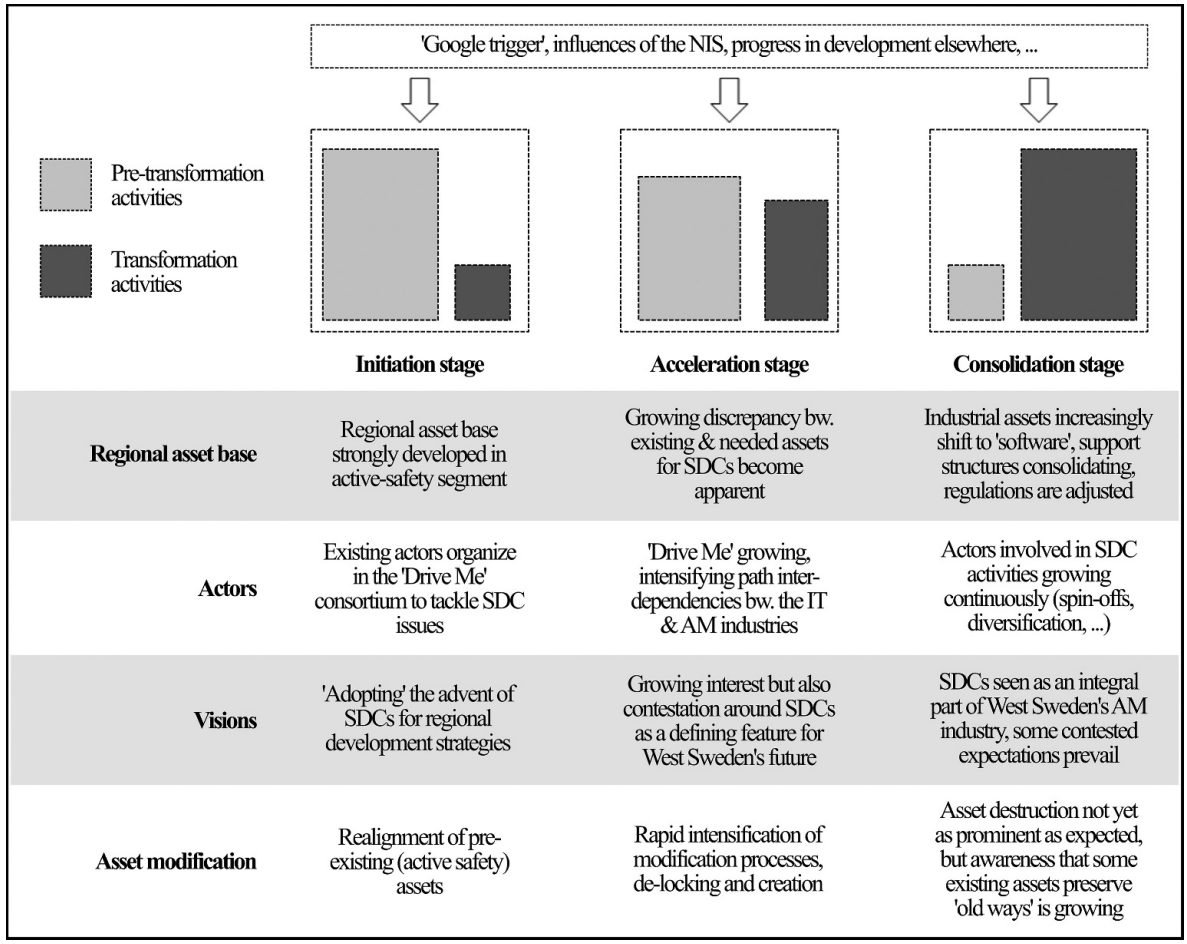

Figure 2. Transformation of West Sweden's automotive industry (AM . . . automotive, IT . . . information technology, NIS . . . national innovation system). Source: Authors' research.

Our approach is inspired by recent conceptualisations (MacKinnon et al. 2019, Trippl et al. 2020) seeking to capture a wider set of resources necessary for radical change to occur. Accordingly, different types of assets (natural, infrastructural, industrial, human, institutional) are seen as both the outcome of previous rounds of regional economic development and the platform for future ones. In line with other contributions (Trippl et al. 2020), this paper shows that fundamental change of mature industries involves substantial asset modification processes. Accordingly, actors from different domains – influenced by historically grown structures and future prospects – are engaging in deliberate and purposeful actions to alter the regional asset base. We claim that different asset modification processes, namely creation of new assets, redeployment of existing assets and destruction of constraining assets, differ in their relative importance depending on the stage of development.

Applying the conceptual model to the empirical case of West Sweden's automotive industry has provided a number of insights. First, the case study confirms the crucial yet often overlooked 'role of the future' for path development processes (Hassink, Isaksen, and Trippl 2019). This paper therefore makes a strong case for incorporating the dimension of vision building and collective belief formation into analyses of innovation-based path development. Visions are a subject to continuous re-evaluation and development, yet they are not random. They reflect previous experiences, current processes and

refer to actors' assessment of the probability of certain scenarios playing out in a certain way (Steen 2016). As our empirical analysis shows, such visions can be contested but agenda setting activities by system level actors can serve as a guide through the long-term, complex processes of path transformation.

Second, our empirical analysis reveals some deviations from the development patterns proposed in the conceptual framework. Most notably, asset creation has not been that important in the initiation stage due to the already mature asset base in the active safety segment.

Third, as the transformation of West Sweden's automotive industry is not yet consolidated and asset destruction processes are expected to take place in later stages of development, large-scale destabilising endeavours are yet to be observed. Thus, further research investigating the nature of asset destruction and de-alignment is required. Key questions may include: What role does power play in this regard? How do incumbents and other actors facilitate or prevent asset destruction or de-alignment? How can policies orchestrate and accelerate asset destruction (Kivimaa and Kern 2016) at different spatial scales?

Lastly, the empirical case proves the necessity to pay attention to inter-path relations (Frangenheim, Trippl, and Chlebna 2020). Path transformation in the automotive industry is facilitated by drawing on assets (skilled labour, working routines) from the IT industry in the region. This leads to both collaboration and competition between the two paths and creates strong path interdependences. More research is required to unravel how transformation activities in one industry affect and are affected by activities in other industries.

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Co-author declaration for the following joint paper

This declaration states the research contribution (e.g. research idea and – question; data compilation, manipulation and modelling; design and preparation of graphics, maps and tables; writing of text) of the candidate, the main supervisor (where he/she is an associate author) and the other authors.

If applicable, the contributions from other PhD candidates who have or intend to include the paper in a thesis should be described. Contributions from master students should also be mentioned.

Research contribution details

Name of candidate:

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Independent contribution of candidate:

Simon Baumgartinger-Seiringer, the PhD candidate, had the initial research idea for this paper and acted as first author. He was therefore responsible for managing the overall process. Simon pinpointed the research gaps addressed, formulated the overarching research goals and aims and developed the paper's conceptual parts (including the framework and the figures). Furthermore, he was involved in the data analysis (transcribed interviews).

In terms of writing, Simon has authored the original draft of the introduction (section 1), the literature review (section 2), the conceptual framework (section 3) and the conclusions (section 5). Moreover, Simon was in charge of the revision process in these sections and addressed the reviewers' and the editor's comments. As corresponding author, he was also responsible for the publication process.

First author's contribution:

The candidate is the first author (for contribution see above).

Contributions of other authors:

Johan Miörner, the second author of this paper, contributed mainly to the empirical part of the paper. He conducted the data collection in West Sweden (qualitative, semi-structed interviews), transcribed these interviews and - together with Simon - analysed this data. He authored the empirical part and addressed the reviewers' and editor's comments that were concerned with the empirical section. Moreover, Johan provided feedback and ideas for developing the conceptual parts of the paper.

Michaela Trippl, the third author of this paper, was mainly in a supervising role. She provided guidance and feedback throughout the whole development and writing process. Thereby, she contributed to all sections of the paper, e.g., in terms of structure, clarity and focus.

Contributions from other colleagues and master students

Has this paper been, or will this paper be part of another doctoral degree thesis?

Yes: ☐ No: ☒

If yes, please elaborate:

Contributions from master students:

Yes: ☐ No: ☒

If yes, please elaborate details:

First author's declaration of contribution for candidate

First author's name:

Not applicable (the candidate is the first author)

Do you verify that the candidate has contributed to this joint paper as described above?

Yes: ☐ No: ☐

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If applicable first author's signature:

Second co-author's declaration of contribution for candidate

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Yes: ☒ No: ☐

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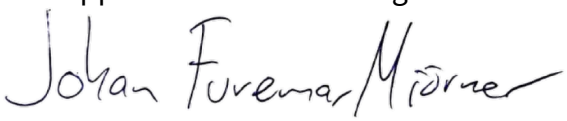

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Paper #2

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'Automotive regions in transition: Preparing for connected and automated vehicles'

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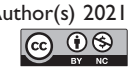

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Automotive regions in transition: Preparing for connected and automated vehicles

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Abstract

The advent of 'connected and automated vehicles' (C/AV) is posing substantial transformation challenges for traditional automotive regions across the world. This article seeks to examine both conceptually and empirically how automotive regions reconfigure their industrial and support structures to promote new path development in the C/AV field. Drawing on recent conceptual advances at the intersection of evolutionary economic geography and innovation system studies, we develop an analytical framework that casts light on how regional preconditions provide platforms for asset modification that underpin different routes of transformation. We distinguish between a reorientation route and an upgrading route. The framework is applied to a comparative analysis of industrial path development and system reconfiguration towards C/AV in two automotive regions, namely Ontario (Canada) and the Austrian automotive triangle.

Keywords

Regional restructuring, new path development, asset modification, innovation system reconfiguration, connected and automated vehicles

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Introduction

Over the last decade, rapid advancements have been made in the field of connected and automated vehicles (C/AV).[1] Together with other mobility innovations such as battery electric engines and car sharing, C/AV pose significant transformation challenges for traditional automotive regions. This article addresses the question of how these regions are reinventing themselves to remain important automotive locales in the era of C/AV. More precisely, our aim is to deepen understanding of the ways in which such transformation processes take place and why they differ across regions.

Arguably, the question of how regions respond to path-breaking innovations has long been on the research agenda in Economic Geography and related disciplines. Recent work has begun to complement conventional Evolutionary Economic Geography (EEG) models, arguing for a systemic approach to innovation-based regional restructuring (Binz et al., 2016; Trippl et al., 2020). This literature shows that regional structural change varies considerably across regions, reflecting highly differentiated opportunities and capacities to adapt industrial structures and the wider regional innovation system (RIS). To advance understanding of variegations in regional capacities to embrace radical change, we develop an analytical framework that places varying regional preconditions at center stage and links them to asset modification processes that underpin new industrial path development and RIS rearrangement. We contrast two routes of transformation, that is, a 'reorientation route' and an 'upgrading route'.

Taking Ontario (Canada) and the Austrian automotive triangle as empirical case studies, the article illustrates the different routes that traditional automotive regions are taking as they strive to cope with the advent of C/AV. Both Austria and Canada are part of the – arguably under-studied – semi-periphery of the global automotive industry (Mordue and Sweeney, 2020; Pavlínek, 2018). According to Pavlínek (2018), such locations are characterized by high levels of foreign ownership and the lack of domestic OEMs, but have relatively high production costs. Due to the move of automobile production to lower labor cost nations, semi-peripheral automotive locations have recorded an absolute or relative (macro-regional or global shares) decline of vehicle production since 2000 and are seeking to redefine their competitive advantage that neither stems from the power of core locations (such as the US or Germany) nor from cost advantages of the integrated periphery (like Mexico or Eastern European countries) (Mordue and Sweeney, 2020). Therefore, Ontario and the Austrian automotive triangle serve as interesting cases for examining *how* places reposition themselves in times of profound change in the context of global automotive production networks.

This article shows that the reorientation route is found in Austria, where automotive and microelectronic firms pursue path renewal and diversification strategies, backed by re-alignment processes taking place in a well-established innovation system. The upgrading route is prevalent in Ontario, where C/AV development is driven by ICT firms and an expansion of RIS support structures in fields such as IT and artificial intelligence.

The remainder of this article is structured in five parts. The next section synthesizes key propositions of the systemic approach to innovation-based regional restructuring and develops an analytical framework. The following sections present the results of our empirical investigation of C/AV development in Ontario and the Austrian automotive triangle and our comparative analysis. Finally, the last section concludes.

Innovation-based regional restructuring: Systemic conceptualizations and routes of transformation

Expounding how structural change unfolds across space is a major focus of EEG research (Martin, 2010). EEG models assert that new growth paths draw on preexisting technologically or skill-related industrial structures and highlight how firms spur regional structural change by recombining existing regional capabilities (Boschma, 2017). These models have helped to grasp the endogenous and firm-driven dimensions of path development. Yet, they are not without their shortcomings. They have been criticized for neglecting exogenous sources of change, downplaying the role of non-firm actors and power, and ignoring the importance of territorial institutions (e.g. Hassink et al., 2019; Pike et al., 2009).

Systemic approach to innovation-based structural change

In response to the critique leveled against conventional EEG frameworks (see above) recent work has begun to scrutinize new path development activities from a systemic perspective (Binz et al., 2016; Trippl et al., 2020), providing a comprehensive understanding of how technological and other forms of disruptions trigger changes in existing industrial paths.

Systemic perspectives move beyond industry-centered explanations and argue for incorporating changes in the wider RIS into analyses of regional industrial path development. They highlight that regional industrial dynamics promote instability and change in the organizational and institutional support arrangements (Isaksen and Trippl, 2016). Put differently, new path development is often associated with a transformation of the support structures of RISs. Systemic conceptualizations extend firm-led views propagated by traditional EEG frameworks and call for the adoption of a multi-actor approach that brings into focus other actors (such as universities, policymakers, intermediaries) besides firms and centers attention on the manifold roles they play in facilitating new path development and RIS reconfiguration (Hassink et al., 2019). Both firms and non-firm actors (that is, innovation system actors) are said to contribute to the modification of industrial, human, institutional and infrastructural assets (MacKinnon et al., 2019; Maskell and Malmberg, 1999) that underpins the restructuring of industries and RISs.

Arguably, the question of how assets are modified for new path development remains poorly understood. Recent work (MacKinnon et al., 2019; Trippl et al., 2020) has sought to shed light on this issue, suggesting that asset modification may take different forms, including (i) the redeployment of existing assets; (ii) creation or importation of new assets; and (iii) the (strategic) destruction of old assets. Asset modification manifests itself in the generation of new (or re-combination of existing) technological and non-technological knowledge, development of the skill base, unlearning of old practices, adaptation of regulatory frameworks, legitimation efforts, financial investments, and so on.

Unpacking change processes in the industrial and support structures

In line with evolutionary frameworks (Martin, 2010), we contend that the capacity of regions to embrace radical innovations like C/AV is shaped by previous rounds of regional development. Focusing on traditional automotive regions and employing a systemic perspective (see the previous section), this does not only direct attention to the historically grown firm and industry structures in these places but also to the organizational and institutional support configurations inherited from the past (Trippl et al., 2020). We maintain that these historically given industrial and support structures provide platforms for asset modification that undergird distinct outcomes in terms of new regional industrial path

development in the C/AV field and RIS reconfiguration (Baumgartinger-Seiringer et al., 2020b).

Lately, various contributions have led to a better understanding of how regional industrial path development and RIS transformation take place. We briefly summarize some key insights from this literature and expound how this work could help to grasp change processes in the industrial and support structures in regions.

Recent work provides a nuanced understanding of regional structural change, distinguishing between different forms of new regional industrial path development. Main forms include (see, e.g. Isaksen et al., 2018) path renewal (referred to as major changes of an existing regional industrial path into a new direction based on the infusion of new technologies and other innovations), path diversification (defined as moves of established firms from other sectors into a new field), and path creation (understood as the rise of new industrial activities through start-up firms). This serves as a stepping stone for a differentiated view of how new path development in the C/AV space may unfold. New industrial activities in the C/AV field and associated asset modification might reflect path renewal activities by innovative automotive firms. Asset modification may also be driven by path diversification endeavors of established firms from other sectors such as the ICT industry, which branch into the C/AV field, or by start-ups and their path creation activities.

As noted above, changes in the organizational and institutional support structures are vital to provide firms pursuing new path development activities with the needed assets. It is argued that – depending on the region under consideration – support structures may be characterized by a high degree of 'thickness', that is, the presence of strongly elaborated and dense support configurations, or they may feature 'thinness', defined as the absence or weak elaboration of support configurations (see, e.g., Isaksen and Trippl, 2016). What is more, support structures may show different degrees of alignment with the industries located in the region (Baumgartinger-Seiringer et al., 2020a). There are strong reasons to suggest that the reconfiguration of support structures takes place in different forms depending on these characteristics. In regions with highly elaborated and strongly aligned structures, RIS changes unfold mainly through reorientation and re-alignment of existing support elements. In regions with weakly elaborated and/or weakly aligned structures, key processes of change include building up RIS elements and align them to regional industrial paths (Baumgartinger-Seiringer et al., 2020a). These considerations pave the way not only for further specifying the initial conditions in automotive regions but also to reflect upon different ways in which support structures in these places may change in response to the advent of C/AV.

Routes of transformation

Employing a systemic approach as outlined above, we distinguish between two different routes of transformation towards C/AV, namely a 'reorientation route' and an 'upgrading route'. The route taken by traditional automotive regions will depend on initial conditions in the form of the industry mix, the innovation capabilities of domestic and foreign firms and their embeddedness in the RIS. The ways in which regions are inserted into global automotive production networks (MacKinnon, 2012; Yeung, 2015) also matter, shaping the room for maneuver (autonomy over new product and process development) of subsidiaries and the role played by multinational enterprises (MNEs) in asset modification. The quality and alignment of the organizational and institutional support configurations found in traditional automotive regions also form essential initial conditions that influence what is possible (and needed) in terms of asset modification.

Accordingly, the 'reorientation route' is expected to be taken in regions hosting a well-established automotive industry that is strongly embedded in elaborated RIS structures. The main impulse for transformation is likely to come from path renewal efforts of automotive firms seeking to reorient themselves to cope with radical change induced by C/AV. This might be complemented by diversification endeavors of firms in other paths such as the ICT sector. On the one hand, the well-developed support structures – often strongly aligned to the needs of established firms – provide assets for new path development activities in the C/AV field. On the other hand, however, the support system itself will require major modification and reorientation. This is because adherence to historically developed assets unable to reorient (Baumgartinger-Seiringer et al., 2020a) and rigid ties between different structural elements might hamper the initiation of change in such settings (Grabher, 1993).

In contrast, the 'upgrading route' is expected to be taken by regions that host an automotive path with weak innovation potential (and thus limited renewal capacities) and poor embeddedness in the RIS. Support structures are either well elaborated but weakly aligned or weakly developed altogether. Despite these conditions, such regions might be attractive locations for transformations. The advent of radical innovations like C/AV might open new windows of opportunity and reveal regional potentials (e.g. in the form of an innovative complementary path, previously unexploited assets, etc.). To benefit and draw on new potentials, upgrading and alignment efforts in both the firm sector and the support structures are necessary. Asset modification might reflect diversification efforts of firms in complementary paths (like the ICT industry) and needs to be backed by building up or further strengthening organizational and institutional support structures and aligning them to the requirements of industrial paths in the region.

Coping with the advent of C/AV: Empirical evidence from Ontario and the Austrian automotive triangle

In this section, we analyze new industrial path development activities and processes of innovation system rearrangement towards C/AV in two regions, namely Ontario (Canada) and the Austrian automotive triangle. These regions have been selected for a comparative case study analysis for two reasons. First, they share some important similarities. Both Ontario and the Austrian automotive triangle are traditional supplier regions at the semi-periphery of the global automotive industry. Second, despite these commonalities, the two regions differ in terms of innovation capabilities residing within the automotive sector and – equally important – within complementary industrial paths. They also differ in terms of their historically grown organizational and institutional support structures. This creates varying preconditions for coping with the advent of C/AV, allowing for empirical examination of the conceptual propositions outlined in section 'Innovation-based regional restructuring: Systemic conceptualizations and routes of transformation'.

Methods and data

The findings from Ontario are based on forty qualitative interviews (including four automotive firms (interview codes OA_1-4), three advanced manufacturing companies (OM_1-3), twelve software firms (OS_1-12), three telecommunication companies (OT_1-3), three representatives from industry associations (OI_1-3), eight government agencies (OG_1-8) and seven representatives from consulting and intermediary bodies (OC_1-7)), participant observation in meetings between various stakeholders and a review of primary and secondary literature over two years (2016–2018). One of the authors also participated in an expert

panel reviewing the current and potential impact of the advent of C/AV on the automotive sector. Our empirical analysis of the Austrian case draws on twenty-five in-depth interviews (including three automotive firms (AA_1-3), three microelectronic companies (AM_1-3), three representatives of industry associations (AI_1-3), seven government agencies (AG_1-7), four representatives from consulting bodies and intermediaries (AC_1-4) and five research and educational organizations (AR_1-5)) in the first half of 2019. To complement the interviews, an intensive document analysis has been carried out. Additionally, participant observation in conferences contributed to further robustness.

Even though the interviews were open-ended and adapted to the interviewee's background, every interview followed a similar structure covering four main areas of inquiry:

1. The broader picture of the transformation of the automotive industry and its impact on the organization/department and the region (concrete changes within the entity/region in recent years; changes in partnerships and competitors; changing spatial patterns).
2. Enabling and constraining regional conditions (talent, capital, knowledge infrastructure, formal and informal institutional set-ups, government support).
3. Modification of firm-specific and regional assets (ongoing endeavors; bottlenecks).
4. Visions and expectations (perception of future development; opportunities and challenges for the entity/region; common/contested visions).

Interviews were usually around an hour long, with some exceptions lasting up to three hours. Transcribed interviews for both case studies were analyzed using a content analysis of themes that emerged from the interviews.

The case of Ontario

Ontario is a traditional automotive region with considerable strengths in parts production and vehicle assembly. Since early investments by US-American MNEs and conclusion of landmark trade agreements such as the Canada-US Auto Pact in 1965 and the North American Free Trade Agreement (NAFTA) in 1993, the automotive sector has been one of the main drivers of growth in the provincial economy (Anastakis, 2005). Although automotive production has fallen 25 per cent from its peak in the early 2000s, it was still the largest automotive region in North America in 2017, with nearly 2.2 million vehicles produced, accounting for 18.5 per cent of manufacturing GDP. Ontario hosts five original equipment manufacturers (OEMs), over 700 parts producers plus 500 tool, die and mold makers, with 85 per cent of the products exported (Ontario, 2019). Their operations are concentrated in the Greater Toronto Area and the southwestern parts of the province (Rutherford and Holmes, 2007). A series of disruptions in the North American automotive industry since the early 2000s, including the increasing shift of vehicle production to southern US states and Mexico, the impact of the 2008/09 financial crisis and shifts in consumer demand, pose a significant challenge for Ontario' automotive sector (Yates and Holmes, 2019).

Initial conditions. Historically grown production structures have created rather weak preconditions for path renewal towards C/AV in the region's automotive industry. The region has traditionally prioritized production over innovation-related activities (Anastakis, 2005). Due to the absence of any domestic OEMs, Ontario's automotive industry has limited autonomy over new product and process development. Additionally, the region does have a number of leading Tier-one suppliers, including Magna International, Linamar, Wescast,

ABC Technologies, and Martinrea. However, these suppliers have thus far performed limited automotive R&D in Ontario and have shown a poor embeddedness in the RIS (Gertler and Wolfe, 2004).

In recent years, however, constraining conditions have gradually been changing towards more enabling ones. On the one hand, the rapid growth of the ICT sector in the region provides new opportunities for renewal activities in the car sector (see below). On the other hand, organizational and institutional support structures have been strengthened through various policy initiatives. In response to the overall decline in vehicle assembly, the policy domain has shifted the focus to expand the research infrastructure for automotive R&D investment. In this regard, the federal government has worked to attract R&D through programs such as the Automotive Innovation Fund and the Automotive Supplier Innovation Fund, which provided financial incentives for MNEs to research greener and more fuel-efficient vehicles in Canada and Ontario (Holmes et al., 2017). Automotive-focused policies were supported by broader funding programs (such as the Network of Centers of Excellence) to incentivize university-industry collaboration (Doern et al., 2016).

Ontario is also home to one of the largest concentrations of ICT firms in North America (Denney et al., 2020). As noted above, this may well benefit path renewal in the automotive sector. At the same time, it creates favorable conditions for diversification activities into the C/AV field by ICT firms themselves. ICT industries are the largest performers of R&D in the Canadian private sector (ISED, 2020). Unlike the automotive industry, ICT clusters emerged by exploiting local knowledge assets to commercialize new products and services (Lucas et al., 2009), featuring a strong embeddedness in the RIS, which is well aligned to their needs.

Ontario's ICT sector is spatially concentrated in three cities. Ottawa's digital economy offers access to hardware expertise, which allows companies to develop reliable networking technologies underlying the internet of things. Ottawa hosts R&D and production activities by established foreign firms (Alcatel-Lucent, Cisco Systems Canada, Huawei Technologies Canada, CIENA Corporation and Mitel Networks) as well as a number of newcomers (Corsa Technologies and CENX) and domestic leaders like QNX (Haley et al., 2017). Toronto is a hub for artificial intelligence (AI) with Google, Uber, Nvidia, LG and Samsung all opening labs in the city to tap into its leading position in machine learning and deep learning (Denney et al., 2020). The federal and provincial governments have strengthened this position by providing support for the Vector Institute, designed to expand the depth of research in AI. Finally, Kitchener-Waterloo has strengths in various ICT segments (communications equipment manufacturing, software etc.) and is also home to the headquarters of large domestic technology companies like Blackberry, Open Text and hosts one of the most vibrant start-up scenes in the region (Spigel, 2016). In terms of the support structures, a vibrant system of research universities, incubators and accelerators, large pools of skilled workers and strong civic and industry associations is found, creating good conditions for path diversification (Figure 1).

Asset modification for C/AV: The firm and industry level. Seventy percent of the interview partners (including industry associations, government officials and companies) stated that the future of the automotive industry in Ontario would lie in the region's ability to capitalize on the expertise residing within the ICT sector (interviews OA_1-4, OS_5-12, OT_1, OI_1-3, OG_1-8, OC_1-5).[2] This would also change the geography of the automotive sector as Ottawa and Waterloo become important players in addition to the traditional automotive clusters around Toronto and the Southwestern parts of Ontario. In other words, the progressive

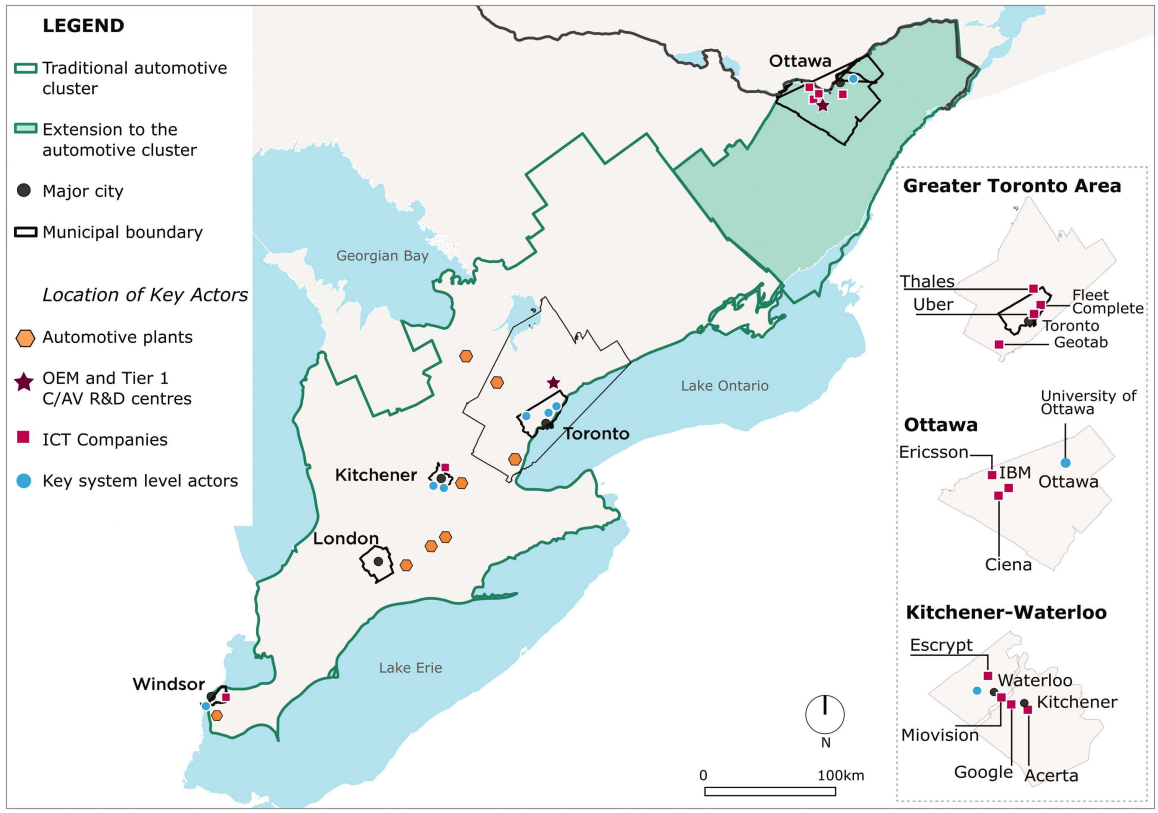

Figure 1. Location of key firm and system level actors in Ontario - Source: authors' compilation based on Cutean (2017), Ivus et al. (2020), AVIN (2020) and author data.

digitization of the automotive industry reveals new potential in Ontario's asset base for automotive players and entrants from the ICT sector to draw upon.

Asset modification for automotive path renewal includes forging linkages to the ICT sector and enhancing the historically weak embeddedness of automotive companies in the RIS. In order to tap into the region's ICT assets, the MNEs are forging a growing range of alliances with the numerous ICT start-up and scale-up firms that are developing technologies for C/AV (OA_1-3, OT_1-3). Furthermore, the automotive MNEs are shifting the locus of their regional investment strategy away from vehicle assembly towards automotive and C/AV R&D (OA_1-3). This strategy involves drawing upon the considerable assets found in the region's research infrastructure and the high quality of labor in fields such as computer science and electrical engineering.

Both GM and Ford are among the more active foreign OEMs who have announced major expansions of their R&D in C/AV related activities and a significant enhancement of the local human asset base. GM is expanding its Canadian Technical Centre in Toronto (in close vicinity to major research centers by IBM, Huawei and others). Its goal is to employ 1,000 research engineers in that centre within the next few years. It recently announced the conversion of its old Oshawa assembly plant to a test center for C/AV and is building a new urban mobility research center in Toronto (Lee-Shanok, 2018). For its part, Ford recently announced the opening of its Ottawa Research and Engineering Centre, staffed with 300 former Blackberry employees, as well as its Waterloo Innovation Centre to help develop connectivity and infotainment software (Davis, 2019; Lord, 2020a). Although the

fundamental decisions about future directions of firm strategy and R&D to be allocated to Ontario are made at the MNE corporate headquarters, (e.g. in Michigan), there is growing evidence that the subsidiaries – by drawing on and bolstering ICT assets in the RIS – have enjoyed recent success in expanding C/AV innovation activities.

The weak link within the region's automotive industry continues to be the domestic Tier-one suppliers who have only allocated 18 per cent of new R&D activities to facilities in Southern Ontario compared with 45 per cent in Michigan and 36 per cent in Germany and Austria (Carey, 2019; Mordue and Sweeney, 2020). Magna, the largest Tier-one supplier, maintains an electronic research center in the Toronto region, but is conducting most of its C/AV research in the US. The exception is Linamar, which recently announced a major investment in a new innovation center working on AI and advanced manufacturing technologies in Guelph, Ontario (Saxon, 2018).

The region's ICT sector does not only support path renewal in the automotive industry but is also moving itself towards the C/AV space (OS_1-12; OT_1-3). Both domestic and foreign ICT companies have been engaging in path diversification activities, expanding their R&D capabilities in AI and 5 G mobile technologies that are critical for the emerging C/AV field. Blackberry has opened an innovation center for C/AVs and is working with the University of Waterloo to test self-driving technology (Newcomb, 2016). It also performs the majority of its C/AV research in Canada (OS_12). Uber's AI research lab in Toronto complements this indigenous research, drawing on research strengths at the University of Toronto (McBride, 2019). QNX continues to conduct its world leading research in operating systems in Ottawa, where Apple has also opened a major research center (Gurman and Webb, 2016). Finally, telecom companies in the region have made substantial investments in a $400 million public-private network (ENCQOR) to promote research into 5 G technologies and their adoption in C/AV (OT_1-2; OI_2; Lord, 2020b).

The region also hosts a pool of tech (predominantly SME) companies, who are developing a wide array of new C/AV-related technologies, but who face high entry barriers to new mobility markets (OS_1-12; Bezruchonak, 2018). They don't just produce in-car technologies but also create solutions for sustainable public transportation systems (e.g. route optimization for fleets) and the intelligent infrastructure needed for connected vehicles (traffic data collection and analysis). One example is Leddartech that recently opened a research lab in Toronto to expand its research on Lidar technology. Our interviews with five of the software companies suggest that in the initial stage they are pivoting between different markets, including intelligent transportation services (ITS) to expand their customer base, since their products and services have broad applicability (OS_1-5).

Asset modification for C/AV: The innovation system level. The success of Ontario in the transformation towards C/AV will not only depend on firm-side asset modification. A wide range of system level actors, including all three levels of government, universities, intermediaries, and industry associations are playing an increasingly active role in shaping asset modification and upgrading the innovation system (KPMG, 2019; Mordue and Karmally, 2020).

Governments at multiple levels have mobilized resources and stakeholders to stimulate concerted action in the C/AV space. One goal of these efforts is to increase the historically weak automotive MNEs' embeddedness in the innovation system and encourage them, as well the more strongly embedded ICT MNEs, to undertake more of their innovation activities in the C/AV space in Ontario.

Increased investment in the research infrastructure has expanded the base of automotive research capabilities. Their historically weak alignment to the automotive path also gives universities the flexibility to pivot away from traditional automotive engineering and

manufacturing to software-driven technological innovation and education (OC_6-7). At present, twenty-four colleges and eleven universities offer auto-related research and training programs, growing the pool of graduates in the region (Ontario, 2019). Subsidiaries exploit the increase in local university research capacity and qualified graduates as well as the region's status as a tech hub to lobby their parent companies for the additional R&D mandates in Ontario (Goracinova and Wolfe, 2019).

State and non-state intermediaries also initiated local action to develop a new bottom-up socio-technical vision for Ontario, drawing on the strengths of non-traditional automotive locations (OI_1-6). Since 2017, both the Waterloo and Ottawa regions have been framed as Autonomous Vehicle clusters (Region of Waterloo, 2019). In each case, intermediaries are collaborating to deepen connections between companies (OS_1-5; OI_1-6). Waterloo's economic development agency partnered with Ontario's automotive parts manufacturer's association (APMA) and has recently announced Project Arrow to showcase the capabilities of local SMEs in C/AV technology. In Ottawa, the region's business association (Kanata North) and foreign investment attraction agency (Invest Ottawa) have partnered with QNX, the city and academia to establish Ottawa as Canada's C/AV capital.

These bottom-up initiatives, along with automotive manufacturing job loss, encouraged a longer-term policy approach on both the provincial and federal level (interviews OP_1-6; OI_1-4). In 2016, Ontario's provincial government launched a ten-year pilot program to allow the testing of automated vehicles on Ontario's roads. In 2017, it introduced the five year, $80 million, Autonomous Vehicle Innovation Network (Kovacs, 2017). It funds training, later-stage R&D projects and has created six regional technology development sites dedicated to specific aspects of C/AV technology. The federal government has launched the $3 million program to advance connectivity and automation in the transportation system. This funding helps the provincial Ministry for Transportation to plan for the implementation of C/AV in the Greater Toronto and Hamilton areas (WSP and OCE, 2019). Overall, in the absence of strong MNE embeddedness in the semi-periphery, institutional asset modification has taken place to support company entry into emerging mobility market GPNs.

Emerging outcomes and challenges. There are considerable efforts underway to accelerate the transition of Ontario from its historical role as a traditional automotive producing region to a new R&D center for C/AV. Upgrading processes are driven by the diversification activities of a dynamic domestic ICT sector and AI and other capabilities residing within the support system that has been expanded over the past few years. Despite Canada's low share of traditional automotive R&D, Ontario has produced an increasing volume of C/AV patent applications (Mordue and Karmally, 2020).

There is also evidence of expanded support structures and attempts to align them to the needs of the automotive and ICT paths. Strong policy initiatives have created incentives for different actors to work and partner in the C/AV space. C/AV-related innovation activities by both automakers and ICT entrants are one the rise in Ontario and lead to a growing degree of embeddedness of automotive and in particular ICT firms in the RIS. Changing Ontario's position in global automotive production networks is a demanding task. Still, the underlying dynamism of the region's ICT industry and responsive support structures give it a competitive edge that may enable changes. A crucial challenge is to continue to increase the historically low levels of automotive R&D that the OEMs and Tier-one suppliers have performed in Ontario (Gertler and Wolfe, 2004; Mordue and Sweeney, 2020).

The case of the Austrian triangle

The automotive industry is a key engine of the Austrian economy. In 2018, almost 400,000 employees (10 percent of the Austrian workforce) were working in companies directly or indirectly connected to the automotive industry (Kleebinder et al., 2019). The industry shows a strong geographical concentration in the provinces of Styria, Upper Austria and Vienna, here referred to as the Austrian automotive triangle. The Austrian automotive industry counts over 900 companies (including internationally recognized firms such as AVL List, Magna Steyr, KTM and BMW's engine plant) and covers large parts of the value chain (Schneider et al., 2018). Over the last two decades, Austrian automotive production has tripled (from 6.38 billion in 2000 to 18.5 billion Euros in 2019; WKO 2020). In contrast to many other semi-peripheral automotive regions, vehicle production has increased both in absolute numbers and relative to European production between 2000 and 2018, but its share of global production has declined (Mordue and Sweeney, 2020). Around 82% of revenue is generated by large companies with 250 or more employees (Schneider et al., 2018). With nearly 90 percent of their products being shipped abroad, Austrian automotive firms show a strong export orientation (WKO, 2019).

Initial conditions. Although Austria is not home to any domestic automotive OEMs, there are favorable conditions for path renewal. The Austrian car industry with its historically grown supplier structure and strong ties to German OEMs exhibits a strong innovation capacity. In the period 2011–2015, every 67th automotive patent applied globally was by an Austrian firm (Helmenstein et al., 2016). Austria has the third highest share of business expenditure on R&D of the total value of production in the automotive industry in Europe (Eurostat, 2017). In 2016, not fewer than 62 percent of the automotive firms were reporting research collaborations with universities and other research organizations (Statistik Austria, 2016).

Additionally, there are enabling conditions for path diversification. Austria hosts a dynamic and R&D-driven microelectronics industry that is strongly interwoven with the automotive industry. Per capita and in percentage of total production value, Austrian manufacturers of electronic components and boards are second only to Switzerland in terms of business expenditure on R&D in Europe (Eurostat, 2017). Firms such as Infineon (semiconductors, 44%), NXP (microelectronics, 47%), AT&S (circuit boards, 36% in segment '*automotive, industrial, medical*'), and AMS (sensors and chips, 26% in segment '*automotive, industrial, medical*') create large shares of their revenue with their automotive segments.[3] These firms recognized early the importance of system understanding and consequently find themselves in promising positions to contribute to and profit from the transformation towards C/AV (Figure 2).

The microelectronics and automotive paths are backed by thick innovation system structures. Especially the automotive industry exhibits a strong embeddedness in a highly elaborated organizational support structure, including research institutes, technical universities, cluster organizations and other intermediaries, lobbying organizations and so on. This holds true for both domestic and foreign players in the automotive field (Trippl and Otto, 2009). Given the large number of employees, policy actors have been showing a strong willingness to support the industry. Many interviewees pointed to a '*special culture of cooperation*' (AA_1) between automotive firms, support organizations and policy. For example, long-standing relations between firms and universities have led to strong alignment of the research and educational system to the needs of the automotive path. Various networking initiatives like 'innoregio styria' and cluster organizations provide platforms for exchange between stakeholders from different domains. While most interviewees emphasized the

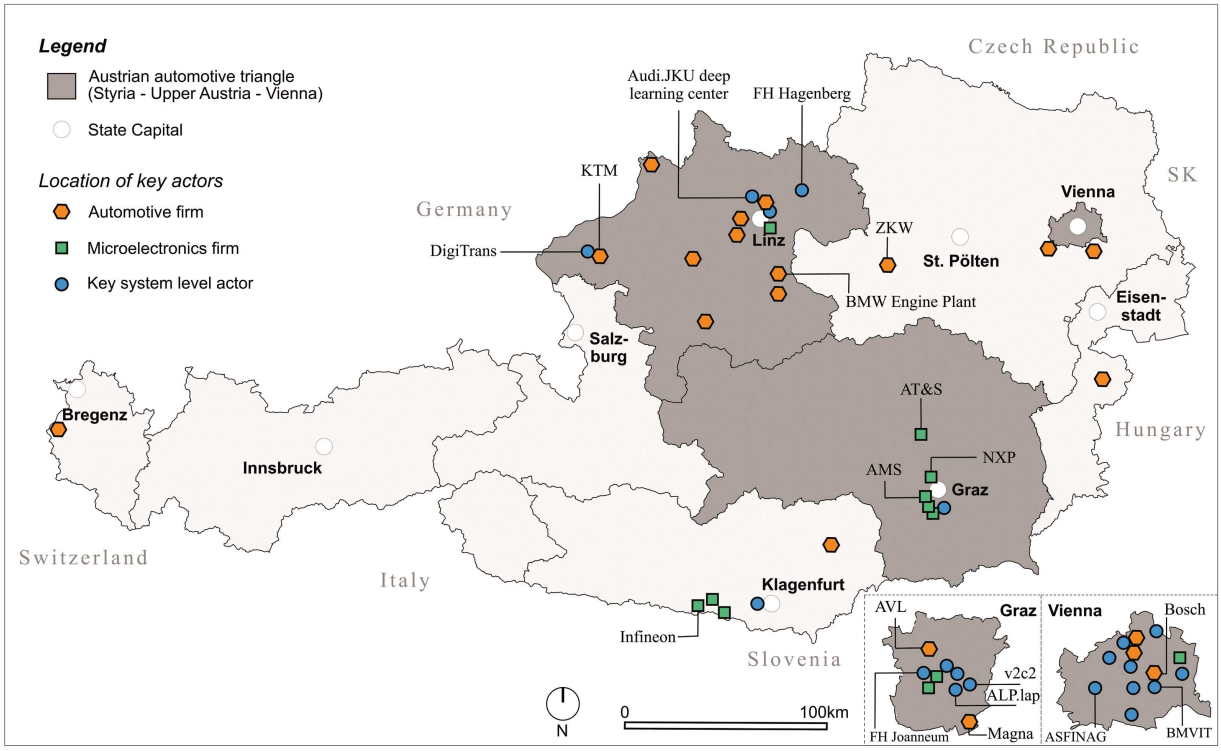

Figure 2. Location of key firm and system level actors in Austria - Source: authors' compilation based on Industriemagazin (2017), Deutschmann (2018), BMVIT (2018) and author data..

positive dimension of these strong ties (AA_1-3, AM_1-2, AI_2-3, AG_1&3–5, AC_1&3, AR_1&3–5), others (also) expressed concerns over negative lock-in effects (AA_1-2, AG_6, AC_2) (Grabher, 1993). In relation to the recent emission scandal, our interviews point to a system formed by authorities, firms, engineers and other actors that '*saw itself in a state of satisfaction*' (AA_2).

Asset modification for C/AV: The firm and industry level. Climate change, the emission scandal and the diminishing importance of cars as a status symbol (AI_3, AC_3, AR_1; Stricker et al., 2018) have led to skepticism about the automotive industry and its future role as a key sector of the Austrian economy. Consequently, many players in the automotive field welcome the advent of C/AV, considering it as a way to cope with the threat of a downturn. Many Austrian suppliers see the shift from hardware and classic mechanical engineering to software as a new growth opportunity and as a chance to reposition themselves within the value chain (AA_1-2, AM_1-3, AI_3). This goes hand in hand with larger trends of de-verticalization and changing relations between assemblers and suppliers, where the former pass responsibilities to the latter due to the increasingly dynamic development of automotive production technologies as well as time and price pressures (Dicken, 2015).

Especially larger R&D-driven supplier firms in both the automotive and microelectronics industry have begun to enter the C/AV field. Arguably, these path renewal and diversification efforts imply the creation and redeployment of human and industrial assets (in form of retraining the work force, recruitment of IT specialists, mergers and acquisitions, etc.). The Styrian firm AVL, the world's largest independent company for the development, simulation and testing of drive systems, has announced various strategic partnerships (among others with the visual computing company Nvidia, German safety certification TÜD

SÜD and the cyber security firm Kaspersky) to deal with challenges such as public acceptance, vehicle certification and security (AVL, 2017, 2018). AVL has also reported high job growth rates in its ICT and C/AV-related fields, but due to a lack of human assets (see also below), AVL is growing faster in other regions than in Styria. The Austrian branch of Bosch (located in Vienna) has recruited a large number of IT specialists and now employs almost 1,000 experts working at the interface between hardware and software domains (Bosch, 2018). Digitalization and transformation towards C/AV and the increasing importance of new powertrains and mobility services force larger suppliers to apply an expensive and high-risk 'catch-all' strategy. Even automotive suppliers with expertise in traditional areas of car development and production are increasingly considering themselves as software firms, reporting in our interviews that C/AV would constitute the fasted growing field (in terms of employees) in their firms (AA_1-2, AI_3).

However, such transitions are not frictionless. Concerning informal institutional assets or 'ways of doing things', the automotive path and the IT industry are dissimilar. Particularly the historically developed values of predictability and determinism are often incompatible with IT and especially AI methods. Once trademarks of the industry, they are now turning into barriers. After several failures in bringing together these 'two worlds', many large companies have recognized the necessity for changes in firm culture (AA_1-2, AM_2-3, AI_2-3). The introduction of flat organizational structures, a 'trust instead of control'-policy, the elimination of core working hours, self-organization models, and shared desk concepts are just representations of the underlying change in culture.

Small suppliers with limited financial capacities and those that are positioned in value chains connected to traditional combustion engine powertrains face high entry barriers to C/AV-related fields (AI_1-3, AC_3). Therefore, several support organizations have begun to actively shape innovation networks and establish links between less innovative supplier firms and the IT industry. Initiatives like 'Connected Mobility' in Upper Austria or 'AutoContact' in Styria are just two examples of such efforts, which have however shown limited success to-date (AI_2-3).

Microelectronic firms are strongly engaged in industrial asset modification. Some of them belong to and operate in several industrial paths. In 2019, Infineon generated 44 percent of its revenue in the automotive segment (41% in 2015), reflecting that the increasing use of electronics in cars is the basis for some of the most significant developments in the technology of automotive production (Dicken, 2015). The firm is investing over one billion Euros in new plants in Austria. Parts of this investment are designated to expand development capacities in Linz for driver assistance systems (Infineon, 2019). AT&S has invested 40 million Euros in its sites in Styria and Nanjangud (India) to expand the production of high-frequency printed circuit boards (ATS, 2018). These are used in sensors for distance measurements that are crucial for C/AVs. The Styrian chip manufacturer AMS is among Austria's most R&D-intensive companies (300 million Euros R&D-expenditures globally in 2019) and has recently announced that – due to the growing demand for sensors for C/AV – the company's future lies in the automotive segment (Industriemagazin, 2019). Drawing on their experience in system thinking, microelectronic firms are able to reposition themselves and become strategic partners of automotive OEMs.

Asset modification for C/AV: The innovation system level. Universities and research institutes play a pivotal role in ongoing transformation processes. Currently, there are 16 universities in Austria offering automotive-related training programs and more than 20 research organizations are working in the fields of automotive technology, combustion engines and automation technology (Statistik Austria, 2020). These organizations have historically grown

links to the firm sector, especially to larger companies. They engage in substantial asset modification processes as evidenced by the establishment of new endowment professorships for automated mobility in Linz, Graz and Vienna, large-scale reorientation in R&D centers like 'Virtual Vehicle' in Styria or the creation of the AUDI.JKU deep learning center in Linz. However, research institutes and universities in particular are deeply embedded in the Central European engineering culture (AM_2, AR1-3&5). Engineering curricula still show a strong focus on traditional competencies. IT competencies such as data analysis or software engineering are largely neglected. Furthermore, our interviewees have expressed concerns over missing IT specialists in both academia and industry (AA_1&3, AM_2-3, AI_1&3, AG_1-2&7). Many consider this as a major obstacle for transformation in the Austrian triangle. It is in particular universities of applied sciences (*Fachhochschulen, FH*) that have begun to respond to this challenge. In 2018, the FH Campus Hagenberg has started the new bachelor's program 'automotive computing' with the goal to bridge the gap between classical software engineering and road-based mobility (FH Hagenberg, 2018). In 2019, FH Joanneum has started Europe's first master's program for 'system testing engineering'. The program is funded by firms (such as AVL, Magna, Infineon, NXP) and designed to address the rising complexity of interwoven software, electronic and mechatronic systems due to automated driving and 5 G (FH Joanneum, 2019). Nevertheless, further asset modification processes in the research and educational system are required.

Moreover, there is a growing awareness of the significance of infrastructural assets for the transformation towards C/AV. Many interview partners have highlighted the importance of opportunities for testing[4] and the digitalization of streets (sensors, high-speed internet, cameras, etc.). This has led to a new role for Austria's federally owned infrastructural operator ASFINAG. ASFINAG has positioned itself early as an active player of this transformation. Today, Austria is in a pioneering role (AA_2, AG_5, AC_1, AR_1&5) in terms of the adaptation of infrastructure (road network, fiber optics, sensor technology & monitoring, mobile radio, C-ITS). ASFINAG has also become an attractive partner for automotive firms, as evidenced by a recently launched cooperation with the big German OEM Volkswagen to test direct data exchange between infrastructure and cars.

Another central actor is the Federal Ministry of Transport, Innovation and Technology (BMVIT). This is for two reasons. First, the BMVIT is responsible for monitoring necessary adaptations within the legal framework and serves as an important consultant for lawmakers. Second, and more importantly, the federal ministry plays an important role in coordination and vision-building activities (AA_1-2, AI_1&3, AG_2&4&6, AR_1&5). It has established a separate administrative department for automated driving with the main agenda to balance the interests of stakeholders, to reduce ambiguities and to form a shared vision. With the help of an expert board and network meetings, two action plans (2016–2018, 2019–2022) have been developed. Cornerstones are the active role to be taken by the public sector, thematic funding[5] in areas like AI, adaptations of legal framework conditions, information, cooperation and the modification of infrastructure.

Emerging outcomes and challenges. In the Austrian automotive triangle transformation processes towards C/AV are progressing, even though many obstacles remain. On the one hand, C/AV development is driven by path renewal activities by automotive incumbents. However, it is mainly larger firms with strong innovation capacities and financial power that pursue large-scale asset modification strategies, while smaller firms have only limited resources and struggle to enter the C/AV field. On the other hand, firms in the microelectronic industry have begun to diversify into the C/AV segment.

Industry dynamics are supported by changes in the organizational and institutional support structures. Universities and research institutes capitalize on their historically strong ties to the industry to play an active role in transformation processes. However, full adaptation of research and education programs has not taken place yet. Further reorientation of support organizations to re-align to the needs of industrial players remains an important challenge (e.g. to ensure the availability of human assets). Another bottleneck is the slow pace of institutional change. This holds particularly true for the historically grown engineering culture and orientation on determinism, precision and safety.

Comparison

As shown in the previous subsections, both in Ontario and the Austrian triangle there are major efforts underway to cope with the advent of C/AV. However, the routes taken by the two regions differ strongly (Table 1). Ontario seems to be embarking on an upgrading route, while the Austrian case features elements of a reorientation route (see section 'Innovation-based regional restructuring: Systemic conceptualizations and routes of transformation').

Table 1. Regional transformation towards C/AVs: Comparing Ontario and the Austrian automotive triangle.

Ontario: Upgrading route	Austrian automotive triangle: Reorientation route
Initial conditions	
• Historically low levels of innovation activities in the region's automotive sector & weak embeddedness of MNEs & Tier-1 suppliers in the RIS: weak preconditions for path renewal • Innovative ICT sector linked to RIS: strong preconditions for path diversification • Fragmentation & dis-embeddedness, but flexibility	• Innovative automotive sector with strong embeddedness in a highly elaborated and well-aligned RIS: strong preconditions for path renewal • R&D-driven microelectronics industry with strong links to RIS: sound preconditions for path diversification • Elaborated platform, but rigidification
Asset modification: firm level and system level	
• Agile ICT firms expand their capabilities in C/AV areas (industrial and human asset creation) • Foreign automotive OEMs begin to tap into ICT industrial and human assets in the region (creation and redeployment) • Universities use flexibility to upgrade from hardware to software education (human asset creation and redeployment) • Vision-building by system level actors; bottom-up initiatives (soft institutional asset creation)	• Large scale reorientation of automotive and microelectronic industrial & human assets through redistribution of resources, M&A, retraining & recruitment (creation & redeployment) • Breaking up rigid soft institutional assets preventing reorientation to software (destruction) • Joint efforts to start new study programs to enhance human asset base (creation) • System level actors redeploy institutional and infrastructural assets; top-down coordination
Challenges	
• Further enhancement of embeddedness of automotive firms in the RIS • Overcoming fragmentation in the emerging C/AV field: interlinking and aligning support structures to benefit path renewal and diversification	• De-locking and re-aligning a well-established system (e.g. education and research domain: rigid structures constrain transformation) • High entry barriers for small firms/ firms in value chains connected to combustion engine

These routes reflect distinct initial conditions. In Ontario, the automotive sector has traditionally prioritized production over innovation-related activities, creating a relatively weak initial base for renewal endeavors. The sector is dominated by foreign subsidiaries with limited innovation mandates and domestic Tier-one suppliers that have most of their R&D located abroad and whose embeddedness in Ontario's RIS was weak. However, the advent of C/AV has led to a shift of perspective. With its dynamic ICT sector, populated by both domestic and foreign R&D-driven companies and a vibrant start-up scene with capabilities in AI and 5 G mobile technologies, Ontario's asset base has great potential, not only for the automotive industry to initiate renewal activities but also for the ICT industry to diversify into the C/AV space. Our findings suggest that both sectors are already responding to these new opportunities. While potential for diversification activities (residing within the innovative microelectronics industry) can also be found in the Austrian triangle, initial conditions for path renewal activities in the automotive industry are more favorable when compared to Ontario. This is because many – albeit not all – Austrian automotive suppliers exhibit strong innovation capabilities. Their renewal efforts are backed by but are also partly hindered by a strong embeddedness in highly elaborated RIS structures.

These varying conditions are reflected in distinct asset modification processes. In Ontario, ICT firms in interaction with universities and supported by policy are most actively pursuing asset modification. Additionally, there are first signs that subsidiaries increasingly tap into and modify the regional asset base for their R&D efforts. However, due to the limited autonomy of these subsidiaries, it is the ICT industry's endeavors that have so far yielded more tangible results. Asset creation and redeployment have been relatively successful, particularly in relation to knowledge, finance, infrastructure and soft institutions like visions. A key challenge is to connect previously unlinked actors and paths and to enhance the historically weak embeddedness of automotive firms into the RIS. In the Austrian Automotive Triangle, asset modification is mainly shaped by established actors, namely automotive and microelectronic firms. They mobilize their longstanding relations with universities and policy makers to embrace C/AV. Asset modification covers both the creation and redeployment of knowledge, finance, infrastructure and legitimacy. One can also find evidence for strategic asset destruction in the field of soft institutional assets. The key challenge is to de-lock and re-align a well-established innovation system. There is clear evidence that not all elements are reorienting themselves at the same pace.

Consequently, our empirical analysis has shown that Austria and Canada – both considered to be part of the semi-periphery of the global automotive industry – find themselves in markedly different situations. Applying a systemic perspective to innovation-based change, we have argued that it is not only the regional automotive path and its position in GPNs that matters. Complementary paths and organizational and institutional support structures also provide platforms for distinct patterns of asset modification, ultimately resulting in different routes of transformation in the Austrian automotive triangle and Ontario.

Conclusions

This article seeks to contribute to a more thorough understanding of how regions respond to potentially path-breaking innovations that pose a threat to their historically grown industries. We assert that this requires scrutinizing the ways in which regions nurture new industrial path development and reconfigure their organizational and institutional support structures. This focus is grounded in a systemic perspective that complements conventional EEG accounts of regional restructuring. Systemic approaches move beyond firm and

industry-led explanations and incorporate changes in the wider RIS into analyses of innovation-based structural change.

In order to further unpack the capacity of regions to embrace radical innovations, we develop a framework that contrasts two routes of transformation, a reorientation route and an upgrading route. The article shows that these routes are contingent on specific initial conditions, particularly the existing asset base, which is shaped by historically grown industrial and support structures in the region. Further, routes differ in terms of the dominant types of new industrial path development and the relative importance of adaptation processes of existing support structures and the creation of new ones. This is reflected in distinct asset modification processes by multiple actors and the challenges involved in such endeavors.

The framework has been applied to an empirical analysis of transformation processes towards C/AV in two traditional automotive regions, namely Ontario (Canada) and the Austrian automotive triangle. Our analysis suggests that Austria is embarking on the reorientation route, where innovative automotive and microelectronic firms capitalize on favorable initial conditions and pursue path renewal and diversification activities towards C/AV, supported by re-alignment processes taking place in a strongly elaborated innovation system. The article also throws light on the dark sides of such RIS configurations, revealing that strong ties and mutually reinforcing elements are hampering transformation. Consequently, evidence suggests that not only asset creation and redeployment, but also strategic asset destruction is necessary for further change. The upgrading route prevails in Ontario where weak initial conditions for path renewal activities by automotive companies are found. The digitalization of the automotive industry has revealed new potential in Ontario's regional asset base, which lies in its dynamic ICT sector and malleable organizations and institutions. This has opened a window of opportunity for the Canadian automotive region to upgrade from a production hub to an R&D center. While there is evidence that some automotive MNEs have begun to draw on the region's IT and AI capabilities, we also find that asset creation and redeployment for C/AV development are mainly driven by path diversification activities of IT firms, backed by an enormous expansion of organizational and institutional support structures.

Arguably, our analysis is based on two traditional automotive regions only. There is a need to study new path development and system reconfiguration towards C/AV in other automotive regions with different preconditions than those considered in this article. This would also help to refine the conceptual framework proposed here. Future work in the field may also extend the framework to other cases to assess other industries and regional contexts facing disruptive change. This would also allow for a better understanding of the policy implications that result from a systemic perspective of industrial dynamics triggered by path-breaking innovation.

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The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Notes

1. Automated vehicles (AVs) are classified by the Society for Automotive Engineers using five levels of automation, ranging from simple warnings of emergency situations (Level 1) to fully automated with no human involvement in driving the vehicle (Level 5) (SAE, 2016). Most AVs on the road today are Level 2, with varying predictions of when we will reach level 5. Connected systems are an integral part of AVs, providing needed information about terrain, location of objects and other vehicles.
2. The remainder of the interviewees acknowledged the advantage its ICT capabilities gave Ontario but also thought becoming a hub for battery production and zero-emissions vehicles was relevant.
3. Numbers according to the firms' latest annual financial reports.
4. ALP.Lab in Styria (2017–2022) and DigiTrans in Upper Austria (2018–2023) are two projects allowing for real-world testing in Austria (BMVIT, 2018).
5. Key programs include 'Mobilität der Zukunft' (since 2012, 70 million Euro have been provided for more than 300 projects to facilitate holistic approaches to mobility through research and innovation), 'KIRAS' (between 2007 and 2018 approx. 84 million Euros have been invested to advance the field of 'comprehensive security', and 'AIM AT 2030' (since 2012, almost 350 million Euro have been earmarked for projects in the field of AI) (for an overview see BMK, 2020).

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Co-author declaration for the following joint paper

This declaration states the research contribution (e.g. research idea and – question; data compilation, manipulation and modelling; design and preparation of graphics, maps and tables; writing of text) of the candidate, the main supervisor (where he/she is an associate author) and the other authors.

If applicable, the contributions from other PhD candidates who have or intend to include the paper in a thesis should be described. Contributions from master students should also be mentioned.

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Independent contribution of candidate:

Simon Baumgartinger-Seiringer, the second and corresponding author of this research article, has contributed to this paper both conceptually and empirically.

Simon co-developed and co-authored the conceptual parts of the paper together with Michaela Trippl (Introduction, Literature review & Conceptual framework and Conclusions). He thereby contributed to pinpointing the research gaps and formulating the research questions & aims and developing the conceptual framework. Moreover, he helped to addressed the reviewers' and editor's comments that were concerned with the conceptual sections.

Empirically, Simon conducted the data collection in the AAT (qualitative interviews, documents, participatory observations), transcribed the interviews and analysed this data (together with Elena Goracinova). He authored the empirical section on the case of the AAT (section 3.3). Moreover, he prepared the map (Figure 2) in section 3.3 and addressed the reviewers' and editor's comments that were concerned with the Austrian case.

Additionally, as corresponding author, Simon was responsible for the publication process.

First author's contribution:

Michaela Trippl, the first author of this paper, had the initial research idea for this paper. She also initiated the collaboration between the research groups in Vienna, Austria and Toronto, Canada. She was responsible for managing the overall process. Michaela was mainly in charge of the conceptual parts of the paper (research gap & aim, conceptual underpinnings and framework). In terms of writing, she co-authored the introduction (section 1), the literature review and conceptual framework (section 2) and the conclusions (section 4) and addressed the reviewers' and editor's comments that were concerned with these sections together with Simon

Baumgartinger-Seiringer. Additionally, she provided feedback and guidance for the analysis of empirical data from the two case studies.

Contributions of other authors:

Elena Goracinova, the third author of this paper, contributed mostly empirically to the paper and was the main author of the empirical section on the case of Ontario (section 3.2). She conducted the data collection in Ontario (qualitative interviews, documents, participatory observations), transcribed the interviews and analysed this data (together with Simon Baumgartinger-Seiringer). Moreover, she prepared the map of Ontario (Figure 1) in section 3.2 and addressed the reviewers' and editor's comments that were concerned with the Canadian case. Additionally, Elena provided feedback and ideas for developing the conceptual parts of the paper.

David A. Wolfe, the fourth author of this paper, was mainly in a supervising role. He provided guidance and feedback throughout the whole development and writing process. David particularly contributed to the empirical section on the case of Ontario (section 3.2).

Contributions from other colleagues and master students

Has this paper been, or will this paper be part of another doctoral degree thesis?

Yes: ☐ No: ☒

If yes, please elaborate:

Contributions from master students:

Yes: ☐ No: ☒

If yes, please elaborate details:

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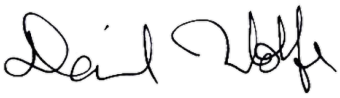
Yes: ☒ No: ☐

If no, please specify:

If applicable co-author's signature:



20.12.2021

Paper #3

Baumgartinger-Seiringer, Simon; Fuenfschilling, Lea;
Miörner, Johan & Trippl, Michaela (2021)

'Reconsidering structural conditions for industrial renewal'

REGIONAL STUDIES
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Reconsidering regional structural conditions for industrial renewal

Simon Baumgartinger-Seiringer[a], Lea Fuenfschilling[b], Johan Miörner[c] and Michaela Trippl[d]

ABSTRACT

This article develops a more comprehensive understanding of innovation-based renewal of industries from a structural perspective. Arguably, established perspectives offer rather simplistic views, portraying structures as either enabling or constraining for certain forms of regional industrial change. Inspired by work in organizational institutionalism on 'institutional infrastructures', this article focuses on the degree of elaboration and coherence as decisive features of regional structural conditions. Arguably, this conceptual lens allows for a better understanding of the potentials and limitations for industrial change entailed in different structural configurations. Empirically, we investigate renewal processes in traditional automotive regions in Austria and Sweden.

KEYWORDS

path renewal; institutional infrastructure; structures; elaboration; coherence

JEL 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 (Markard et al., 2012; Organisation for Economic Co-operation and Development (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 favourable economic, social, cultural and institutional structural conditions (Martin, 2010) 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 helped to specify what structural preconditions matter for regional industrial change, placing an emphasis on assets, skills, connections and competencies inherited from previous rounds of development, which are said to shape present and future activities. Regional industrial change is thus conceived as a 'path-dependent' process. 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 directs attention to technological and knowledge-related assets within regions (Boschma & Frenken, 2011). This view, however, has attracted criticism for being too narrow, neglecting other important factors for changes of regional industries such as endowments of formal and informal institutions, support organizations like universities, intermediaries and so on (Carvalho & Vale, 2018; Hassink et al., 2019).

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Adopting a broader view and seeking to capture the wider structural conditions 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 et al., 2020) and institutional thickness (Amin & Thrift, 1994; Zukauskaite et al., 2017). This has enriched our understanding of the 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 article is to advance a comprehensive perspective on the role of structural conditions for industrial change in regional contexts to better understand why some regional industries succeed in renewing themselves while others fail.

We contend that economic geography may benefit from a deeper exchange with other disciplines in the social sciences, which have explored the relationship between various forms of structures and change processes. In this article, we argue for the value of recent work on 'institutional infrastructure', a concept developed within organizational institutionalism in sociology, for conceptualizing the transformative capacity of regional industries.

Institutional infrastructure as a concept 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 et al., 2011; Hinings et al., 2017). Besides identifying structures that are particularly relevant for change processes in a particular industry, the concept focuses attention on the degree of elaboration of the infrastructure (i.e., the number and degree of the institutionalization of structural elements) as well as its coherence (i.e., the degree to which structural components are mutually reinforcing one another). While certain industries seem to have an institutional infrastructure that is well aligned, others can be characterized by a conflicting or poorly developed infrastructure. A core assumption in this article 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 article is structured as follows. In the second section, we discuss why it is necessary to take on a more comprehensive approach to structures in order to understand industrial renewal. We then provide in the third section a literature review of some of the most important work in institutional theory, focusing on the notion of institutional infrastructure. In the fourth section we develop a framework that explains how elaboration and coherence of structural conditions might affect innovation-based industrial renewal. In the fifth section, we use the framework to analyse two automotive regions in transition. The sixth section concludes.

CONVENTIONAL PERSPECTIVES ON THE ROLE OF STRUCTURES IN REGIONAL INDUSTRIAL CHANGE

EEG explains industrial change through diversification processes stimulated by recombinations 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 an emphasis on the diversity and relatedness of regional industrial capabilities, highlighting the positive impact of sectoral related variety for industrial diversification (Boschma, 2017; Neffke et al., 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, coming 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 so 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 favour 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 (Hassink et al., 2019). Advocates of the RIS concept propagate a broader perspective on structural preconditions for regional industrial change (Isaksen & Trippl, 2016; Trippl et al., 2020).

An RIS consists not only of the firms and industries located in a region, but also of the wider support organizations (universities, intermediaries, policy actors, etc.) and institutional arrangements, including both formal (regulations, laws) and informal institutions (culture, norms, values) (Asheim & Gertler, 2005). Despite its focus on regional conditions, the concept does not neglect the openness of innovation systems. Regions are influenced by extra-regional linkages and are embedded in institutional setups at higher spatial scales.

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 support organizations, networks and

institutional setups, offer a favourable 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 firms and support organizations, institutional set-ups and the degree of industrial specialization, and assess the impact of such structural conditions on innovation patterns and new path development within regional economies. They find that organizationally thick and diversified RISs (often found in core regions) are more likely to facilitate new path development and renewal activities than organizationally thick and specialized (old industrial areas) or thin (peripheral regions) RIS. Highly specialized and/or thin structural conditions are believed to favour continuity rather than change.

These contributions imply that once a region provides certain structures, particular types of development are likely to occur. Contrasting this view, we contend 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. While it might be the case that thick and diversified structures offer great potential for industrial change, they may 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 relation between those elements. We believe that recent work in organizational institutionalism offers highly relevant insights in this regard.

ORGANIZATIONAL INSTITUTIONALISM AND THE NOTION OF INSTITUTIONAL INFRASTRUCTURE

In the last decades, institutional theory has been highly influential in organization and management studies to explain organizational behaviour and change (Greenwood et al., 2017). Studies have shown that actors are embedded in an institutional environment that affects their cognition and behaviour and that legitimacy, that is, 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 behaviour (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 a 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 et al., 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, that is, 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 et al., 2012, p. 2).

Research has furthermore shown that fields differ in their capacity to innovate and change. 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 large range of studies that implicitly or explicitly deal with some aspects of institutional infrastructure and developed a list of elements to be considered (see Table A1 in the supplemental data online, and elaborated in more detail below). 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.

Institutional infrastructure specifies those cultural, relational and structural elements that research has shown to be crucial for the reproduction and/or change 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. Regulatory bodies enable and constrain action, and thus have an effect on what gets institutionalized or deinstitutionalized. 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, for example, funding schemes, tax incentives, patent laws, industrial policies, and societal values and visions. This, in turn, will affect which types of knowledge are generated and which types of technologies will be developed and diffused. The presence of many informal governance bodies 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.

However, the concept of institutional infrastructure not only specifies the set of structural elements that prevail in a field, but – more importantly – assesses how they work in concert (Hinings et al., 2017). The idea is to understand the condition of a field and its transformative capacity, which is linked to (1) the degree of elaboration and (2) the coherence of the elements that together form the institutional infrastructure (Zietsma et al., 2017).

First, the degree of elaboration of the infrastructure in a field varies and has consequences for field activity. The different elements can be institutionalized to different degrees (or be lacking altogether). There is a 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 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; Zucker, 1977).

Arguably, 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, one could assume that having a strong infrastructure in place is necessary for incorporating change. Examples may include the development of new standards, new training programs, new regulations, new awards, new events, etc.

Second, the condition and transformative capacity 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, that is, 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. This is reflected in the notion of institutional complexity (Greenwood et al., 2011). Fields that feature a high institutional complexity come with incompatibilities and diverging meaning, practices and prescriptions for action (Hinings et al., 2017; Zietsma et al., 2017). In contrast, fields with low institutional complexity are settled around one logic with high levels of consistency and predictability (Greenwood et al., 2011).

Overall, the concept of institutional infrastructure specifies the set of structural elements that prevail in a field and considers them together. It focuses attention to the degree of elaboration/institutionalization of a field as well as its coherence and provides a new perspective on the relationship between structural conditions and field maintenance and change (Hinings et al., 2017; Zietsma et al., 2017).

IMPLICATIONS FOR STUDYING INNOVATION-BASED REGIONAL INDUSTRIAL RENEWAL

The notion of institutional infrastructure offers valuable insights for studying the role of regional structural conditions in industry renewal. It helps to assess and compare specific structures that enable, hinder and shape processes of innovation-based change and path development in particular industries. Therefore, investigating the role of institutional infrastructure, its degree of elaboration and coherence is a way to improve our understanding of industrial change from an institutional perspective.

Hinings et al. (2017) and Zietsma et al. (2017) review a large variety of empirical case studies (often focusing on industries, i.e., organizational fields) that either implicitly or explicitly deal with institutional infrastructure and its implication for field-level change. In this section, we seek to systematize these implications for studying innovation-based regional path renewal. Hence, we focus on an industry in a specific region. However, it is important to note that some of the relevant structural elements (e.g., regulatory or educational bodies, standard setting agencies, etc.) might be located elsewhere and still have significant influence on the regional industry's development. Thus, the elements are of multi-scalar nature.

At the same time, there might be structural elements in place at the regional level that are virtually irrelevant for the industry under consideration but are rather tailored to the needs of other sectors located in the region. Herein lies an important difference between the approach proposed in this article and the RIS concept. Both offer relatively broad perspectives on structural conditions. However, the former defines the set of relevant structural elements for a particular industry, while the latter incorporates the setup for the entire regional economy. While both approaches have their merits (see also conclusions), it is argued here that the concept of institutional infrastructure is better suited to unravel how relevant structural elements operate in concert (Hinings et al., 2017) and, hence, allows for a more nuanced understanding of enabling and constraining conditions residing in different structural configurations.

This section is structured as follows. First, we discuss different degrees of elaboration and coherence and the

potentials for and constraints to innovation-based renewal they hold. Second, based on these two characteristics, we zoom in on different types of structural conditions and unravel how they may affect the initiation and unfolding of transformation processes of regional industries.

To begin with, the structural elaboration (i.e., the number and development of structural elements for a particular industry in a region) might be either high or low (Hinings et al., 2017; Zietsma et al., 2017).

High elaboration implies that a large number of elements – often substantially developed – 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 structural elements can be used as a platform to bring innovation-based change processes forward (Trippl et al., 2020). Thus, change processes may diffuse and consolidate quickly through well-developed elements, such as education programmes, industry associations or field configuring events (Hinings et al., 2017). On the other side, the presence of many elements – such as regulators, collective interest organizations or status differentiators – requires alteration of a large number of structural components. In other words, many locks might have to be unlocked to trigger change and structures can form strong and overlapping entry barriers, making highly elaborated structural configurations rather resistant to change (Hinings et al., 2017). An important reason is that support for established industries is often strongly institutionalized within the elements that reproduce the dominant rules of the game, making it difficult for change processes to break through (Kivimaa & Kern, 2016).

In contrast, *low elaboration* indicates a poor endowment of infrastructural elements and a weakly built-up infrastructure (thinness). Such structural conditions might be beneficial for innovation-based change processes, as they offer leeway, autonomy and flexibility for the creation of novelty (Hollingsworth, 2000). Zietsma et al. (2017) highlight that low elaboration might provide space for innovation and also weaker field boundaries. Accordingly, one can expect little resistance and considerable experimentation due to the lack of structural components as well as easy access of new actors because of low entry barriers (Hinings et al., 2017; Logue, 2014). However, the lack of structural preconditions might also form a strong barrier to change, as there is no platform to set alterations in motion; that is, there are no elements in place through which change can be distributed. This might be particularly problematic after the initiation and experimentation stage, when accelerating and consolidating change becomes vital (Baumgartinger-Seiringer et al., 2021).

Regarding coherence, that is, the degree to which structural components are mutually reinforcing one another, Hinings et al. (2017) and Zietsma et al. (2017) differentiate between high coherence ('unitary') and low coherence ('competing').

When elements are in a state of *high coherence*, strong agreement on general principles, values and directions is likely (Zietsma et al., 2017). This means that the diffusion of change is facilitated and conflicts can be expected to occur rarely. However, strong ties and reinforcement between structural elements might also be a source of rigidity (Hinings et al., 2017), leading to high resistance to change in the first place (Grabher, 1993) and periods of path dependence and continuity (Empson et al., 2015). Swimming against the stream is often difficult. Hollingsworth (2000) points out that in settings where pressures to conform are greatest, individuals have relatively low autonomy to pursue independent strategies, leading to organizational isomorphism. Accordingly, the initiation of change in highly coherent structures is often hampered; yet, once initiated, change is likely to be diffused rapidly.

In contrast, *low coherence*, on the one hand, might stimulate change, as it might entail an increased capacity to adapt to new circumstances, in particular in early phases (Logue, 2014). Where pressures to conform are weak, actors have greater autonomy to respond to new developments and to be innovative (Hollingsworth, 2000). Additionally, dissent may lead to higher levels of competition between different visions and directions of change, which might have a stimulating effect. 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. As a consequence, change might be frequent, yet difficult to consolidate (Hinings et al., 2017).

Based on these considerations, it is possible to categorize regional industries depending on their elaboration (high and low) and coherence (unitary and competing). This typology of structural configurations (Table 1) offers the basis for a more nuanced discussion of the connection between structural conditions and regional industrial change processes.

As indicated by the discussion above, the connection between structural conditions and regional industrial change can only be fully grasped against the background of the relationship between structures and agency

Table 1. Institutional infrastructure and different structural configurations.

	Unitary (high coherence)	**Competing (low coherence)**
High elaboration	Established	Contested
Low elaboration	Aligned/emerging	Fragmented

Source: Based on Hinings et al. (2017).

(Grillitsch & Sotarauta, 2020). As Zietsma et al. (2017, p. 404) point out, the different types of structural configurations 'have significant impact on the agency that is possible for various actors within the field'. Therefore, the influence of structural configurations on the pace and scope of innovation-based alterations is strongly connected to the embedded actors' capacity to generate (or prevent) change. This capacity is not distributed equally among all actors. It rather depends on the individual subject's position occupied in the field, which – in turn – might be reinforced by the prevailing structural conditions (Battilana, 2006). This has two important implications. First, these structural conditions entail a 'systematic bias' and might privilege (or create barriers to) one group over another in terms of their scope of action (Hinings et al., 2017, p. 183). The institutional infrastructure in a region is selectively reinforcing some forms of actions and strategies, while hindering or reducing the effect of others (Miörner, 2020). Second, actors (incumbents or newcomers) work on structural elements, that is, they will purposefully try to challenge or maintain elements, depending on whether they hamper or support their intentions (Hinings et al., 2017). This relates to the literature on 'institutional work' that studies 'the purposive action of individuals and organizations aimed at creating, maintaining and disrupting institutions' (Lawrence & Suddaby, 2006, p. 215).

Jolly et al. (2020) have recently introduced a differentiation between change and maintenance agency[1] in the context of regional path development and highlight that both play a crucial role in path development processes. Hinings et al. (2017) argue that efforts geared towards challenging or maintaining structures can be either focused or distributed, coordinated or uncoordinated, complementary or contradictory, depending on the structural conditions. To summarize, it is crucial not only to pay attention to institutional infrastructures but also to their interaction with agency to understand change (Zietsma et al., 2017). This enables us to cast more light on the types of structural conditions and their potentials and opportunities for as well constraints and barriers to industrial change.

Industrial structural conditions that feature both a high elaboration *and* coherence are referred to as *established* (Table 1). These characteristics apply, for instance, to mature and prospering regional industries, with many elements like collective interest organizations, formal regulators, professional associations, informal governance bodies or educational programs in place. These elements bear potential for innovation-based industrial change, as they can be used as channels to distribute and consolidate change. The strongly reinforcing state in these settings can accelerate this process, as agreement on the direction of change is likely. At the same time, change might be hard to set in motion. The reason is that established settings provide a 'distinct dominance order' and influential actors – often incumbents with vested interested – have a strong motivation to preserve this order (Zietsma et al., 2017, p. 402). What is more, the high structural elaboration might form substantial entry barriers for new actors (Hinings et al., 2017). Maintenance agency might thus be relatively focused and coordinated, leading to periods of reproduction, while change agency is likely to be seen as contradictory and inconsistent with the strongly institutionalized ways of doing things. This does not mean that established industries do not change. However, renewal processes might follow a temporal pattern (Baumgartinger-Seiringer et al., 2021). In early stages change might be slow, yet in later stages, it could unfold rapidly.

Structural configurations characterized by a high elaboration but low coherence are described as *contested*. These characteristics apply, for instance, to mature industries that face crises or profound pressures (Empson et al., 2015). The presence of many elements may provide the necessary structures for innovation-based change. In contrast to established settings, both the likelihood for change and conflict about its direction is high. This is because agency is expected to be rather uncoordinated, distributed and often contradictory due to low levels of coherence. This might favour considerable experimentation and competition between old, formerly strongly institutionalized and new ways of doing things (i.e., competition between change and maintenance agency), in particular in early phases of change. However, the many structural elements might constitute locks that need to be unlocked (Zietsma & Lawrence, 2010), making the consolidation in later stages of change relatively difficult. Once a direction has been agreed on, the high structural elaboration might again support change.

Industrial structural conditions that feature a low structural elaboration but high coherence are referred to as *aligned*. Such conditions can be found, for example, in structurally poorly endowed industries that follow relatively clear rationalities (Logue, 2014). Zietsma et al. (2017, p. 418) characterize aligned configurations as 'underorganized domains' that begin to converge around mutual interests, objectives and values between actors. As such, change is likely to be agreed on. Agency in these settings is often focused and coordinated. Poor endowments of structural elements make maintenance agency difficult and change agency likely. Additionally, the low elaboration might provide leeway and opportunity for novelty and poses relatively low entry barriers. However, as many elements have to be built, consolidation might be a lengthy process. Moreover, aligned configurations bear the risk of falling out of alignment due to the lack of structural elaboration and the weak stability coming with it (Zietsma et al., 2017).

Finally, structural configurations that combine a low elaboration and a low coherence can be referred to as *fragmented*. These characteristics apply, for instance, to unsettled industries with limited institutional infrastructure. Different ideas about the way forward exist. In such settings, actors are disconnected, networks and institutional elements prescribing ways of doing things are not fully established (Zietsma et al., 2017). On the one hand, this leads to room for manoeuvre and favours change agency, with hardly any (entry) barriers and little pressure

Table 2. Degrees of elaboration and coherence: implications for change.

	Unitary (high coherence)	Competing (low coherence)
High elaboration	*Established* + structure for change; agreement on objectives – hard to set change in motion	*Contested* + structure for change; likelihood for change – conflict is likely
Low elaboration	*Aligned* + leeway and opportunity, change is likely to be agreed on – long way to go, missing stability	*Fragmented* + extensive room for change – require both 'construction & persuasive work'

Source: Authors' own elaboration.

to conform. On the other hand, the fragmentation and the uncoordinated actions coming with it, as well as the missing structural elements will require both construction and persuasive work to consolidate change in a lengthy and tedious process.

In sum, the concept of institutional infrastructure offers a promising new – and arguably more comprehensive – perspective on the impact of structural configurations on innovation-based industrial change, highlighting both the potentials and constraints held by different types of structural conditions (Table 2).

REGIONAL AUTOMOTIVE INDUSTRIES IN TRANSITION: THE ROLE OF INSTITUTIONAL INFRASTRUCTURES IN WEST SWEDEN AND THE AUSTRIAN TRIANGLE

Employing a comparative case study analysis, this section applies our conceptual framework to two automotive regions in transition: the 'Austrian Triangle' and 'West Sweden'. In both regions, the automotive industry is currently undergoing substantial changes due to increasing digitalization and the advent of connected and automated vehicles (CAVs).

Case comparisons are particularly useful when cases share a set of commonalities, but also display variation on some aspects of theoretical relevance (Rihoux & Lobe, 2009). As the results in this section will show, both the Austrian Triangle and West Sweden are characterized by highly elaborated regional structures that have evolved over long periods of time. However, when comparing the structural preconditions at the time when transformation processes were initiated in the two regions (around 2010), one can find decisive differences. The structural elements in Sweden were less coherent, that is, they were reinforcing each other to a lesser extent than those in Austria. Thus, these two comparable empirical cases are suitable to shed light on theoretically relevant aspects of structural conditions for innovation-based industrial renewal.

Our empirical investigation serves as a first test of the applicability of our conceptual framework. By investigating how the combination of the degree of elaboration and coherence influences change processes extending across different regional industrial contexts, we seek to demonstrate how our reconsideration of the role of structural configurations could help to better understand industrial renewal processes in concrete empirical settings. Moreover, the comparison of the two regional automotive industries provides additional insights into how change processes unfolded under certain structural preconditions, allowing us to draw further conclusions (discussed in the sixth section section).

The empirical analysis is based on an extensive document analysis and 45 in-depth qualitative interviews (25 of them taken in Austria in the first half of 2019 and another 20 one in Sweden between March 2017 and May 2018) with representatives of firms, research organizations, intermediaries and policy makers. Interviews lasted between 30 minutes and two hours, with the majority of them being around one hour. The interviews were semi-structured and organized around themes derived from the conceptual discussion, such as the influence of existing structural conditions, the details of ongoing change processes, and opportunities and challenges. Furthermore, each interview guide was adapted to the particular actor type and case, and reflected our background knowledge of actor characteristics gained through previous interviews or the analysis of secondary material. We identified relevant interview partners based on an initial analysis of secondary data followed by a snowballing method (Valentine, 2005). For each of the two cases, the interview process continued until a point of 'data saturation' (Glaser & Strauss, 2017) was reached. The interviews were transcribed and coded according to a set of theoretically informed categories derived from the conceptual framework (Saldaña, 2015).

The Austrian triangle

Potential within structures

The automotive industry in Austria is one of the country's economic drivers. As much as 10 percent of the workforce depends on the automotive sector (Kleebinder et al., 2019), even though the country does not host any original equipment manufacturers (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 (Trippl

et al., 2021). Our analysis shows that the Austrian automotive triangle can be characterized by its distinctly 'established' structure.

The institutional infrastructure of Austria's automotive triangle is historically established and highly elaborated. A wide array of institutional infrastructure elements is 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 A2 in the supplemental data online). 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. 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.'

In addition, the institutional infrastructure has reflected 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 agencies, 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. 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.' These structural conditions 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, leading to relatively coordinated maintenance agency. Accordingly, the more radical change processes which are currently observable were largely inconsistent with the way the industry in the Austrian triangle was organized.

Yet, our interviewees have also pointed out that the enabling dimension of strongly elaborated and coherent institutional infrastructures should not be overlooked. Highly elaborated structures offer reliability, even though they might be hampering in early phases of radical change processes. However, in later stages of the path development process, 'established' structures might function as a platform for upscaling and enable more substantial change. For example, a representative from a technical university commented on new agile automotive players in the United States in the following way:

> At some point maybe, these new players 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. … 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, is reinforced by concerns over the climate crisis, calling 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).

Our analysis reveals that after a phase of reluctance, in which change was deterred and seen as contradictory, actors have begun to embrace CAVs as a new field of innovation and value creation. As one interviewed researcher put it: 'Five years ago, it became clear that the classical, mechanical engineering potential for innovation was exhausted; now we have a new hype around CAVs.' The fact that a wide set of coherent elements has to change was and still is connected to various efforts of change agency targeting the reorientation of existing institutional infrastructure 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 decarbonization organized a number of large-scale network meetings with 140 stakeholders that resulted in two strategy plans ('Aktionspläne', 2016–18, 2019–22), outlining the most important measures jointly carried out by actors from industry, policy and academia for this transformation to unfold.[2] The high coherence of the elaborated structures strongly facilitated such a collaborative approach to change, which arguably leads to an even stronger coherence of structures for CAVs in the Austrian triangle.

One of the biggest 'unsettled' issues concerning the current unfolding of change is the integration of information technology (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, shedding light on change agency in 'established' types of structures. However, an analysis of curricula and interviews taken with representatives of technical universities shows that these reorientation endeavours 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. The aftermath of the scandal clearly shifted incentives away from maintenance to change agency. 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.

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 Volvo Group (parent company for Volvo Trucks, Volvo Buses and others), as well as a range of suppliers, automotive technology firms and consultancies, catering to local as well as global markets (Miörner & Trippl, 2019). 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 organizations, science parks, cluster organizations and incubators, testbeds, innovation support initiatives, governance bodies at the local, regional and national levels, and funding organizations (for a detailed list, see Table A2 in the supplemental data online).

In terms of coherence, previous studies point to a high degree of coherence as a significant characteristic of the regional industry from a historical perspective, with strong reinforcing effects between the elements (James et al., 2016). However, both elaboration and coherence declined in the late 1990s and early 2000s. In that period the regional industry was realigning towards more technology-focused 'active' safety features as the primary competitive edge (James et al., 2016). Nevertheless, while the elaboration of the institutional infrastructure quickly increased again after the global financial crisis, it had not regained the strong coherence that had characterized the industry historically. 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 were reinforcing each other to a lesser extent.

In other words, our empirical analysis reveals that West Sweden can be characterized as a 'contested' structure, with institutional infrastructure elements pointing towards different, sometimes contradictory, directions of change, rationalities and logics. 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: '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.'

Our interviews also 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 low levels of 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).

The relatively low degree of coherence is also 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). Instead of being dominated by clearly defined 'automotive' elements, firms in the automotive industry are engaging with infrastructure elements being shared with other regional industries, within cross-industry thematic focus areas. The same goes for educational and research programmes; instead of being oriented at 'automotive technology' they are focusing on broader themes, such as artificial intelligence (AI) and machine learning.

In order to understand the shift towards CAVs, the combination of a high degree of elaboration and relatively low degree of coherence in the institutional infrastructure of the automotive industry has explanatory power. When it comes to potentials for change, 'contested' structures increase the likelihood for change to occur, which was also confirmed by our empirical results. The competition over direction of change in the region provided plenty of opportunities for change agents to pursue their strategies and intentions, and 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 CAVs (e.g., test infrastructure and funding programmes). For example, one technology expert at Chalmers University said with respect to autonomous technology: '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 and it was easy to trigger change processes. Actors had a lot of freedom to engage in change agency, primarily targeting the reorientation of existing elements, but also involving the introduction of new ones focusing explicitly on CAV development.

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. 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, but simultaneously balancing with agency targeting the maintenance of status quo. With the large number of well-developed institutional infrastructure elements in

place, interviewees argued that it would not have been a feasible strategy to try to 'change everything at once' (interview with regional industry expert). Nevertheless, the analysis also highlights the introduction of dedicated CAV elements, such as new education programs for automotive artificial intelligence.

In other words, a 'contested' institutional infrastructure featuring a low degree of coherence in terms of technological focus, direction of change, and long-term goals promoted experimentation and transformative efforts among a wide range of actors. In combination with a high degree of elaboration, this meant that actors were incentivised to engage in change agency and the development of solutions related to CAVs defined broadly, sometimes even defined in contradictory ways. For example, organizations 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 in the institutional infrastructure. This is manifested in a tension between change agency opting for radical change, and maintenance agency with the goal of sustaining the status quo to the largest extent possible.

But yet, the existence of a wide range of change directions also enabled 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-oriented' one.

COMPARISON AND CONCLUSIONS

This article advocates a more comprehensive understanding of structural conditions for innovation-based regional industrial renewal. Established 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 elaborated 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 'contested' 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 and change agency early on compared with the Austrian triangle with its more 'established' structural conditions, where change is now, after a period of reluctance and maintenance agency, unfolding quickly. These observations are in line with expected distinct temporal patterns of industrial change associated with different structural conditions. Moreover, 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 have become even more coherent. 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.

Importantly, our framework moves structural influences centre stage. Yet, the concept should not overstate their importance at the expense of agency. As outlined above, the different structural configurations 'have significant impact on the agency that is possible for various actors within the field' (Zietsma et al., 2017, p. 404). At the same time, structures are created, maintained and disrupted by the actors who are influenced by these structures in the first place (i.e., 'the paradox of embedded agency'; Hinings et al., 2017, p. 183). Accordingly, it is crucial to examine the impact of varying degrees of elaboration and coherence on innovation-based change in the context of the 'recursive and dialectical' interaction between structure and agency (Lawrence et al., 2011, p. 55). Our empirical investigation confirmed that the different structural conditions in Austria and West Sweden promoted certain types of agency (i.e., activities either oriented towards change or maintenance) while impeding others depending on the stage of the ongoing process of industrial renewal.

Juxtaposing the results of our conceptual and empirical analyses with studies emphasizing 'related variety' as a core explanatory variable for understanding how structural

conditions shape regional path development (Boschma, 2017; Neffke et al., 2011) reveals highly relevant insights. In the Austrian automotive triangle, fitting the description of an 'established' structure, elements were in place to leverage the combination of related capabilities from different sectors, but the very same structures made it hard for actors to set change in motion. In West Sweden, representing a 'contested' structure, existing inter-industry linkages fostered by shared institutional infrastructure elements facilitated the combination of more unrelated capabilities, but transformation processes have been slowed down by the lack of consensus on the direction of change. In other words, our study explicates that focusing on regional knowledge capabilities alone is not sufficient to explain innovation-based renewal processes. Transformative change in regions characterized by highly elaborated institutional infrastructures need to be triggered by actors' agency and depends to a large degree on the continuous reinterpretation and reorientation of existing institutional infrastructures. Related and unrelated diversification must thus be understood as processes that are subjected to both structural influences beyond knowledge capabilities per se (in the current study exemplified by the influence of the degree of elaboration and coherence of existing institutional infrastructures) and agentic processes.

This implies that future studies should pay more attention to the role of other industries located in the region and to their institutional infrastructure. While still under-theorized in the original literature, inter-industry relations have been framed as field overlaps enabling mechanisms of influence (Zietsma et al., 2017). They might have an either positive or negative impact on the development of the industry under consideration. Potentially, an aligned industry (low elaboration and high coherence) might be able to compensate its lack of structural elaboration by drawing on already existing elements or resources from an adjacent field (Hinings et al., 2017). At the same time, an established industry might lose resources to other industries in such a process.

Future work should further exploit the potential benefits of combining institutional perspectives and conceptual apparatuses from economic geography. Our approach directs attention to relevant regional structural elements and their conditions for a particular path. However, the relationship to the broader regional structures requires more investigation.[3] The broader regional setup an industry is embedded in has important implications, opening up promising avenues for future research. First, the link between different configurations of institutional infrastructure (Table 2) and different RIS types (Isaksen & Trippl, 2016) should be examined. It arguably makes a difference for an industry with – for instance – fragmented structural conditions (low elaboration and coherence) whether it is embedded in a thick and diversified, in a thin or in specialized RIS. One could assume that change processes in such an industry are easier to set in motion in the former region than in the latter, as the broad variety of existing elements could be integrated in the industry's institutional infrastructure. Second, the relation between the region and the industry will also depend on the latter's degree of spatial embeddedness. In essence, the stronger the regional embeddedness of an industry, the stronger regional structural conditions will affect its development. In contrast, industries that are oriented globally in terms of their innovation and valuation practices are more independent of regional conditions (Binz & Truffer, 2017). Third, as outlined above, other regional industries play a crucial role. In sum, exploring the role of the region is complex but a promising next step.

Finally, this article 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 acknowledge that the structural conditions themselves are often subject to alterations in regional processes of industrial change. Future work should not only focus on the conditions for innovation-based change, but should also examine how structural configurations and the degree of elaboration and coherence are evolving themselves in transformation processes. It would be intriguing to further advance the typology of different configurations presented in Table 2 and develop different pathways of change under these conditions (Hinings et al., 2017).

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NOTES

1. According to Jolly et al. (2020, p. 179), maintenance agency 'involves actions such as introducing new practices to create deterrence for change, supporting the persistence of existing institutional routines, and using narratives to support the routinization of existing practices and adherence to rules'.
2. Among other things, this implies the initiation of projects for real-world testing, newly established 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.

3. We are grateful to an anonymous reviewer for very helpful remarks in this regard.

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Supplemental File

Table A1: Dimensions of institutional infrastructure

Institutional infrastructure element	Examples
Collective interest organizations	Unions, professional associations, industry associations
Regulators	Public agencies and international organizations
Informal governance bodies	Certification/standardization/accreditation organizations
Field configuring events	Conferences, trade shows, fairs, festivals
Status differentiators	Labels, rankings, awards
Organizational models or templates	Professional partnerships, hybrid organizations
Categories	Technology classes, genres, listed corporations into industries
Norms	Education and professional training
Relational channels	Normative networks, epistemic communities

Source: adapted from Hinings et al., 2017, p. 169

Table A2: Highly elaborated regional institutional infrastructures: most relevant elements in the Austrian triangle and West Sweden (partial list)

Institutional infrastructure element	Austrian triangle	West Sweden
Collective interest organizations (+funding)	Federal research promotion agency FFG, and its Styrian counterpart SFG, Unions like ÖGB, PRO-GE, …	Business Region Göteborg, Lindholmen Science Park, FKG, Bil Sweden, Almi Invest Västsverige, Chalmer Ventures, VINNOVA-FFI, Drive Sweden
Regulators / Formal governance bodies	Austrian Ministry for Transport, Innovation and Technology, Austrian Ministry for Digital and Economic Affairs, City of Vienna, Federal State of Styria, Federal State of Upper Austria, AustriaTech, Stabstelle Mobilitätswende & Dekarbonisierung, Federal infrastructure operator ASFINAG …	City of Gothenburg, Swedish Energy Agency (Energimyndigheten), Vinnova, Swedish Road Authority (Trafikverket), Västtrafik, Region Västra Götaland, VTI, Göteborgs Stads Parkerings AB, Swedish traffic agency, Swedish transport agency
Informal governance bodies (certification & standardization)	Automobile clubs like VCÖ or ÖAMTC, Certification bodies like Kuratorium für Verkehrssicherheit (KfV), testbeds like Digi.Trans or Alp.lab	Automobile clubs like Kungliga Automobilklubben, testbeds like Drive Me project
Field configuring events	Conferences/events like 'automotive.2019', 'autocontact2019', 'Vernetzte Mobilität', 'Automated driving conference', Vienna Autoshow …	Conferences like the Drive Sweden Annual Forum, 'AI in Automotive – Reality check' 'Vehicle Electronics & Connected Services', 'Conference on Driver Distraction and Inattention', Seminar: AI & Automation – What does it really mean?
Education, research and professional training	Technological Universities in Vienna and Graz (Styria), various universities of applied sciences, Audi.JKU deep learning center, ARS electronica, Mobility.lab Graz, Virtual Vehicle in Graz, Lakeside, Austrian Institute of Technology (AIT) …	Chalmers University of Technology, University of Gothenburg, Skövde University, University of Borås, University West, The Swedish Research Institute (RISE): RISE ICT, RISE Victoria, RISE Knowledge Centre: Battery and Hybrid Systems, Chalmers University of Technology, University of Gothenburg, WASP…
Relational channels, Intermediaries	Automotive Clusters in Upper Austria (Automobil Cluster) and in Styria (Mobilitätscluster), Intermediaries like Wien ZWA, Connecting Austria, A3PS…	AI Innovation of Sweden, Lindholmen Science Park with Open Arena, Johannebergs Science Park, Innovatum, VINK, Mobility Xlab, Stena Center, Framtidens Företag, Älvstranden Utveckling, CampX by Volvo Group, Mobility XLab, Asta Zero, VTI Sims IV, Drive Me, ElectriCity with demo arena, RISE Awitar, Electromobility lab for electrical vehicles, TSS, Stena Industry Innovation Laboratory

Source: own elaboration based on Hinings et al., 2017, p. 169

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Co-author declaration for the following joint paper

This declaration states the research contribution (e.g. research idea and – question; data compilation, manipulation and modelling; design and preparation of graphics, maps and tables; writing of text) of the candidate, the main supervisor (where he/she is an associate author) and the other authors.

If applicable, the contributions from other PhD candidates who have or intend to include the paper in a thesis should be described. Contributions from master students should also be mentioned.

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Independent contribution of candidate:

Simon Baumgartinger-Seiringer, the PhD candidate, acted as first author of this paper. He was therefore responsible for managing the overall process. Simon pinpointed the research gaps addressed and formulated the overarching research goals and aims. He was mainly in charge of translating the concept of 'institutional infrastructures' to the sphere of economic geography and thereby developed the paper's conceptual framework. Moreover, he conducted the data collection in the AAT (qualitative interviews, documents, participatory observations), transcribed and analysed this data (together with Johan Miörner). In terms of writing, Simon authored the introduction (section 1), the literature review on concepts in economic geography (section 2), the conceptual framework (section 4), the empirical section on the AAT (section 5.1) and the conclusions (section 6). Moreover, Simon was in charge of the whole revision process. As corresponding author, he was also responsible for the publication process.

First author's contribution:

The candidate is the first author (for contribution see above).

Contributions of other authors:

Lea Fuenfschilling, the second author of this paper, had the initial idea and – as expert for institutional theory – introduced organizational institutionalism and in particular the concept of 'institutional infrastructures' to the other authors and in the paper. She authored section 3. Additionally, she provided feedback and ideas for developing the conceptual part of the paper.

Johan Miörner, the third author of this paper, contributed mainly to the empirical part of the paper. He conducted the data collection in West Sweden (qualitative interviews, documents, participatory observations), transcribed the interviews and - together with Simon - analysed this data. He authored the empirical part on West Sweden (section 5.2). Moreover, Johan provided feedback and ideas for developing the conceptual parts of the paper.

Michaela Trippl, the fourth author of this paper, was mainly in a supervising role. She provided guidance and feedback throughout the whole development and writing process. Thereby, she contributed to all sections of the paper, e.g., in terms of structure, clarity and focus.

Contributions from other colleagues and master students

Has this paper been, or will this paper be part of another doctoral degree thesis?

Yes: ☐ No: ☒

If yes, please elaborate:

Contributions from master students:

Yes: ☐ No: ☒

If yes, please elaborate details:

First author's declaration of contribution for candidate

First author's name:

Not applicable (the candidate is the first author)

Do you verify that the candidate has contributed to this joint paper as described above?

Yes: ☐ No: ☐

If no, please specify:

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Yes: ☒ No: ☐

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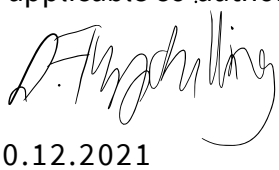
If applicable co-author's signature:



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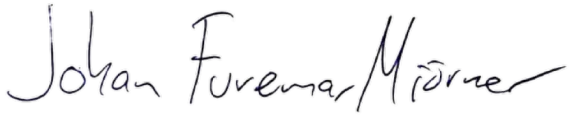

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Paper #4

Baumgartinger-Seiringer, Simon (2021)

‘*The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency*’.

The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency

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Abstract

This article seeks to advance perspectives on powerful incumbent firms in (new) regional industrial path development. Drawing on recent insights from Transition Studies, it is argued that this – hitherto often neglected – actor group plays a crucial role in shaping the pace and direction of regional path development through agency oriented towards both change and maintenance. Building on systemic perspectives at the intersection of evolutionary economic geography and innovation studies, particular emphasis is placed on incumbent firms' interventions to reconfigure or stabilize their surrounding regional innovation system to support their intentions. To this end, this article examines how incumbents exert their influence through various forms of power as means by which they promote or hinder regional industrial change. Empirically, the role of incumbent firms in a traditional automotive industry in Austria is investigated. It is shown how they leverage their power to propel the industry's digitalization and suppress its decarbonization.

Keywords

regional restructuring, path development, incumbents, agency, automotive industry, power

Introduction

A substantial body of literature in evolutionary economic geography (EEG) has contributed to our understanding of the unfolding of (new) regional industrial path development[1] (Hassink, Isaksen, and Trippl 2019). While much of this work has traditionally relied on structural explanations, the most recent years have witnessed an increasing attention devoted to the role of agency in creating, recreating and altering paths (Grillitsch and Sotarauta 2020; Hassink, Isaksen, and Trippl 2019). Yet, hitherto, the debate is centred around types of change agency (Bækkelund 2021), that is, agency oriented towards '*identifying change strategies and demolishing, renewing, and building new structures*' (Jolly, Grillitsch, and Hansen 2020, 177). Novel contributions have questioned this one-sided view and called for an incorporation of agency oriented towards maintenance, stability and suppressing change (Henderson 2020; Bækkelund 2021; Jolly, Grillitsch, and Hansen 2020).

Arguably, the strong focus on change agency not only obscures the wider range of agentic practices in processes of (new) regional path development (Henderson 2020), but also limits our understanding of the role of different actors, as it puts emphasis on those bringing novelty to the region. Oftentimes, this is attributed to new firms and innovative Schumpeterian (e.g. start-ups or spin-offs) or institutional entrepreneurs. Actors who actively mitigate or suppress change and seek to maintain the status quo have received limited attention (Jolly, Grillitsch, and Hansen 2020).

A common view is that among these actors are large incumbent firms. Indeed, other strands of literature (such as Transition or Management Studies) emphasize the inertia inherent to incumbents, as they often benefit from the status quo, protect their strong vested interests and thus are unlikely to promote change or champion radical innovations (Heyen, Hermwille, and Wehnert 2017; Patala et al. 2019). The scarce accounts of incumbent firms in the regional path development literature associates them with incremental changes promoting existing paths (Neffke et al. 2018).

Yet, while these perspectives are well grounded in empirical observations (Turnheim and Sovacool 2020), recent insights from transition studies and the management literature also show that incumbent firms are more than actors of resistance. They not only suppress but sometimes embrace disruptive innovations and exploit new opportunities (Kumaraswamy, Garud, and Ansari 2018; Patala et al. 2019). Thus, incumbents might show ambidextrous behaviour and exert both maintenance and change agency in different stages of regional industrial change or even simultaneously (Jolly, Grillitsch, and Hansen 2020).

This article draws on recently developed systemic approaches to path development that combine insights from EEG with the Regional Innovation Systems (RIS) approach (Isaksen and Trippl 2016; Trippl et al. 2020) to examine mature regional industries in phases of transformation. It highlights the role of large incumbent firms centrally embedded in elaborated

[1] An umbrella term referring to various forms of the rise and growth of new economic activities in regions, including the formation of new industries and the substantial transformation of existing ones (Isaksen and Trippl 2016).

RISs[2] and understands them as an important actor type due to their historically grown power, particular interests and influence on other regional and national innovation system elements and on international actors. Here, attention is devoted particularly to incumbents' interventions to shape the wider regional system structures in their favour. It is argued that more explicit attention to their maintenance as well as change agency will help to unravel processes of new regional path development and system reconfiguration or the lack thereof more comprehensively.

The ambition to advance perspectives on incumbencies in regional industrial path development opens up a variety of research questions, ranging from who (are the ones that opt for change/maintenance and why?) to when (under what conditions do incumbent firms strive for change/maintenance?) and beyond. This article – without neglecting the importance of other inquiries – focuses mainly on *how* incumbent firms exert their influence to drive or hinder regional industrial change. To this end, it draws on insights from Transition Studies to better understand their motives and disentangle different channels through which they make use of their power (Geels 2014).

Empirically, this article focuses on incumbent firms in a traditional automotive region, namely the Austrian automotive triangle (AAT), which currently finds itself in fundamental transitions (Trippl et al. 2021), facing two major upheavals simultaneously. First, the increasing digitalization and the advent of automated and connected vehicles is both an opportunity to redefine the regional industry's competitive advantage but, in many ways, also a decisive break with its successful past (Baumgartinger-Seiringer et al. 2021). Second, the climate crisis increase pressure for change towards a sustainable future and away from the combustion engine. As will be shown in this article, incumbent firms react differently in response to different upheavals and thereby substantially contribute to steering the development of the AAT.

The remainder of this paper is structured as follows. The next section reviews the regional path development literature and complementary strands on incumbents and agency as well as on maintenance and change. In section 3, the conceptual framework will be outlined. Section 4 analyses the empirical case of the AAT. Finally, section 5 concludes.

Different perspectives on the role of incumbent firms

Insights from the regional path development literature

Older evolutionary approaches in Economic Geography have a long tradition in explaining mechanisms of maintenance, focusing on causes of regional industrial continuity, path dependency and lock-ins (Martin and Sunley 2006). In contrast, more recent contributions

[2] Importantly, not all mature industries are embedded in highly elaborated RISs. Surrounding regional structural configurations can differ substantially and provide quite different implications for change processes (Baumgartinger-Seiringer et al. 2021). This paper investigates mature industries in well-developed RISs.

consider the past not as a constraint for dynamic regional development but as a resource to be exploited and harnessed for change processes in the present (Martin 2010; MacKinnon et al. 2019). Thereby, path development is seen as enabling rather than constraining and as a mechanism of dynamic regional economic evolution (Martin 2010). This understanding is one pillar of recent systemic approaches that cast light on a broad base of relevant regional assets (including natural, infrastructural, industrial, human and institutional assets) considered both as the outcome of previous rounds of economic development and the platform for future ones (Trippl et al. 2020).

Recently, the regional path development literature has devoted increasing attention to the role of agency[3] and its interplay with structures to explain regional industrial change or continuity (Grillitsch and Sotarauta 2020; Miörner 2020). This new body of scholarly work has brought forward different distinctions in order to disentangle the structure-agency nexus in a more fine-grained way. Researchers have differentiated between firm and system level agency (Isaksen et al. 2019), between innovative Schumpeterian entrepreneurship, place leadership and institutional entrepreneurship (Grillitsch and Sotarauta 2020) and between change and maintenance agency (Jolly, Grillitsch, and Hansen 2020).

The latter can be seen as a response to previous studies that portray agents as heroic and homogeneous pioneers of change (Henderson 2020). In contrast, Jolly et al. (2020, p. 179) cast light on 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 routinization of existing practices and adherence to rules*', that is, to maintenance agency. This article combines the differentiations between change and maintenance agency on the one side and firm and system level agency on the other. While the former generally distinguishes agentic practices based on their fundamental goal (change/maintenance), the latter is mainly concerned with their field of influence (restricted to a firm/organization or geared towards adaptations of the wider RIS).

In this context, it is important to note that one shouldn't confuse types of agency with types of actors: the same actors can pursue different types of agency throughout the span of a path development process or even at the same time (Jolly, Grillitsch, and Hansen 2020; Baumgartinger-Seiringer, Miörner, and Trippl 2021). As regards actors, much work in EEG (particularly the so-called 'Utrecht-school') traditionally emphasizes the role of entrepreneurial firms that are seen as the main driver of regional industrial evolution (Hassink, Isaksen, and Trippl 2019). In contrast, systemic approaches consider multiple relevant actors, including firms (both entrepreneurial newcomers like start-ups and established ones), supportive organizations and policy actors (Isaksen and Trippl 2016). Each of these can become a source of both maintenance and change (Jolly, Grillitsch, and Hansen 2020).

There is little explicit work on incumbent firms in the recent regional path development literature. Implicitly, they are often portrayed as rather rigid. As most firms pursue path dependent learning, radical innovations are often attributed to start-ups or spin-offs (Martin

[3] In a broad manner, agency can be understood as '*actions or interventions by actors in order to produce a particular effect*' (Sotarauta and Suvinen 2018, 90).

and Sunley 2010). Incumbents tend to strengthen existing regional specializations but can be stimulated to diversify into new activities by new firms (Neffke et al. 2018).

However, arguably, overemphasizing the role of new entrants in bringing novelty (to the region) limits our understanding of how well-established actors drive and suppress regional industrial change. Other strands of literature offer different perspectives on incumbent firms that – as is argued here – can contribute to advancing our understanding of their role in regional industrial path development.

Insights from Innovation Studies

While a more thorough review of this literature is beyond the scope of this article, Schumpeter's evolving perception of the role of different actors in innovation processes offers important insights for a more comprehensive picture.

While in earlier contributions, he identified individual entrepreneurs as the pioneers of industrial change (referred to as 'Schumpeter Mark I'), Schumpeter increasingly recognized the role of big incumbent firms in innovation processes in later works ('Schumpeter Mark II') (Fagerberg 2009), in which he elaborated on several reasons why established large firms have particular advantages. Schumpeter attributes their favourable position to the dominant market or even monopolistic position. Accordingly, large incumbent firms can allocate larger budgets to R&D, cope with higher risks due to their diversification and prevent imitation by competitors. Moreover, because of their larger range of activities, more opportunities for unplanned innovations/discoveries arise. Furthermore, they often are well-known and more appealing to talented employees (Stephan 2013).

Albeit of high relevance, Schumpeter's perception of incumbents arguably only represents one side of the coin and obscures a more nuanced view on their role as actors of both change and maintenance. A view that is needed as we face a period of growing concerns about the grand societal challenges in which incumbents' heterogeneity of responses and strategies might only increase (Steen and Weaver 2017). Recent discussions in Transition Studies are highly relevant in this regard.

Insights from Transition Studies

Over the last two decades, a body of literature on sustainability transitions has emerged to unravel change in socio-technical systems, such as mobility or power supply (Kivimaa and Kern 2016). A key theoretical concept brought forward is the multilevel perspective (MLP) which distinguishes between three analytical levels to disentangle drivers for and barriers to transitions, namely the landscape (deep structural trends and external factors like demographic, economic or environmental change), regime (the mutually reinforcing structures making up the socio-technical system, like technologies, institutions, markets, infrastructure etc.) and niche

level (spaces in which innovations are developed and tested). According to the MLP, socio-technical transitions are the outcome of top-down pressures from the landscape level and bottom-up developments in niches that together destabilize the regime (Geels 2002).

In response to critique highlighting the lack of attention for power, the bias towards bottom-up dynamics and the insufficient emphasis on incumbent actors, Geels (2014) casts light on the role of regime actors resisting change. In doing so, he draws attention not only to incumbent firms, but also to policymakers, as these two groups often form core alliances on the regime level due to mutual dependencies. On the one hand, incumbent firms depend on policymakers due to regulations (property rights, tariff protection, etc.), tax systems and public procurement. On the other hand, policymakers depend on incumbent firms because of their 'structural power', as they provide jobs, taxes and economic growth (Geels, 2014). The influence of this coalition in hindering change processes has also been observed in the context of current transformations in the automotive industry (Späth, Rohracher, and Radecki 2016).

According to these contributions, incumbents are powerful yet lethargic, part of the regime and interested in keeping the status quo due to strong vested interests based on their historically developed positions and relationships within socio-technical systems (Heyen, Hermwille, and Wehnert 2017). In other words: incumbents are seen as actors engaging in maintenance agency.

This perspective rests on good reasons: not only is it based on empirical observations (Turnheim and Sovacool 2020), there is also a large body of literature in management studies explaining this behaviour. Kumaraswamy et al. (2018) offer different explanations why incumbents have limited interest and ability to embrace emerging technologies. First, incumbents face an economic dilemma: radical innovations are usually not aligned with their business model and competencies. Thus, driving them forward comes with the risk of cannibalizing their own existing offerings, highly efficient production systems and profit streams. Second, radical change might threaten incumbents' identities, templates and mental models. Third, as incumbents are usually large firms, inertia and organizational myopia are often hindering fast responses. Fourth, scholars have also proposed affective explanations (e.g. fear to lose out when compared to competitors or let down shareholders) on the management level that lead to the inability to respond in real time.

However, despite the conceptual and empirical evidence, the view that they only resist change is increasingly questioned and calls to pluralize perspectives on incumbencies have become louder (Turnheim and Sovacool 2020; Steen and Weaver 2017). Indeed, there is some evidence that regime actors are considerably more dynamic than often assumed as they change their strategies over time and not all incumbents remain stuck in old ways if they are able to overcome internal barriers outlined above (Hansen and Coenen 2017). As Turnheim and Sovacool (2020) point out, incumbent firms can leverage their power, finance and influence and become important sources of change agency when seeing value in tactically engaging with transitions (for instance to outmanoeuvre rivals).

With all that in mind, it is also important to note that incumbents often engage in pluralistic responses. They can perpetuate a traditional business model and core functions of a regime, for instance by lobbying for political support, while simultaneously investing in niche activities

(e.g. R&D) (Späth, Rohracher, and Radecki 2016), that is, they can exert change and maintenance agency simultaneously. Thus, it is important to acknowledge both the transformative potential and the influence to maintain the status quo of powerful incumbents at the same time (Späth, Rohracher, and Radecki 2016).

It is argued that incorporating this emerging, more holistic picture of incumbent firms' responses to transformation pressures will contribute to a more comprehensive understanding of regional industrial path development in mature industries.

Towards a more comprehensive understanding of incumbents in regional industrial path development

This section proposes a conceptual framework that helps to unravel the role of powerful incumbents in shaping regional path development processes in mature industries through change and maintenance agency. To this end, this framework (a) departs from the particular position of incumbent firms in their surrounding RIS, (b) highlights the important interplay of structures and agency to understand strategies of actors in regional path development and (c) elucidates the different channels through which incumbents exert their power.

Incumbents and Regional Innovation Systems

Departing from a systemic approach to new path development, this article understands incumbent firms as agents situated in historically inherited regional economic, social and institutional structures (Martin 2010).

Oftentimes, incumbent firms have been strong historical forces in shaping the very structures they are embedded in through their engagement in previous rounds of regional path development. Incumbents in many cases have forged strong ties and mutual or one-sided dependencies to other actors within and outside the region (such as other firms or policymakers), support organizations (like educational bodies or intermediaries) are often tailor-made for their needs and formal (like regulations) as well as informal (traditions and norms) institutions have often developed in tandem with them (Geels 2014; Isaksen and Trippl 2016). Thus, incumbent firms are often strongly aligned with their surrounding regional and national innovation systems and embedded in global innovation and production networks, making them particularly powerful as their position and influence is often reinforced and privileged by prevailing regional as well as extra-regional structural conditions (Baumgartinger-Seiringer et al. 2021).

This article emphasizes regional factors. Thus, it is argued that the power of incumbents stems especially from their influence on the wider regional innovation system and other elements within. However, extra-regional influences affecting their strategies – such as higher governance levels, inter-regional linkages or headquarters elsewhere – are not neglected.

The implications of incumbents' embeddedness in their surrounding RIS are twofold. First, there are indeed strong conceptual arguments from a systemic perspective to assume that incumbents tend to reproduce and maintain existing regional structures from which they often benefit. However, they not always do so, but can become forces of change under certain circumstances outlined above (Turnheim and Sovacool 2020). Second, due to their structural power and resources, incumbents can be seen as particularly effective in modifying the regional asset base if they opt for change.

Structures and agency

To understand the strategies of agents in general, one must acknowledge the complex interdependence between structures and agency. Actors find specific opportunities and constraints for industrial change residing within regional structural preconditions (Baumgartinger-Seiringer et al. 2021). That is, structures will limit the scope of action of embedded actors (Emirbayer and Mische 1998). However, they never fully determine the course of action, as agency is not only shaped by historically developed structures but also by perceived futures and expectations. While structural preconditions enable and constrain actions in the present (Grillitsch and Sotarauta 2020), it is the perceived opportunities in these conditions which agents aim for and allocate resources to (Steen 2016). Accordingly, agency is best understood as an inter-temporal process and as the '*capacity to contextualize past habits and future projects within the contingencies of the moment*' (Emirbayer and Mische 1998, 963).

Consequently, in order to create, recreate or alter paths, actors (incumbents or newcomers) – situated in historically inherited structures and driven by their visions and expectations – *'work on structural elements, that is, they will purposefully try to challenge or maintain elements, depending on whether they hamper or support their intentions*' (Baumgartinger-Seiringer et al., 2021a, p. 9).

It is well established that new path development depends on RIS reconfiguration (e.g. changes in training programs or institutional frameworks), as established innovation systems are usually unfit to provide the necessary assets to meet new demands (Isaksen and Trippl 2016). That is, regional structural elements in many cases do hamper innovators' intentions. Hence, powerful incumbent firms striving for change or maintenance not only engage in firm level (concerned with adaptations within their own organization) but also in system level agency (Isaksen et al. 2019). They have the capacity to work on and reconfigure the wider RIS.

However, this mechanism might very well go in the opposite direction. Powerful actors opting for reproduction of the status quo might exert influence to maintain certain impeding innovation system structures to mitigate or prevent change that would be detrimental to their intentions ('system stabilization').

Thus, incumbents steer path development processes directly (through firm level agency) but also indirectly, as they reconfigure or stabilize the RIS to support their interests.

Incumbents and their channels of power

Now, in what ways do incumbent firms leverage their particular structural position to change or maintain the course of path development and system reconfiguration? There is little conceptual research in the context of regional path development on concrete channels through which power and influence is exerted[4].

Geels' (2014) work on the role of regime actors specificizes different forms of power used to mitigate and resist fundamental change by drawing on insights from political economy. First, incumbents can draw on instrumental power, that is, using their many resources (e.g. authority, money, personnel, …) to achieve their goals (in interactions with other actors). Second, they can resist change through discursive power by shaping discourses and setting agendas using their positions and media access. In doing so, they influence not only what is being discussed but also in what way. Third, incumbents possess material power. They can defend themselves and their position by drawing on their technological capabilities and financial resources to improve the technical dimension of the current regime. This strategy is often coupled with discursive approaches and promises that the solution is 'around the corner'. Fourth, incumbents exert influence through institutional power which are connected to the broader governance structures and political cultures (e.g. seemingly neutral 'hands-off' policies that privilege powerful and resourceful incumbents) and their political leeway (Geels 2014).

While Geels conceptualizes regime stability as the outcome of active resistance by incumbent actors and thus maintenance agency, this article argues that these very channels can be used to leverage their power to promote change. Instrumental, discursive, material and institutional forms of power are not only means by which incumbents can maintain and reproduce regional structures, but also by which they can be altered (Table 1).

Table 1: Channels of power oriented towards change/maintenance (Source: own elaboration based on Geels, 2014).

	Change	**Maintenance**
Instrumental	using resources to **alter** structures/structural elements	using resources to **maintain** structures/structural elements
Discursive	Shaping the discourse to **push** for change	Shaping the discourse to **prevent** change
Material	Improve technical dimension of **new** technology (+promises)	Improve technical dimension of **old** technology (+promises)
Institutional	Using the institutional power to **pave the way** for change	Using the institutional power to **resist** change

[4] A notable exception is Sotarauta's (2009) work on power and influence tactics in the promotion of regional development in Finland by development officers. However, this work focuses on intermediaries and, thus, on an actor type with a very different power base than incumbent firms.

In summary, the conceptual framework proposed here unravels *how* incumbent firms exert their influence to promote regional industrial change or maintenance. Based on their particular position in regional as well as extra-regional structural conditions and driven by their perceived future, they engage in agency that reaches beyond their own organization. They reconfigure or stabilize their surrounding RIS to support their intentions. To this end, incumbent firms draw on various forms of power to shape the direction of regional industrial path development.

The role of incumbents in the Austrian automotive triangle's development

The empirical section studies the role of incumbent firms in the 'Austrian automotive triangle', a traditional automotive region concentrated in the three provinces Styria, Upper Austria and Vienna (Trippl et al. 2021). The AAT has been selected as it hosts several well-connected and long-established companies (Schneider et al. 2018; for an overview see Appendix), making it an interesting case study to examine how powerful firms shape the pace and direction of regional path development and system reconfiguration.

This section first outlines the methodology used for data collection and analysis. Then, it provides insights into the structural conditions of the Austrian/global automotive industry to unravel the interplay of structures and agency in this specific case. Finally, it analyses strategies of incumbent firms in response to two different upheavals the industry and the AAT are currently facing.

Methodology

The analysis is based on 25 in-depth semi-structured interviews with incumbents (six with incumbent firms and three with representatives in industry associations), but also experts in universities and research institutes (five), intermediaries (four) and government agencies (seven) in the AAT. On average, they were around an hour long with some exceptions lasting up to three hours. All interviewees have gained profound knowledge of the regional industry and the broader RIS through their – usually longstanding – occupation.

The interviews were complimented with an intensive document analysis of policy-documents, interviews in newspaper articles and press statements of incumbent firms and their interest organizations like the Federation of Austrian Industries (IV) and the Austrian Economic Chambers (WKO). Furthermore, the author has participated in relevant conferences in the AAT contributing to further robustness. The transcribed interviews and complementary material were coded and analysed using a qualitative content analysis based on themes corresponding to the analytical framework. As previous research has argued, such a qualitative case study approach is suited to unravel the interlinkages between agency and structure (Jolly, Grillitsch, and Hansen 2020).

Importantly, the empirical investigation focuses on the period between 2012 and 2019. This timeframe was selected for two reasons. First, our interview partners highlighted the year 2012 as the point of initiation of transformations. Second, the interviews were conducted in 2019 and, hence, allow for an in-depth and robust *retrospective* analysis of this particular episode of regional industrial path development.

The (Austrian) automotive industry

There are several specific characteristics of the (Austrian) automotive industry considered crucial here to understand processes of change and maintenance.

First, the automotive industry is a key sector of the Austrian economy. Almost 10 percent of the Austrian workforce (almost 400.000 persons) were employed by companies connected directly or indirectly to the industry in 2018 (Kleebinder et al. 2019). Moreover, the industry is dominated by large long-established incumbents, around 82% of revenue is generated in companies with 250 or more employees (Schneider et al. 2018). The automotive path is embedded in and aligned with a strong RIS that consists of many research institutes, (technical) universities, cluster organizations and so on (Trippl et al. 2021). Given the size and elaboration of the automotive path and its surrounding support system, it is hardly surprising that policymakers are eager to support the industry, while – at the same time – hesitant to limit its scope of action (e.g. through regulations). This mirrors Geels' (2014) notion of the alliance on the regime level that often prevents change.

Second, the car industry is traditionally relatively stable. It was long developing rather incrementally and has shown a remarkable capacity to withstand transition pressures (Späth, Rohracher, and Radecki 2016). However, technological progress and ecological concerns are expected to boost fundamental transformations now.

Third, from a management studies perspective the industry is a systemic one, meaning that different components or modules by different firms need to be compatible. In such industries, innovations might alter the 'system's architecture', that is, the form and function of its components and their interfaces. Consequently, innovations have the potential to significantly change roles, relations, rules and transactions (Kumaraswamy, Garud, and Ansari 2018). This can be considered both a threat and an opportunity for the AAT due to its semi-peripheral position in automotive global production networks (GPNs) (Mordue and Sweeney 2020). Pavlínek (2018) characterizes such semi-peripheral regions by their lack of domestic OEMs (Original Equipment Manufacturer), relatively high production costs and their need to redefine their competitive edge in light of recent moves of production to low-cost locations. The AAT indeed hosts only supplier firms, which exhibit a strong export-orientation and forged strong ties to German OEMs. 87% of products manufactured in the AAT are exported, a majority of them to Germany (WKO 2019). The implications for Austria's automotive industry are mixed. On the one hand, the empirical analysis has clearly shown a fear that radical changes in strategies of partner OEMs in Germany might alter established central European production networks and render certain competitive advantages and components manufactured in the AAT

obsolete. This especially holds true for the many firms in value chains connected to the combustion engine. In 2018, a quarter of the production value of 17 billion Euros was generated in the sector 'engines and transmissions' (Högelsberger and Maneka 2020). On the other hand, in consideration of the high R&D-intensity of the industry, the strong support structures of the RIS and trends of de-verticalization in the global automotive industry (Trippl et al. 2021), our interviewees also pointed to the opportunity of supplier firms to reposition within value chains.

Fourth, the automotive industry's systemic architecture, elaboration and capital-intensity give incumbents a decisive advantage in times of disruptive change. Disruptors in such industries are often highly dependent on the very incumbents they seek to challenge, i.e. 'the disruptor's dilemma' (Kumaraswamy, Garud, and Ansari 2018). Thus, incumbents in the automotive sector are particularly influential.

Analysing incumbents' strategies: change and maintenance

Drawing on these more principal considerations, this section will now analyse the concrete strategies of incumbent firms in the AAT and examine how they leverage their four channels of power in response to '*the two megatrends that will have a lasting impact on the automotive industry: 1) decarbonization and 2) digitalization*' (as one representative of a research organization put it).

As will be shown, they react with agency oriented towards maintenance in case of the former, while responding with change strategies in face of the latter. This is explainable by opportunities and constrains found in the structural preconditions and perceived futures.

Decarbonization: Incumbents as actors of maintenance

Mobility is a key field in which decarbonization must happen to fight the climate crisis and increasing resource depletion (Späth, Rohracher, and Radecki 2016; Pichler et al. 2021). While this insight is hardly controversial anymore, the ways to achieve this goal are. They range from more radical ideas questioning the prevailing car-ownership-model altogether to mere efficiency improvements of conventional powertrains. As in many other countries, sustainable mobility over time has been increasingly equated with the electrification of cars in Austria (even though different approaches are still being discussed).

In contrast to more profound changes to the mobility system, the shift to e-cars is an approach to green mobility relatively compatible with the interests of the car industry (Späth, Rohracher, and Radecki 2016). However, the structural orientation on the combustion engine in the AAT leads to strong path dependencies and makes this transformation one with high disruptive potential (Högelsberger and Maneka 2020).

Accordingly, the interests of industrial players and politicians in respect to added value and employment stand in stark contrast to ecological goals. Thus, incumbent firms have used their

channels of power mainly to engage in maintenance agency over the period of investigation that strongly steered the direction of regional path development and system stabilization towards reproducing established ways of doing things.

Instrumental – Sustainability. The empirical investigation has shown that the period of 2012 to 2019 in the AAT was characterized mainly by the hesitancy of incumbent firms to leverage instrumental power in relation to sustainability concerns and the electrification of cars. Thus, the unwillingness to use their resources must be considered an important and deliberate form of maintenance agency.

There are several reasons for this behaviour. First, interviewees have pointed to the reluctance of higher-tier-firms to position themselves and described a downstream network effect that prevents lower-tier-firms from doing so too. For instance, a chief strategist of one of Austria's largest automotive incumbent firms said that '*the unwillingness of German OEMs, their fighting that something is not implemented, even if it should be [from an environmental perspective], that creates a field of tension for us*'. This statement points to the fact that while incumbent firms are powerful within the surrounding RIS, their influence in automotive GPNs is limited due to the AAT's semi-peripheral position (Mordue and Sweeney 2020). Moreover, some of the most important incumbents in the AAT are subsidiaries of multinational corporations with their HQs elsewhere[5] (see appendix). Accordingly, maintenance strategies of automotive incumbents in the region are – at least to some extend – outcome of external influences.

This situation conserves traditional supply chains and poses an immense system level challenge for smaller firms that lack the advantages of larger companies (e.g. financial capacities for R&D, see literature review), on which they depend due to the industry's systemic architecture. Thus, incumbents (within the AAT and broader GPNs) refusing to engage in change agency have a strong signalling effect on other elements in the RIS. This holds true not only for other firms but also for the education and research domain, on which incumbent firms traditionally exert a strong influence (Trippl et al. 2021). An analysis of the curricula of relevant degree programs, as well as our interviews with researchers confirmed that classic mechanical competencies are still predominant. In this respect, interviewees reported on active maintenance agency and vested interests of both firm and non-firm actors (e.g. in universities).

Second, the empirical analysis confirmed well-established reasons for the inertia of incumbent firms, such as sunk costs, the development of a distinctive specialized technological regime or a pool of skilled workers (Martin and Sunley 2006). These arguments have been brought forward throughout the interviews in relation to a historically developed excellence in combustion engine technology in the AAT. Hence, the reluctance to allocate resources to this transformation is clearly tied to a perceived danger of cannibalizing own existing offerings,

[5] Other work on the AAT has argued that the leeway of foreign owned firms is limited (Pichler et al. 2021). However, research conducted for this article has shown that incumbent firms with HQs elsewhere (in particular Magna) have been important forces of system reconfiguration/stabilization.

highly efficient production systems and profit streams (Kumaraswamy, Garud, and Ansari 2018).

Third and closely related, this hesitancy is connected to mutual dependencies between incumbent firms and policymakers (Geels 2014). According to some interviews, the conflict of interest (environmental protection vs. economic performance) with which policymakers are confronted resulted in a lack of directionality and pressure on dominant incumbent firms.

While the empirical investigation has drawn a clear picture, it is important to note that there are firms, both newcomer and incumbents, that have been engaging early in this transformation. The activities range from manufacturing cases for the modified engine compartment (ADG Austria Druckguss), to battery development (Kreisel Electronic) and simulating alternative powertrains (AVL).

Discursive – Sustainability. The analysis has revealed three framings in the AAT to counteract increasing sustainability concerns (similar strategies has been observed in Stuttgart, see Späth, Rohracher, and Radecki 2016).

First, a strategy commonly used by incumbent firms is to frame the combustion engine as a pillar of regional economic prosperity. This is related to expressed concerns about the far lower complexity of electric engines, lower potentials for value creation, high investments necessary and the potential loss of jobs (Högelsberger and Maneka 2020). Second, incumbents have framed their own role in this debate as one with little to no responsibility. Instead, they see either the customers/market or policymakers in charge. Thereby they drew a picture of passive actors merely reacting to external forces that strongly contrasts the self-image of a highly innovative regional industry. Third, incumbent firms have applied counter framings to delegitimize new ways (Kumaraswamy, Garud, and Ansari 2018). These revolve around two points. On the one hand it is often argued that – taking everything into account – e-mobility is not cleaner than conventional engines and on the other hand that there are better alternatives for clean mobility such as the fuel cell in the future (and thus engaging in this transformation does not pay off).

While it was not possible to assess the concrete impact of these discursive strategies on the process of regional path development, previous studies have shown that incumbents' rhetoric is a powerful tool to establish and reproduce the order of things in periods of socio-technical change (Patala et al. 2019). Moreover, in the context of regional development, the potential to influence others and frame their thinking can be seen as particularly significant, as regional change often rests on co-operation and co-ordination (Sotarauta 2009).

Material – Sustainability. There is strong evidence for material strategies of incumbent firms targeting the improvement of established technologies. This has been confirmed by interviewees but also becomes apparent through companies' own PR tools such as press releases or websites. In a booklet released in 2018, the large BMW engine plant stated that it is '*still fully committed to further developing the combustion engine*' and highlighted its

importance for the '*diesel-land Austria*' (BMW Group 2018). Incumbents such as Magna, AVL or miba have reported similar innovation endeavours and resources allocated to areas no longer needed in e-cars (mostly incremental changes in fuel systems, coupling systems or exhaust aftertreatment systems). While this behaviour is connected to a certain degree of novelty, it inhibits larger-scale alterations in the regional industry and can thus be seen as a form of maintenance agency (Bækkelund 2021).

This tendency to persist on the combustion engine has also been found by others. In their work on perspectives for a social-ecological transformation of the Austrian automotive industry, Högelsberger and Maneka (2020, p. 422) summarize: '*A high level of confidence in the ecological modernization of combustion technology can be observed. The majority of actors consider the internal combustion engine to be viable for the future, which is justified by its allegedly high optimization potential. […] This idea of an incremental innovation process - remaining within the framework of combustion technology - is often accompanied by scepticism towards e-cars*'[6]. Indeed, a survey conducted in 2018 with automotive suppliers has indicated that improvements of conventional powertrains were still considered the most crucial field of product innovation by many firms in the AAT (Pichler et al. 2021).

The interviews as well as other research have shown that this opinion is widespread in the RIS and shared by parts of the workforce and – at least to some extent – by the research domain (Pichler et al. 2021; focus 2017). Accordingly, spurred by material strategies of powerful companies and historically high levels of cooperation, a belief in the future viability of combustion technology has manifested in the AAT.

Importantly, some interview partners (particularly in the research domain) expressed concerns about lock-in tendencies, a system in self-satisfaction (Trippl et al. 2021) and outspoken criticism of this current development path. Others argued that perpetuation of old technology and business models is merely the basis for diversification endeavours. Thus – as is reasoned – maintenance agency can sometimes be a necessity to reap the resources to engage in change agency (particularly in relation to costly efforts towards digitalization).

Institutional – Sustainability. Incumbent firms also made use of their institutional power to withstand sustainability transitions. On the one hand, incumbents have leveraged this kind of power actively, that is, they have used their institutional leeway. Indeed, representatives of incumbent firms confirmed well-established connections to politicians (which is hardly surprising given incumbents' structural power), even to the highest levels of the Austrian government. However, they not only have exerted influence in the background. Very recently incumbent firms (such as Magna, MAN, KTM and others) also tried to apply public pressure through an open letter to the chancellor to speak out against a ban for combustion engines on the EU level, arguing that this would inhibit innovation, cost many jobs and lead to a loss in

[6] Quote translated by the author.

value of approximately five million Austrian cars (see also discursive strategies) (Wiener Zeitung 2021)[7].

On the other hand, there are passive forms of institutional power, which are connected to broader governance and political structures that privilege powerful incumbents, such as seemingly neutral 'hands-off' policies (Geels 2014). Indeed, being open to all types of technologies (e.g. hydrogen) to combat climate change is a recurring argument used by both representatives of the automotive industry and the federal government to legitimize 'continue as before' strategies based on the assumption that the 'solution is around the corner' (VCÖ 2018). Moreover, interviewees reported on institutionalized structures that favour maintenance agency, e.g. existing funding pools oriented towards established competencies. In this respect, a recent report on environmentally harmful subsidies in Austria found that the prevailing business model based on cars with combustion engines is supported with indirect subsidies amounting to 1.3 billion Euros per year (Pichler et al. 2021).

Digitalization: Incumbents as actors of change

Austria's automotive industry places high hopes in the digitalization of cars. In a period dominated by scepticism about the industry's future in light of the climate crisis, the emission scandal and the overall image of cars, the advent of increasing automatization is welcomed by many as a new field of innovation in accordance with AAT's profile (Trippl et al. 2021). Moreover, as Trippl et al. (2021) argue, there are several enabling (regional) conditions, ranging from general trends in the global automotive industry (e.g. de-verticalization) to the high innovation capacity in the AAT (based on R&D expenditure, patents, research collaborations). Moreover, Austria hosts an innovative and R&D-intensive microelectronics path that is traditionally interwoven with the automotive industry, sees opportunities for further diversifications and plays an important role in system reconfiguration. For all these reasons, incumbent firms have leveraged their channels of power mainly to actively engage in change agency in this transformation since around 2012.

Instrumental – Digitalization. Incumbent firms have used their many resources to reorient the RIS and thereby significantly influenced the direction of regional industrial path development. In light of the increasing complexity and need for cooperation, many incumbent firms have further strengthened their ties with other regional actors. Interviewees reported on renewed life in several consortia including traditional cluster organizations, well-established competence centres such as Virtual Vehicle in Graz and newly initiated corporations such as Silicon Austria Labs (a science-industry centre founded in 2018 working on – among other things – automated driving). Many well-known incumbents sit on the steering boards of these consortia.

[7] This letter was written in 2021 and must be seen in the context of increasingly widespread consensus that phasing out of the combustion engine in its current form is inevitable. Yet, it shows how widespread maintenance agency still is in the AAT.

Moreover, incumbent firms have begun to forge new strategic links between firm and system level actors, for instance between Siemens Mobility Austria and the federally owned infrastructural operator ASFINAG (that itself positioned early in this transformation) to further digitalize motorways and provide the basis for automated driving. Collaborations have also been institutionalized with projects like 'innoregio', a meeting between firm level and system level actors taking place every three months to coordinate activities in Styria.

Powerful firms have also made use of their historically strong influence on the research and education domain (Trippl et al. 2021). Firms like AVL und Infineon have funded new endowment professorships related to automated driving at universities in Graz and Vienna. AVL, Infineon, Magna and NXP have played a pivotal role in starting and funding the new master's program 'System Test Engineering' at Johanneum Graz (University of Applied Science). In 2017, German OEM Audi has partnered with Johannes-Kepler university Linz and opened the audi.JKU deep learning centre. In 2018, Magna and the technical university in Graz have reinforced their cooperation (existing since 2004) to also cover research in the area of automated driving (for an overview of most of these activities, see BMVIT 2018). In doing so, incumbent firms, on the one hand, gain valuable research results based on the dynamism and freedom of universities and, on the other hand, shape tomorrow's graduates.

As previous research has shown, these actions of system reconfiguration – often in cooperation with the federal ministry for transport (BMVIT) – have led to an increased coherence between an already highly cooperative industry and surrounding RIS elements (Baumgartinger-Seiringer et al. 2021).

Discursive – Digitalization. The empirical analysis has shown two main discursive strategies used by incumbents to legitimize the need for action: an opportunity and an urgency framing.

The opportunity argument is connected to a strong belief in the high innovation capacity. Accordingly, many interviewees and documents (particularly those in relation to the micro-electronic path) have emphasized that the right conditions to meet these new challenges and to tap new markets are in place regionally.

The urgency framing is underpinned by the conviction that the digital transformation will completely revolutionize the car and cannot be stopped. It is tied to the notions that the sources of revenue are shifting from hardware to software and that data-collection is vital to survive in a transformed automotive industry. Hence, the urgency framing echoes the fear of a potential loss of prosperity expressed in response to sustainability concerns, but this time around to motivate change rather than maintenance.

Albeit not as common, the necessity for digitalization is sometimes motivated by promises of more sustainable and safe cars. Accordingly, it is argued that lower levels of car production due to car-sharing and self-driving cars, intelligent traffic management and traffic harmonization offer new ways to promote safety and sustainability. Accordingly, there is some evidence that growing environmental concerns were redirected to promote the industry's digitalization.

Material – Digitalization. Incumbent firms in the AAT have been engaged in countless activities to propel the ongoing digitalization process, ranging from the development of intelligent lights used for automated driving (e.g. for communication with pedestrians or other analog road users) (ZKW) to testing services for ADAS (Advanced Driver Assistance Systems) both in virtual and real-world scenarios (AVL) and developments to digitalize the car key (NXP). The 2018 annual press talk of Bosch-Austria also presents an interesting example. Klaus Foquet (sole director at the time) highlighted both the need to invest in areas of connected mobility *and* the combustion engine (i-magazin 2018) and, hence, motivated material strategies for maintenance ('*Diesel has a future*') *and* change ('*creation of innovative solutions in areas such as connected mobility*').

Importantly, drawing on their experience in system thinking and high investments in R&D, microelectronic firms have played an important role in regional reconfiguration and become strategic partners of automotive OEMs (Trippl et al. 2021). Firms such as Infineon, AT&S or AMS have been engaged in developing a broad range of microelectronic solutions for automated driving. Microelectronic incumbents have traditionally strong ties to the automotive industry that will only strengthen as the demand for sensors will further increase (currently there are around 100 in a typical car, predictions say that it will be several 1000s in the future). Propelled by these circumstances, AMS – one of the most R&D-intensive firms in Austria – declared that its future lies in the automotive segment (Industriemagazin 2019).

Yet, it should be noted that all these changes do not come without frictions. Interviews and previous research (Trippl et al. 2021) have shown that there is an incompatibility between the historically developed trademarks of the AAT (determinism, safety, predictability, …) and new software-based methods (agile, flat hierarchies, short development horizons, …). It has turned out that this is a particular problem for traditional automotive companies. Thus, incumbents that – due to their size – often suffer from inertia (Kumaraswamy, Garud, and Ansari 2018), have begun to radically modify their firm cultures (Trippl et al. 2021).

Institutional – Digitalization. Due to a reported mismatch between rigid institutional assets and new demands tied to the inflow of IT knowledge (Baumgartinger-Seiringer et al. 2021), institutional change (e.g. questions of insurance) is seen as a necessity for the consolidation of change.

Interviews have shown that incumbents leverage their institutional power to put pressure on policymakers, e.g. to adjust regulative frameworks quickly to the technical status-quo or to better support international recruitment. Particularly in relation to testing automated solutions in real world environments, incumbent firms have been described as proactive – and successful. Today, there are two testing sites in the AAT: the ALP.Lab in Styria and DigiTrans in Upper Austria. The former was founded in 2017 by incumbent firms AVL and Magna together with scientific partners. The latter is run by a consortium of firm-level (e.g. incumbent firms Hödlmayr International, Reform-Werke Bauer and MAN) and system-level actors (such as the

university of applied science Steyr and the Austrian Institute of Technology). Both projects are supported by ASFINAG and BMVIT.

Despite mutual dependencies and these success stories, the situation has been described as difficult by some. Policymakers on the national level are confronted with very proactive incumbent firms and – fuelled by international competition – with their 'race to-the-bottom' demands on the one side and difficulties to align different governance levels (European and sub-national) on the other.

Discussion and Conclusion

The analysis has shown how incumbent actors in a mature regional industry have shaped industrial path development and regional innovation system reconfiguration/stabilization in their favour through change and maintenance agency. It has been argued that their agentic practices are best understood from a structure-agency perspective. Based on distinct structural conditions and driven by their perceived futures, incumbents leveraged their influence to either drive (digitalization) or resist (decarbonization) transformations.

In doing so, they made use of instrumental, discursive, material and institutional forms of power (Geels 2014). The empirical investigation has not only confirmed that these channels are indeed tools for both, maintenance *and* change, but also that they differ in significance. From a systemic perspective, those forms of power with the capacity to influence other RIS elements rank high in relative importance. In relation to decarbonization (maintenance), this has applied particularly to the material dimension of power that – in conjunction with discursive strategies – led to a manifestation of a strong belief in the future viability of the combustion engine and, thereby, contributed strongly to system stabilization. In contrast, instrumental power was paramount to reconfigure the system in ways that allow for more cooperation, which is seen as imperative for digitalization (change).

Overall, this paper aimed at disentangling *how* incumbents exert influence to drive or hinder regional industrial change. Future research should complement this research by putting more emphasis on who are those that strive for change or maintenance and – in particular – under what circumstances.

There are several further aspects worth underlining. First, incumbent firms have distinct advantages and disadvantages over other firms (see section 2). These are particularly pronounced in case of the AAT due to structural characteristics of the automotive industry. Accordingly, the power of incumbent firms might vary substantially between industries as it depends on factors such as the industry's architecture, capital-intensity and regional embeddedness. Hence, testing the analytical framework in the context of a less elaborated and backed industry/RIS would provide important additional insights. Second, the investigation has focused on the meso-level. On the micro-level it becomes clear that not all incumbents act identically. Both their power and strategies largely depend on their competencies, ownership, embeddedness in the RIS, markets, visions etc. Third, a dynamic understanding of agency is

needed (Jolly, Grillitsch, and Hansen 2020; Baumgartinger-Seiringer, Miörner, and Trippl 2021). While the empirical investigation focused on the period between 2012 and 2019 and provided a clear picture, the last years (2019-2021) have shown that the strong defensive stance towards e-mobility is increasingly fragile. For instance, Magna has recently started to assemble a niche e-car for Jaguar. This development is strongly connected to more political (including fines from the European level) and economic pressure (through US and Asian firms entering the market) and a trend reversal towards e-mobility in Germany starting in 2019 (Olle et al. 2020). Forth, this very influence of German OEMs is crucial to understand regional path development and system reconfiguration in the AAT. Thus, despite the weight of incumbent firms, even they depend strongly on extra-regional factors, reflecting power asymmetries between core and semi-peripheral regions in automotive GPNs (Pavlínek 2018).

More generally speaking, incumbent firms are not considered to play a major role in new path development, but rather portrayed as actors who tend to reproduce the status-quo. Indeed, incumbents can become strong barriers to change, their role is important to understand why paths fail (Blažek et al. 2020) or new path development does not succeed (questions hardly examined so far). Hence, maintenance agency has a dark side in the sense that it bars the way to progress. However, other research has cast light on positive forms of maintenance/reproductive agency oriented towards the consolidation of change that should be considered equally important for our understanding of regional industrial development (Bækkelund 2021; Baumgartinger-Seiringer, Miörner, and Trippl 2021).

Further, this article makes a strong case for advancing systemic perspectives on innovation-based regional change by incorporating the role of power. RIS reconfiguration or stabilization depends strongly on influential actors capable of shaping or maintaining their surrounding RIS in their favour. Hence, such actors possess 'systemic power'[8] to alter other elements (e.g. other firms, the organizational support structure or institutional setups). Accordingly, power is an important dimension of what Miörner (2020) has termed 'system selectivity': The power configuration within the RIS affects what is possible in terms of change (i.e. what type of change is 'selected').

Indeed, the empirical analysis has shown that the AAT was not conducive for development per se in the period of investigation, but for a certain type of regional industrial change. Led by powerful incumbent firms, the RIS was reconfigured in ways to support digitalization, while stabilized to constrain decarbonization. The reason is that the former upheaval – despite being very radical itself (Trippl et al. 2021) – was more compatible with the industry's regional setup or the 'system's architecture' (Kumaraswamy, Garud, and Ansari 2018). In other words, digitalization was less disruptive in relative terms and, hence, a more 'system-stabilizing' innovation.

This raises questions concerning the interdependence between different disruptions. On the one hand, there are hints that the increasing digitalization and sustainability transitions reinforced each other (e.g. observed discursive strategies to legitimize steps towards digitalization with

[8] This idea is not new, power is often defined as a capacity to control other actors or to produce intended effects on others (Sotarauta 2009).

growing sustainability concerns). On the other hand, it became clear that assets (e.g. financial ones, workforce) allocated to digitalization efforts are bound and, therefore, cannot be used to respond to – arguably more important – sustainability concerns. This poses a challenge for both research and policy to move beyond a hitherto often neutral or indifferent stance towards innovation.

Finally, this article offers insights in light of recent calls for regime destabilization and exnovation (Kivimaa and Kern 2016). Such measures will have to find answers to the power of incumbents and their different channels of influence. Moreover, the alliance between powerful firms and policymakers constitutes a particular challenge, as the latter are important actors of destabilization in the first place. One way to approach these problems is the implementation of directionality and challenge orientation on the innovation system level, thereby placing societal challenges at the core of innovation processes (Tödtling, Trippl, and Desch 2021) and recalibrating 'system selectivity'.

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